Second Edition

OCR Version

CSP

Certified Safety Professional

EXAM STUDY WORKBOOK

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SPAN™ ExamPrep

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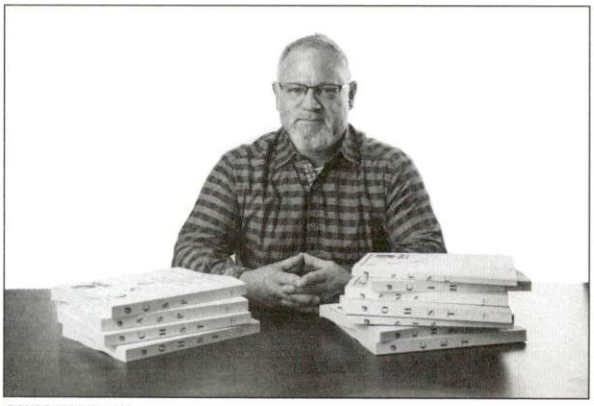
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With 28 years of global occupational safety and health consulting experience, Dr. Snyder partners with stakeholders to develop strategies for improving safety and health management systems by conducting workplace evaluations, facilitating research to improve safety performance, and designing customized educational curriculum. Daniel served in the Army in military intelligence and as a safety liaison for implementing field expedited safety training as part of the National Incident Management System for disaster response. He holds a doctorate degree in Human Resource Development and Adult Lifelong Learning from the University of Arkansas. As the former owner of SPAN, he is a subject-matter expert on certification exam blueprints, safety and health management systems, and safety training, and is currently a consultant to ClickSafety.com. He is the author of the SPAN Exam study workbooks and serves on several standards and professional development committees, including the Chairperson for the ANSI/ASSP Z490.1 Criteria for Accepted Practices in Safety, Health and Environmental Training Standard. Daniel is a member of the U.S. Technical Advisory Group to the ISO Technical Committee 283 responsible for the ongoing development and enhancement of *ISO 45001, (OHSMS), international standard.* Dr. Snyder's research-based consultancy and curriculum help organizations develop influential safety leaders. Daniel is an accomplished speaker and author whose works include the Ethics chapter in the American Society of Safety Professionals' *Consultants Business Development Guide (2015)* and the National Safety Council's *Pocket Guide to Safety Essentials, 2nd Edition (2014)*. Dr. Snyder is dedicated to advancing health and safety professional development by offering safety expert services. He can be contacted at expert@danielsnyder.com.

Introduction

There are two primary goals of this curriculum:

1. Provide candidates the knowledge and skills to successfully attain Certified Safety Professional® (CSP) certification.
2. Enhance skills, knowledge, and abilities as a safety professional.

This workbook is designed to be used as a resource for self-directed study in preparation for the CSP exam. In the fast track, three-day workshop conducted by SPAN™ Safety Workshops, participants are provided expert guidance and use the same content presented in these workbooks. This curriculum is also used in the SPAN™ CertBok® Exam Prep Online Learning Management System (LMS).

Workshops are conducted periodically throughout the year so that professionals can take the examination as soon as they are prepared. Visit the SPAN™ website for workshop dates and locations: www.spansafety.com

The exam is designed for candidates with four years of professional safety experience with a bachelor's degree. Depending on the university, candidates may qualify as a Graduate Safety Professional (GSP). Generally, it takes the average safety and health practitioner about 40–60 hours of dedicated self-study, in addition to a workshop, to adequately prepare for the examination. The self-study can generally be accomplished in about 4 to 12 weeks.

The workbook is divided into two volumes designed for self-study and facilitated professional development workshops. After each section of the workbook, there are fully developed explanations for the answer selected for each question. In many cases, information about all selections offered as possible answers will be included to assist in developing a better understanding of the subject. These sessions are designed to allow the safety professional to measure progress during the extended program of self-study that is normally required to pass the certification exams.

Considerable effort has been made to fully develop and explain the concepts and techniques discussed. However, given the differences in the background and experience of the safety practitioners sitting for the CSP examination, it is impossible to explain all concepts to all candidates. The materials are based on the exam blueprint and subject matter expertise.

Browse through the first volume, stopping and reading whenever a subject or question is of interest. Study explanations to all questions as these represent much of the exam's philosophy and may add significant value to candidates' test preparation. These are only suggestions.

After reviewing the text, establish a study plan. There are voluminous resources available for each domain of the exam blueprint. Simply stated, chance favors the prepared mind, and candidates should have a study plan. Budget adequate time to master the material.

This text is designed to optimize study time. There is no extraneous or "nice to know" information. All the information is important. Concentrating on the areas emphasized in the text should reduce research and study time considerably.

The Board of Certified Safety Professionals (BCSP) exams have changed dramatically in the past few years, and SPAN™ conducts ongoing research and development to ensure accuracy and quality of curriculum based on the actual exam blueprint. ***These volumes do not contain actual CSP test questions*** and use a question-and-answer format with detailed explanations. Difficult concepts or theories may have material presented in a table, diagram, illustration, or a paraphrased format. This method is used to allow broad coverage of the material and optimize study efforts.

The beginning sections of the workbook are devoted to enhancing knowledge and skills in:

- the exam process.
- study and testing techniques.

Content may serve as preliminary exercises to engage the analytical portions of the brain and help prepare candidates for the mathematical components of the exam. The problems are representative of the exam based on the blueprint.

From the introductory sections, the text progresses to individual areas in each of the nine CSP exam blueprint domains. These nine blueprint domains use the question and answer format designed to mimic the types of questions offered on the exam. Explanations are offered to reduce research time because the examination covers a tremendous amount of subject matter.

The questions presented are representative of the questions found on the actual examination(s). For this reason, candidates must understand the area (areas) to

which the question is pertaining. Many times, this will require additional study. However, do not stray too far from the subject; otherwise direction and focus will be lost. Follow what the workbook attempts to provide.

Approximately 62.8% of the scored questions must be answered correctly to pass the CSP examination. Master the concepts contained herein. Becoming familiar with the subject areas in these workbooks through repetition will help to identify areas of strength and weakness unique to every individual.

The assumption that only fully qualified safety practitioners will attempt to sit for the CSP examination means everyone using this workbook has a solid foundation in the safety and health field. Given this assumption, no attempt has been made to provide a basic safety text. Rather, the problems presented in this book are representative of questions that will likely appear on the CSP examination and are based on the exam blueprint. The workbook is designed as a guide and depending upon an individual's knowledge baseline, additional research may be required.

The challenge of achieving certification is a difficult task. Embrace the journey of professional development in preparation for the exam. The modern safety professional must be an adaptive leader and lifelong learner.

This curriculum has been carefully checked for accuracy, but errors may exist. Should an error be discovered, contact the author via info@spansafetyworkshops.com.

The Safety Professional

A ***safety professional*** is one who applies the expertise gained from a study of safety science, principles, and other subjects and from professional safety experience to create or develop procedures, processes, standards, specifications, and systems with a primary focus on achieving optimal control or reduction of the hazards and exposures that may harm people, property, or the environment. "Safety science" is a twenty-first-century term for everything that goes into the prevention of accidents, illnesses, fires, explosions, and other events that harm people, property, and the environment (ANSI/ASSE 2009). The use of appropriate methods and techniques results in loss prevention and loss control.

A ***Certified Safety Professional***® (CSP) is a safety professional who has met and continues to meet the criteria established by the BCSP and is authorized by the BCSP to use the Certified Safety Professional® title and the CSP credential.

To perform their professional functions, individuals practicing in the safety profession generally have education, training, and experience from a common body of knowledge, such as physics, chemistry, biology, physiology, statistics, mathematics, computer science, engineering mechanics, industrial processes, business, communication, and psychology. Professional safety studies include industrial hygiene and toxicology; design of engineering hazard controls; fire protection; ergonomics; system and process safety; safety and health program management; accident investigation and analysis; product safety; construction safety; education and training methods; measurement of safety performance; human behavior; environmental safety and health; and safety, health, and environmental laws, regulations, and standards. Many have backgrounds or advanced study in other disciplines, such as management and business administration, engineering, education, physical and social sciences, and various fields. Others have advanced study in safety, and this additional background extends their expertise beyond the basics of the safety profession.

An American national standard sets forth common and reasonable parameters of the professional safety position in the ANSI/ASSP Z590.2-2003 *Criteria for Establishing the Scope and Functions of the Professional Safety Position* publication. Safety professionals must plan for and manage resources related to their functions. By acquiring the knowledge and skills of the profession, developing the mind-set and wisdom to act responsibly in the occupational context, and keeping up with changes that affect the safety profession, the required safety professional functions can be performed with confidence, competence, credibility, and respected authority (ANSI/ASSP 2017).

Safety professionals' precise roles and responsibilities depend on the companies or organizations for whom they work. Different industries have different hazards and require unique safety expertise. However, most safety professionals do at least several of the following:

1. ***Hazard Recognition***: identifying conditions or actions that may cause injury, illness, or property damage
2. ***Inspections/Audits***: assessing safety and health risks associated with equipment, materials, processes, facilities, or abilities
3. ***Fire Protection***: reducing fire hazards by inspection, layout of facilities and processes, and design of fire detection and suppression systems
4. ***Regulatory Compliance***: ensuring that mandatory safety and health standards are satisfied

5. ***Health Hazard Control***: controlling hazards such as noise, chemical exposures, radiation, or biological hazards that can create harm
6. ***Ergonomics***: improving the workplace based on an understanding of human physiological and psychological characteristics, abilities, and limitations
7. ***Hazardous Materials Management***: ensuring that dangerous chemicals and other products are procured, stored, and disposed of in ways that prevent fires and exposure to or harm from these substances
8. ***Environmental Protection***: controlling hazards that can lead to undesirable releases of harmful materials into the air, water, or soil.
9. ***Training***: providing employees and managers with the knowledge and skills necessary to recognize hazards and perform their jobs safely and effectively
10. ***Accident and Incident Investigations***: determining the facts related to an accident or incident based on witness interviews, site inspections, and collection of other evidence
11. ***Advising Management***: helping managers establish safety objectives, plan programs to achieve those objectives, and integrate safety into the culture of an organization
12. ***Record Keeping***: maintaining safety and health information to meet government requirements, as well as to provide data for problem solving and decision-making
13. ***Evaluating***: judging the effectiveness of existing safety and health-related programs and activities
14. ***Emergency Response***: organizing, training, and coordinating skilled employees about auditory and visual communications pertaining to emergencies such as fires, accidents, or other disasters
15. ***Managing Safety Programs***: planning, organizing, budgeting, and tracking completion and effectiveness of activities intended to achieve safety objectives in an organization or to implement administrative or technical controls that will eliminate or reduce hazards
16. ***Product Safety***: assessing the probability that exposure to a product during any stage of its life cycle will lead to an unacceptable impact on human health or the environment and determining the appropriate auditory and visual hazard warnings
17. ***Security***: identifying and implementing design features and procedures to protect facilities and businesses from threats that introduce hazards

Safety professionals work virtually anywhere that people might be exposed to hazards and provide technical assistance in identifying, evaluating, and controlling hazards globally. Because safety is an element in all human endeavors, the performance of these functions, in a variety of contexts in both public and private sectors, often employ specialized knowledge and skills. Typical settings are manufacturing, insurance, risk management, government, education, consulting, construction, health care, engineering and design, waste management, petroleum, facilities management, retail, transportation, and utilities. Within these contexts, they must adapt their functions to fit the mission, operations, and climate of their employer. Not only must individuals practicing in the safety profession acquire the knowledge and skills to perform these functions effectively in their employment context, through continuing education and training, they need to stay current with new technologies, changes in laws and regulations, and changes in the workforce, workplace, and world business, political, and social climate (**Table 1**).

Professionalism, Ethics, and Codes of Conduct

Is it safe? How safe is safe enough? Who decides? These are perhaps the most critical and frequently asked questions posed to OSH professionals. A primary role of the safety professional is to help stakeholders and decision-makers define acceptable risk (INSHPO 2017, ASSE) and find tolerable solutions.

The art and science of occupational health and safety requires a dynamic mix of technical competencies and interpersonal skills. The philosophy of safety professional practice is a hybrid of social and physical sciences (**Table 2**). Together, "the art and science of safety" provide the professional competencies required to influence decisions impacting occupational health and safety (Snyder 2018).

- Do we think differently when thinking scientifically than when thinking ethically?
- Can you find scientific answers to the questions "What is reasonable?" or "What is fair?"

A ***professional*** is a member of a group of colleagues who has articulated a set of standards and values and

Table 1 10 Basic Principles of Safety ()

1.	An unsafe act, an unsafe condition, and an accident are all symptoms of management systems problems.
2.	Circumstances that will produce severe injuries are predictable and can be identified and controlled.
3.	Safety should be managed like any other company function. Management should direct the safety effort by setting achievable goals and by planning, organizing, and controlling to achieve them.
4.	The key to effective line safety performance is management procedures that fix accountability.
5.	The function of safety is to locate and define the operational errors that allow accidents to occur. This function can be carried out in two ways: a. by asking why accidents happen—searching for their root causes b. by asking whether certain known effective controls are being utilized
6.	The causes of unsafe behavior can be identified and classified. Some of the classifications are Overload (the improper matching of a person's capacity with the load), Traps, and the worker's decision to error. Each cause is one that can be controlled.
7.	In most cases, unsafe behavior is normal human behavior; it is the result of normal people reacting to their environment. Management's job is to change the environment that leads to unsafe behavior.
8.	There are three major subsystems that must be dealt with in building an effective safety system: the physical, the managerial, the behavioral.
9.	The safety system should fit the culture of the organization.
10.	There is no one right way to achieve safety in an organization; however, for a safety system to be effective, it must meet certain criterions. The system must: (1) force supervisory performance; (2) involve middle management; (3) have top management visibly showing their commitment; (4) have employee participation; (5) be flexible; (6) be perceived as positive.

Petersen, D. Techniques of Safety Management: A Systems Approach. (4th ed.). Des Plaines, Illinois: American Society of Safety Engineers, 2003.

Table 2 Philosophy of Safety

Philosophical Branch	Philosophical Focus	Speculative Question	Operative Question
Metaphysics	Study of Existence	What's is reality?	What is the perceived reality of the organizational safety and health culture?
Analytic	Study of History	Is there meaning in the historical process?	Will predictive analytics prevent future mishaps?
Epistemology	Study of Knowledge	How do I know?	How does communication training, education inform workers about workplace hazards and risk control measures?
Politics	Study of Force	What can I do?	How is decision-making power influenced?
Logic	Study of Reason	How do I validate reasoning?	What evidence is needed to accept or reject hypotheses?
Ethics	Study of Action	What should I do?	Who is impacted by the outcome of this decision?

Snyder, D. J. (2018). *Philosophia Soteria: How occupational safety and health professionals influence decision makers. Theses and dissertations.* https://scholarworks.uark.edu/etd/3140

can enforce them, at the very least, by exclusion from the group and who aims to show several different ways to think through a problem in professional ethics rather than merely describe what professionals say are their problems (sociology of ethics). Professionalism can be defined as having skill and competency in work. The ethical question is "Will the work be beneficial to others?" Work itself doesn't have moral status; however, the execution of work has moral status. Professional ethics helps a professional decide when faced with a moral dilemma. The complexity can involve many people with many issues, the history of the issues, and who decides, not just what is decided (Strahlendorf 2004).

"Ethics" and "morality" are often used interchangeably, but they are different.

- Morality—making choices with reasons
- Ethics—the study of HOW the choices are made (i.e., "ethics is the study of morality")

Ethics is a rational reflection upon good and evil (without weighing in on the question of heaven or hell, angels and demons). The word *ethics* refers to our identification of the "good" in any given situation as well as the rationale for the identification. Ethics engages each of us at the level of the thought and the reasoning process that goes into every decision we make, whether for our own happiness or that of another. Sound ethical judgment arises when proper thought habits provide confidence in doing the right conduct.

As safety consultants (and mature adults), should make choices that are responsible, defensible, and appropriate. Decide upon the highest good and prioritize all other options, "the lesser goods," in a hierarchy. This could be applied to a risk assessment or matrix (Keys, Rodriquez, and Walaski 2014).

Reflecting on professional ethics and codes of conduct assist with choices about what one ought to do.

- Descriptive ethics—"What IS?"
- Prescriptive ethics—"What OUGHT to be?"

Codes of ethics require objectivity, which means that there are principles and values outside of the individual that the members of the community share and that individuals will be measured against.

There are rigorous professional guidelines and regulations regarding ethics for a safety professional. Below is a list of some of them:

1. Board of Certified Safety Professionals Code of Ethics and Professional Conduct (**Table 3**)

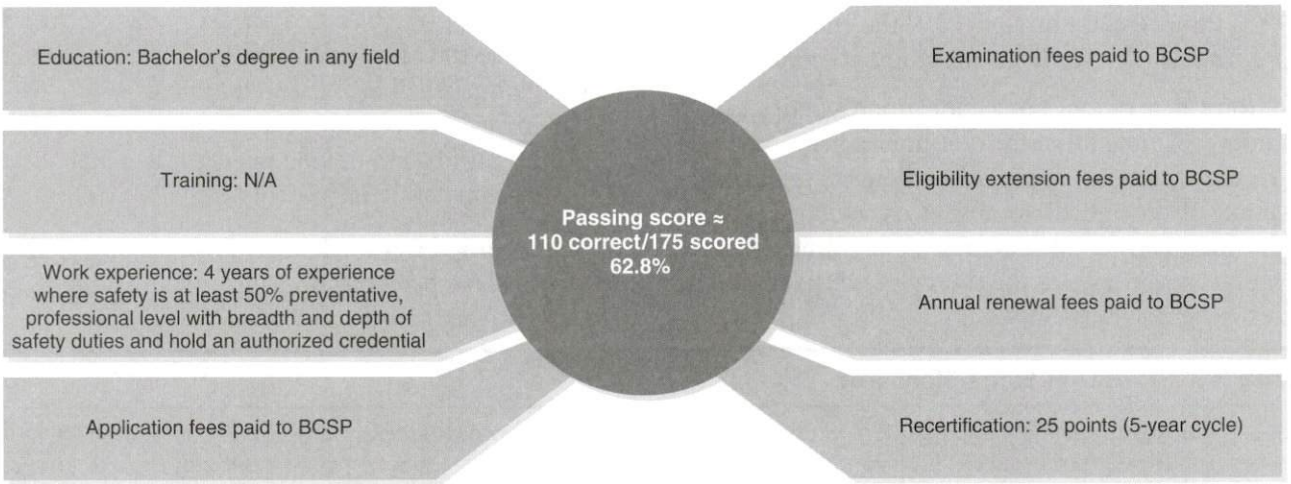
Table 3 BCSP Code of Ethics Standards

HOLD paramount the safety and health of people, the protection of the environment, and the protection of property in the performance of professional duties and exercise the obligation to advise employers, clients, employees, the public, and appropriate authorities of danger and unacceptable risks to people, the environment, or property.
BE honest, fair, and impartial. Act with responsibility and integrity. Adhere to high standards of ethical conduct with balanced care for the interests of the public, employers, clients, employees, colleagues, and the profession. Avoid all conduct or practice that is likely to discredit the profession or deceive the public.
ISSUE public statements only in an objective and truthful manner and only when founded upon knowledge of the facts and competence in the subject matter.
UNDERTAKE assignments only when qualified by education or experience in the specific technical fields involved. Accept responsibility for their continued professional development by acquiring and maintaining competence through education, experience, professional training, and staying current on relevant legal issues.
AVOID deceptive acts that falsify or misrepresent their academic or professional qualifications. Do not misrepresent or exaggerate their degree of responsibility in or for the subject matter of prior assignments. Presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, or past accomplishments with the intent and purpose of enhancing their qualifications and their work.
CONDUCT their professional relations by the highest standards of integrity and avoid compromise of their professional judgment by conflicts of interest. When becoming aware of professional misconduct by a BCSP certificate recipient, take steps to bring that misconduct to the attention of the Board of Certified Safety Professionals.
ACT in a manner free of bias regarding religion, ethnicity, gender, age, national origin, sexual orientation, or disability.
SEEK opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health, and well-being of their community and their profession by sharing their knowledge and skills.

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2. American Society of Safety Engineers' Code of Professional Conduct
3. American Industrial Hygiene Association and American Conference of Governmental Industrial Hygienists Joint Ethical Principles
4. American Board of Industrial Hygiene Code of Ethics
5. International Code of Ethics for Occupational Health Professionals
6. Federal Contractor Code of Business Ethics and Conduct (48 CFR 3.10)
7. American Society of Civil Engineers Code of Ethics
8. National Society of Professional Engineers Code of Ethics
9. Institute of Hazardous Materials Management Code of Ethics

As a safety professional, you should be familiar with the codes of conduct pertinent to your work. However, in and of themselves, they are insufficient. You must also develop a robust code of personal ethics. The avoidance of wrong is not the same as doing right. Safety professionals must honor a high ethical standard, one that encompasses not just ourselves but our clients, colleagues, and community. A professional must not only behave ethically but also encourage ethical behavior in others.



Modified from BCSP Credentials At-A-Glance, Board of Certified Safety Professionals. https://www.bcsp.org/safety-certifications/at-a-glance

About the CSP Exam

Shortly after the turn of the century in this country, persons practicing the art and science of safety work began appearing. These practitioners came from different academic backgrounds and had a multitude of work experience ranging from operations to engineering. They all had one common goal: promoting the safety and health of employees. Until the Certified Safety Professional® certification program began, they also had no standard measure of qualification.

The CSP is currently its own certification by the BCSP. With few exceptions, one must attain the ASP before achieving the CSP designation, which is the gold standard in safety certification.

The BSCP was chartered by the American Society of Safety Engineers (ASSE) in 1969 to establish a method of measuring qualifications for the safety profession. The board established qualification standards and began issuing certification shortly after being founded. Although chartered as an independent, separately incorporated board, the BCSP has several sponsoring organizations that provide members to the BCSP board of directors. These sponsoring organizations are as follows:

- American Society of Safety Engineers (ASSE)
- American Industrial Hygiene Association (AIHA)
- National Safety Council (NSC)
- Institute of Industrial Engineers (IIE)
- Society of Fire Protection Engineers (SFPE)
- International System Safety Society (ISSS)
- National Fire Protection Association (NFPA)
- National Environmental Training Association (NESHTA)

Accredited Certification vs. Certificate Program

Accredited Certification	Certificate Program
Results from an assessment process	Results from an educational process
Typically requires some amount of professional experience	For novice and experienced professionals
Awarded by a third-party, standard-setting organization	Awarded by training and educational programs or institutions
Indicates master/competency as measured against a defensible set of standards, usually by application or exam	Indicates completion of a course or series of courses with a specific focus; is different than a degree granting program
Standards set through a defensible, industry-wide process (job analysis/role delineation) that results in an outline of required knowledge and skills	Course content set in a variety of ways (faculty committee; dean; instructor; occasionally though defensible analysis of topic care)
Typically results in a designation to use after one's name; may result in a document to hang on the wall or keep in a wallet	Usually listed on a resume detailing education; may result in a document to hang on the wall
Has ongoing requirements to maintain; individual must demonstrate knowledge of content; holder must demonstrate he/she continues to meet requirements	Is the result; an individual may or may not demonstrate knowledge of course content at the end of a set period in time

The BCSP's certifications are accredited by independent, third-party organizations that regularly evaluate certification requirements. Accreditation assures:

- Governance
  - Nominations/elections
  - Peer participation
  - Public participation
- Financial disclosure
  - Stability and financial condition
  - Budget details
- Fairness to candidates
- Examinations
  - Validity
  - Reliability
  - Passing scores
- Recertification
- Independence from preparation
- Management systems

International accreditation is provided by the American National Standards Institute (ANSI 17024/ISO).[16] National Accreditation is achieved through both the National Commission for Certifying Agencies (NCCA)[17] and the Council of Engineering and Scientific Specialty Boards (CESB).[18]

The CSP designation is the premier certification in the safety profession. No other single means of measuring safety and health practitioners' qualifications is as widely accepted or respected. At publication of this text, there are over 12,000 Associate Safety Professionals® and over 14,000 Certified Safety Professionals®.

Benefits of Certification

The process of certification commands a considerable amount of effort. Many safety practitioners wonder if the advantages of certification justify all the effort. The average person holding the CSP credential today earns nearly $25,000 more than others in the safety field who hold no certification. The latest survey from the BSCP indicated that the average salary of those holding the CSP certification is approximately $98,000.

The primary advantage of certification is that it provides a credential. The ASP/CSP indicates that a safety professional has achieved a standard level of qualification as judged by their professional peers. This level of qualification is important in establishing credibility within the field of Safety, Health, and Environment (SH&E). Employment opportunities are much greater for personnel holding CSP certification, the courts recognize the certification as a step toward authentication as an expert witness, and it is almost always required to do consultant work in the field of safety today. There are several reasons that should cause candidates to think about starting the process of obtaining certification *right now.*

- A growing trend by states to license safety professionals, much like physicians, engineers, architects, and other professionals. Some states have that authority under their duty to "protect the health, safety and welfare of the public."

[16] ASP, CSP
[17] ASP, CSP, OHST, CHST, STS
[18] CET

- Substantial support to modify existing safety and health laws to acknowledge certified "safety specialists." Some projects require a certified professional to be on staff.
- Certified Safety and Health professionals obtain employment earlier and receive greater compensation than noncertified employees.
- As the requirements increase, the examinations may become even more dynamic, complex, difficult to pass, and expensive, both in time and financial investments.

These and other recent developments add up to a future environment where a certification is going to be the desired/required credential. Being a CSP will become much more important, more lucrative, and more difficult to obtain. Like the other professional certification/registration examinations, the ASP and CSP exams should be taken as early in one's career as possible.

Overview of the CSP Certification Process

The following information concerning the requirements for certification may have changed after publication. It is strongly suggested that candidates contact the BCSP for current information. For exact requirements, go to the BCSP website at www.bcsp.org and review the CSP complete guide. There are common questions by potential candidates such as "What do I have to do to get the CSP?"

The CSP is a certification awarded by BCSP to individuals who meet all the requirements established by the board. Along with the education and experience requirements, candidates must successfully complete the examinations (**Figure 1**).

ASP/GSP/CSP Qualifications

Those candidates possessing other acceptable registration or certification may waive the ASP exam.

All others must successfully complete the ASP prior to receiving the CSP certification.

Minimum Academic Requirements

- Bachelor's in any field (from an accredited[19] school)
- Bachelor's from a QAP School (BCSP Qualified Academic Program for GSP)

[19]Accredited School is one that is recognized by the US Department of Education or the Council for Higher Education Accreditation (CHEA).

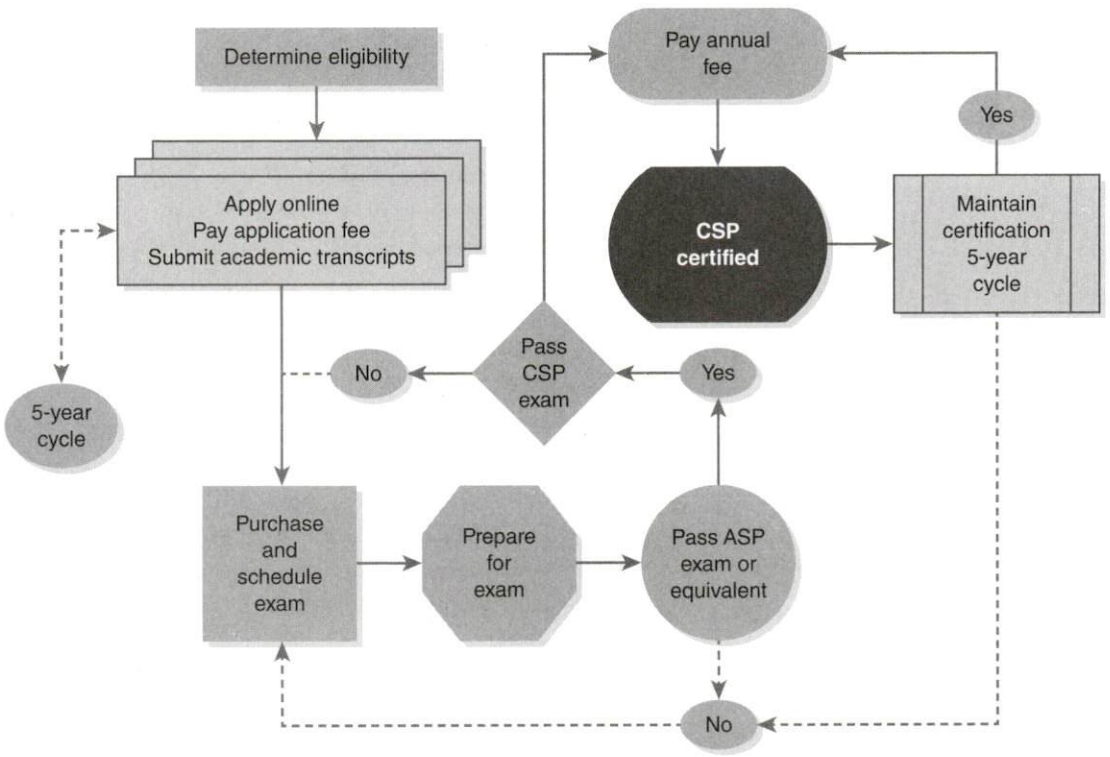


Figure 1 Certification Process

  - The Graduate Safety Practitioner (GSP) designation is a path offered to the CSP certification for qualifying ABET-ASAC[20]or AABI[21] graduates.
  - GSPs receive a waiver of the ASP examination.

Experience Requirements

- 4 years' minimum plus the academic requirement
- Qualifying criteria for experience
  - Full-time position (or part time ≥ 900 hrs/yr)
  - Professional safety is primary function (≥ 50% of position).
  - Primary responsibility must be the prevention of harm to people, property, or the environment.
  - Must be at professional level (responsible charge)
  - Breadth: Safety Tasks, Hazard Types, etc.
  - OHST/CHST count as one year of experience.

Pass the ASP and CSP examinations leading to the CSP certification (with some exceptions that waive the ASP exam, including the GSP designation).

Recertification Requirements

- 25 points every 5 years
- 10 point categories (some with point limitations)
- Practice
- Membership
- Service
- Publishing, presenting, patents
- Writing exam questions
- Professional development conferences
- Safety-related courses, seminars, quizzes
- Continuing education
- New advanced degree
- Other certifications/reexamination

A candidate for certification may take the CSP exam after meeting the academic/experience requirements. The CSP is truly a comprehensive practice test. It covers the applied knowledge expected of a safety professional at the practitioner level.

Before taking the Comprehensive Practice Exam, the academic/experience requirements must be met, the ASP's passing scores must be recorded (unless waived by other registration or certification), and the candidate must have 4 years of acceptable professional safety experience. When a candidate has successfully completed the Comprehensive Practice Examination, they are designated a "Certified Safety Professional®."

The entire process of certification generally takes from 3 to 6 months, allowing plenty of time to **PLAN** an individual study program.

The above information is accurate as of this printing. For more current information, candidates should contact the board at:

Board of Certified Safety Professionals
8645 Guion Road
Indianapolis, IN 64268
Phone (317) 593-4800
Fax (317) 593-4400
www.bcsp.org

[20]Accreditation Board for Engineering and Technology (ABET)–Applied Science Accreditation Commission (ASAC)
[21]Aviation Accreditation Board International (AABI)

The CSP Examination Blueprint

01 Advanced sciences and math	**02** Management systems	**03** Risk management
04 Advanced application of key safety concepts	**05** Emergency preparedness, fire prevention, and security	**06** Occupational health and ergonomics
07 Environmental management systems	**08** Training and education	**09** Law and ethics

Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.

The CSP examination is designed to test applied knowledge and the application of experience gained through professional practice. The computerized test consists of 200 questions. Candidates are allowed 5.5 consecutive hours to complete all questions. Laminated scratch paper and a marker will be provided by the testing service, but candidates must provide approved calculators (two allowed). After finishing the computerized examination, a pass–fail grade will be given. A detailed score report will be mailed later from the BCSP if a candidate fails the exam.

Domain 1 Advanced sciences and math	Domain 2 Management systems	Domain 3 Risk management	Domain 4 Advanced application of key Safety concepts	Domain 5 Emergency preparedness, fire prevention, and security	Domain 6 Occupational health and ergonomics	Domain 7 Environmental management systems	Domain 8 Training and education	Domain 9 Law and ethics
Anatomy and physiology concepts, chemistry concepts, physics concepts, mathematics, statistics for interpreting data, research methodology, microbiology, calculate required containment volumes and hazardous materials storage requirements, statistics calculations from data sources	Measure/analyze/improve organizational culture, techniques and analysis for incident investigation, management of techniques, techniques of system safety analysis, business continuity and contingency plans, leading and lagging safety/health/environmental and security performance indicators, safety/health/environmental management and audit systems, requirements for plans/systems and policies, management principles or document retention, principles and techniques for budgeting/finance and economic analysis, techniques for management leadership, techniques and concepts for project management, analyze and interpret data, management principles of authority/responsibility and accountability, management, management systems and benchmark comparison, causal factors analyses, develop/implement and sustain environmental/safety and health management systems, evaluate and analyze survey data, perform gap analyses, show business need through financial calculations, performance standards and benchmark metrics	Methods for hazard identification and analysis, risk analysis, risk evaluation, risk management process, risk management process costs and benefits, principles of insurance/risk transfer, prioritize risk management options by applying risk-based decision-making tools, calculate metrics for organizational risk, hazard analysis and risk assessment, use the hierarchy of controls to select risk treatment or controls, explain risk management concepts and options to decision-makers, stakeholders, and the public	Principles of safety through design and inherently safer designs, engineering controls, administrative controls, personal protective equipment, chemical process safety management, redundancy systems, common workplace hazards, features of life safety, principles of fleet safety, principles of transportation safety, materials handling, foreign material exclusion, management of hazardous materials, worksite issues of multi-employees, sources of information on hazards and risk management options, safety design criteria for workplace facilities/machines and practices, machines/tools/equipment safety and practices, workplace hazards, human performance, calibrate/use/maintain data, logging/monitoring/and measurable equipment, identify relevant warnings/signs/labels, interpret specifications/technical drawings/process flow diagrams and plans	Emergency/crisis/disaster response planning and business continuity, pre-planning and practice, fire protection/prevention, and suppression systems, layers of protection, hazardous materials transportation and security, workplace violence and techniques for prevention, Incident Command System (ICS), active incident management, emergency management system	Principles of advanced toxicology, carcinogens, principles of ergonomics and human factors, recognize occupational exposures, evaluate occupational exposures, control occupational exposures, substance abused of employees, epidemiology fundamentals, occupational exposure limits, exposure evaluations, sampling equipment, data interpretation from exposure evaluations	Methods of environmental protection and pollution prevention, migration/interaction of released hazardous materials through air/surface water/soil and water table, principles of sustainability, wastewater treatment plants/onsite wastewater treatments, and public water systems, restrictions of hazardous substances and registration/evaluation/authorization and restriction of chemicals, practices of waste management, hazardous waste operations	Methods and techniques for education and training, requirements of training/qualification, and competency, methods for determining a training program's effectiveness, techniques for effective presentations, training needs assessments, development of training programs, development of training materials, conduct training, assess training competency, development of training assessment instruments	Legal issues, confidential information protection, development process of standards, professional practice ethics, labor and management relationship, BCSP Code of Ethics, workers' compensation, interpret regulations/laws and consensus standards and codes, concept application of BCSP Code of Ethics

Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.

Taking the Computer-Based Exam

One major goal of the BCSP is to offer certification examinations with a high degree of validity and reliability to promote a fair assessment of a candidate's competency as a safety and health practitioner.

Testing on computer is done via Pearson VUE (www.pearsonvue.com).

Examinations can be taken every business day at many locations throughout the world. Many locations also have evening and Saturday hours.

Candidates must complete an application and return it, supporting information and application fee ($160) to the BCSP. Once a candidate has been approved and has paid the examination fee ($350), the board will mail an examination authorization letter. Once the application is approved, candidates have one year to arrange for an actual examination date. Arrangements are made directly with Pearson VUE via online or the national toll-free number **888-269-2219**. Some Pearson VUE Testing Centers are busier than others, so schedule early if possible.

At the Pearson VUE centers, a candidate signs in, presents identifications, and is seated at a computer workstation. The center provides laminated graph paper and a marker. There is a short orientation and practice program to acquaint candidates with the examination procedure. During actual testing, a small clock in the monitor screen corner keeps track of the remaining time.

ABSOLUTELY NO NOTES OR REFERENCE MATERIALS ARE ALLOWED! Laminated graphing paper and writing utensils will be provided, but candidates must provide personal calculators. After finishing the computerized examination, a pass–fail grade will be given. A detailed score report will be mailed later from the BCSP.

For worldwide locations, look at the web site www.pearsonvue.com.

Frequently Asked Questions about the Computer Exam

NOTE: Remember, the best and most current source of information on procedures and policies for the computer test is directly from the BCSP at 317-593-4800 and www.bcsp.org.

Question How do the questions appear on the computer screen? How do I make answer selections? Can I back up or mark questions so that I can come back to them? Do I need to be a computer whiz to take this test?

Answer Examination questions appear one at a time and resemble the questions in the text. With a mouse or keys, the candidate selects the preferred answer and moves on to the next question. Questions may be marked for further review or skipped and revisited later. After the last question, a list appears and shows item numbers, answers selected, and questions marked or skipped. Since the computer test is very "friendly," candidates do not have to be computer literate to take this exam.

Question Can you bring food or drinks into the exam room?

Answer No. All candidates are given a small locker for personal belongings, including snacks, purses, watches, etc. Access to this locker may or may not be allowed depending upon the testing center.

Question What can I take into the exam room?

Answer Only the allowed one or two calculator(s) and ID cards are permitted. Everything else must go into personal lockers.

Question What is furnished in the exam cubicle?

Answer One laminated sheet of paper, one marker and the computer monitor, keyboard, and mouse.

Question What is the workstation/cubicle like?

Answer It is generally very nice, although this may vary with different Pearson VUE Centers. Cubicles are large, with a desktop about 3' × 4', excellent lighting, in a very quiet setting, with comfortable, padded adjustable chairs. The keyboard and mouse take up all the space in front of the monitor, so calculations must be done off to the side.

Question Are there any children in the exam room?

Answer No. The room is for adult testing only. All children activities are in separate areas of the Pearson VUE Center.

Question How many other people are in the room?

Answer There are multiple workstations in the exam room. The number of people varies with time and day. The proctor has a view of the entire room via a glass window and corner mirrors on the ceiling. Testing is also taped by video and audio monitoring.

Question Can I take breaks?

Answer Yes, as many and as often as necessary. However, the clock keeps running and signing out is required each time, along with a fingerprint check.

Question Do I need IDs?

Answer One ID with photo and signature is mandatory. A photograph and a fingerprint are done during sign-in.

Question Do I need my authorization letter with Candidate ID number?

Answer This letter is usually not required, but it is advised to take it just in case. The ID number is always needed when scheduling examination appointments.

Question Can I schedule the exam any time?

Answer No. Certain times are designated for professional exams. Book testing slot several weeks in advance to secure the desired time and day.

Question Is there enough time to finish the exam?

Answer This is very subjective. Most candidates have found there was plenty of time to finish testing and have adequate review time, but other people did not finish in the allotted time. The time per question (1.5 minutes) is the same as the written exam, and the authors found the computer not to be a factor in this area.

Question Are there graphs to interpret? How clear are the graphics?

Answer Yes, there are a limited number of graphs to read. They are a little harder to read on the screen, but not significantly. Graphics are quite acceptable.

Question Are the math formulas provided?

Answer If a problem required a formula(s), then they should be provided in the question.

The computer exam is a positive, convenient way to take the exam. The Pearson VUE people were friendly and helpful. The cubicles are quiet and well-lit, and the chairs are relatively comfortable. There is adequate table space and the computer was user friendly and nonthreatening.

Conditions may vary considerably between testing locations. Please contact authors at 417-724-8348 or email info@spansafetyworkshops.com. Feedback is greatly appreciated.

A listing of Pearson VUE center locations is available through the Pearson VUE website. More complete information can be obtained by calling or faxing the BCSP. **Good Luck on the exam!**

Applied Study & Exam Techniques

The examination blueprint outlines how the items on an examination are distributed across domains and tasks/topics. Some keys to success include:

1. Analyzing knowledge gaps and identify strengths and weaknesses
2. Designing a solid examination study plan
3. Developing test-taking strategies
4. Proper use of the calculator

Converting your subject strengths and weaknesses into a study plan is likely to increase your overall examination score. Scoring well in one subject area can compensate for a weaker score in another subject area. However, there may not be enough items in your strong areas to achieve a passing score.

Note that knowledge and understanding are essential in passing the examination. Relying only on simulated examination items is not the best way to increase knowledge and understanding. Use simulated items to provide insight into the areas in which you should engage in additional study.

Knowing how to take the examination will help improve your score. The examination uses multiple-choice items with only one correct answer and three incorrect answers. Remember, the goal is to get as many items correct as possible. There is no penalty for selecting an incorrect answer. However, only correct answers count toward reaching the passing score.

- Read the items carefully.
  - Psychometricians design multiple choice questions so that all the possible answer choices are plausible. Use deductive and inductive reasoning to eliminate detractor answer choices.
- Understand the problem.
  - Consider the context.
  - What is given? What is wanted?
- Use examination time wisely.
  - Conduct multiple passes solving the "easy" problems first and saving the challenging problems for the end.
- Complete all items.
  - Blank answers are scored as wrong answers.

While studying resources, identify main thoughts or themes in the literature review. Draw on your experience and on professional and study references and rewrite important ideas in your own words. This helps you remember the concepts in context. Additional references are listed later in the workbook.

In establishing a good study regiment, it is important to find a place conducive to studying. A good study area should:

- Be chosen exclusively for the purpose of studying. Avoid using a garage, workshop, family room, or other area that represents recreation or other distractions. Find a location that represents a study island, where study is the **only** activity.
- Have good lighting, ventilation, be temperature controlled, comfortable, and quiet.
- Must have a large table or desk to spread necessary readily available study and reference materials. The purpose is to dedicate a comfortable, personal space with minimal interruptions.

Securing a good place to study should eliminate as many external distractions as possible. Also, candidates should consider how to minimize internal distractions. Total elimination of external distractions is often possible; however, total elimination of internal distractions is nearly impossible and can only be minimized through focused thought.

Helpful hints for focusing the mind for studying include the following:

1. Set realistic time limits, determining what to study and keeping with a schedule. Studying a subject too long at one time can lead to daydreaming, which reduces study effectiveness.
2. Personal factors can be distracters and result in additional frustration. All efforts should be attempted to avoid personal issues. Rescheduling the test date may be a consideration if serious personal problems exist.
3. Minimize dealing with outside details. Having too many obligations and/or responsibilities enables "brain creep." Consider keeping a notebook in the study area and jotting down appointments and details of projects as these brainstorms appear. It's impossible to totally prevent these details from surfacing, but by documenting them, it may free the mind to resume studies.
4. Being physically and mentally prepared to study is beneficial. Much of the following suggestions are common sense but probably deserve repeating.
   - Eat a well-balanced diet. Increase protein intake; a proper level of blood sugar enhances studying effectiveness.
   - Get plenty of sleep. Establish and maintain a regular work/rest cycle.
   - Exercise is beneficial for more than just an exam preparation. Consider choosing a form of exercise that provides enjoyment and relaxation.
   - Avoid mental fatigue. Allocate down time for breaks. The average professional should study for the CSP exam for two to four weeks. DO NOT attempt to cram overnight.

Volumes I and II apply a question-and-answer (Q & A) format that allows candidates to concentrate on knowledge gaps and avoid over studying material in areas where the candidate already possesses enough knowledge to pass the exam.

The research has been completed by the authors who have taken the exam and researched the blueprint areas of interest, developing targeted learning outcomes. This allows candidates to determine if their current level of knowledge is adequate or if a more in-depth understanding is required.

Fundamental to this technique is a good core of questions. The technique is intended to be useful to practitioners who have mastered the skills and tasks necessary to perform in the safety and health arena.

Most adult learners enjoy the process of learning. The difference lies in the ability to retain what is important to the accomplishment of a goal and reject what is not important. Embrace the aspect of professional development while preparing for the CSP examination.

When using this text properly, the authors believe candidates can master those areas necessary to achieve the goal of passing the CSP examination with minimum effort on research and actual study. The technique also has some very beneficial side effects. Candidates will also find that the learning process will enhance skill sets in becoming an improved and more proficient safety and health practitioner.

However, the process assumes candidates have the discipline to do the research and study the material where deficiencies may exist. Attempting to study using only the material presented in these volumes becomes a risk for not being adequately prepared for the examination.

The steps to using the Q & A method:

1. Dead reckoning: using existing knowledge, experience, test-taking strategies to attempt answering the question.

2. Process check: reviews the results of each practice session and then studies the explanation
3. Validate knowledge: Was this a known or an unknown concept? Is the answer achieved with current knowledge base or the correct answer achieved by an educated guess or dumb luck?

Note: This is a critical step in the Q & A learning process and determines if one can proceed or needs to gain more knowledge on the subject. Additionally, is the knowledge base on this subject broad enough to answer questions of similar difficulty on the subject? *"True genius is an uncluttered mind armed with only relevant knowledge"(John R. Monteith, Rogue Betrayer Book 2 of the Rogue Submarine Series).*

4. Filter: either move on or take notes. When comfortable with knowledge on the subject move on to the next question. However, if the current level of knowledge on the subject or other aspects of the subject feels inadequate, then take additional notes about the information that is needed.
5. Enhance deficiencies: Research and study deficient knowledge areas. After completing a set of questions and writing notes on information to study, a knowledge deficiency study plan can be developed. Then research and study the material necessary to enhance the required knowledge. The authors advise focusing on notes in the text and staying on subject. It is very easy to wander onto some other interesting subject and lose sight of the desired learning outcome. Keep the goal in mind to pass the test the first time!

Applied Logic: Socratic Method

A look at a representative question, answer, and explanation will tend to illustrate and explain the process (**Figure 2**).

Question:

1. **The concept of management review of an Occupational Health and Safety Management System (OHSMS) is to assure the SMS is suitable for the organization's needs, is adequately staffed and resourced, and is:**
   A. effective at achieving desired results.
   B. on schedule to meet implementation deadlines.
   C. on track to meet financial goals.
   D. is clearly understood by all participants.

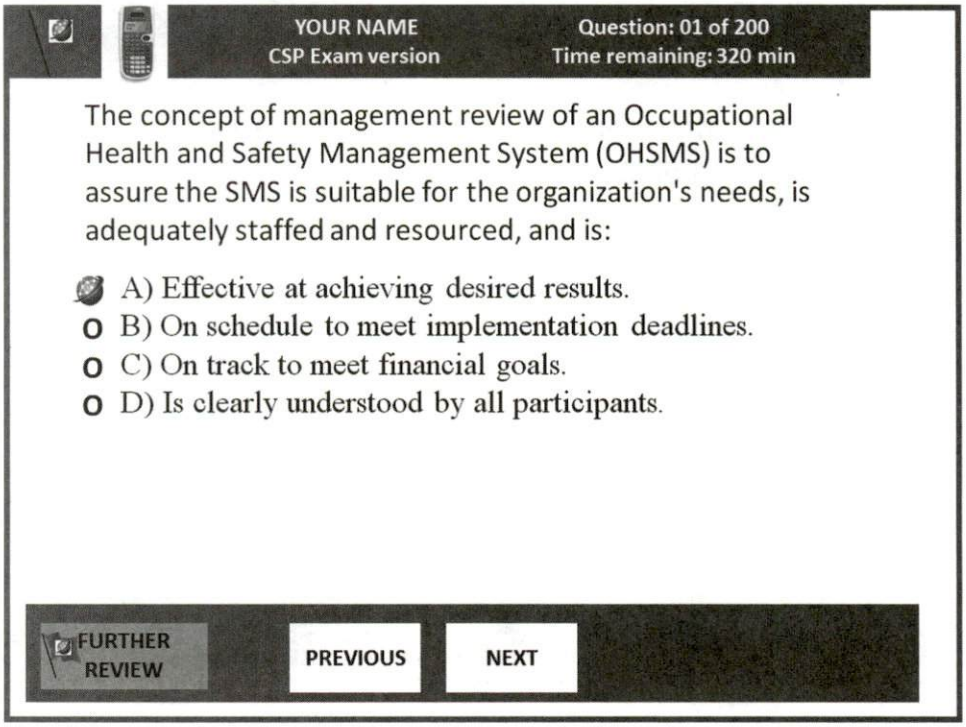


Figure 2 Applied Logic Example Question

Answer:

The most correct answer is A because top management must perform periodic management reviews of the OHSMS to ensure its continuing:

- Suitability (Does the system address conformance and meet the organization's needs?)
- Adequacy (Are the resources enough to maintain and improve the OHSMS?)
- Effectiveness (Is the system getting results?)

How much will candidates need to know about the subject of OHSMS? That is a key question an exam candidate should be asking right now. If OHSMS represents a strong area, a candidate probably has significant knowledge about the concepts outlined in references, such as ANSI Z-10, ISO 45001, BSI 18001, OSHA VPP, and is comfortable with this question and the general subject. Another possibility is that one is basically knowledgeable on the subject but could use some more focused descriptors. Another scenario may be that a candidate knows very little about OHSMS, requiring more focus on concept details and application techniques.

How far into the topic does a student need to explore? The level of detail in the example question may serve as a representative indicator. Beyond the basics, another key indicator is the repetition of the questions. Content frequently appearing with only minor changes in question format indicates that the subject matter is important, and the authors anticipate the actual exam will have several questions dealing with that subject.

The Q & A method of studying is a proven method. The basic outline is delivered with questions, and students can then determine individual levels of subject knowledge. When additional knowledge is required, they can conduct more research and study to develop the required knowledge or skill. This learning technique has proven to be successful for many different levels of adult learners because **the individual** determines what material to study.

Please contact the authors at info@spansafetyworkshops.com with any questions or feedback on these study materials.

Example Computer Graphic User Interface

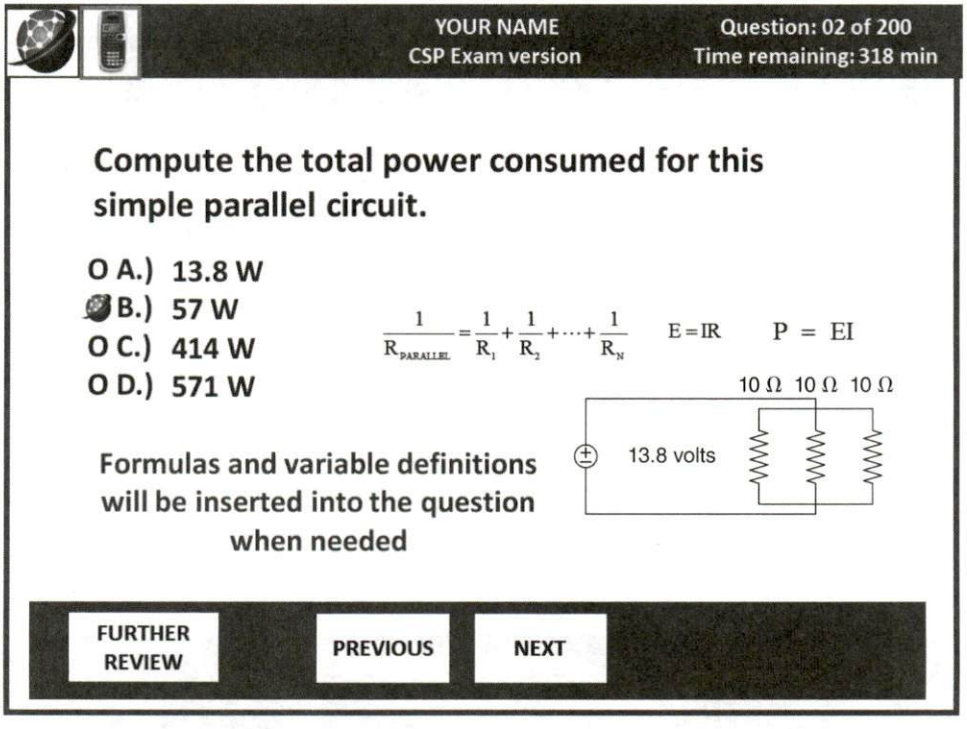


Figure 3 Computer Graphic User Interface Example Question 1

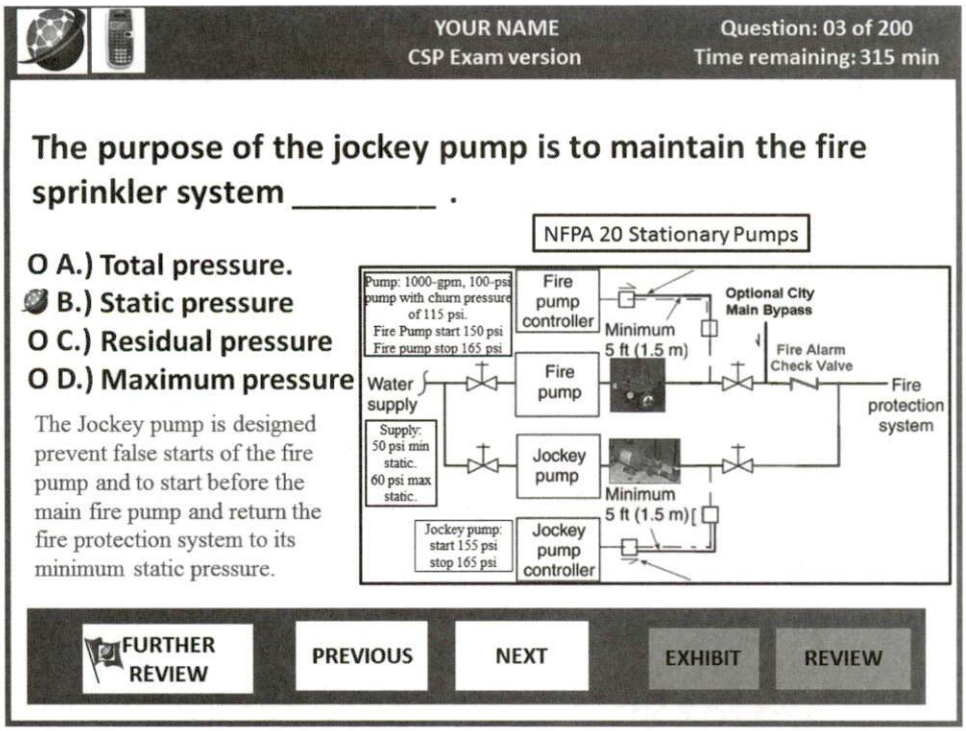


Figure 4 Computer Graphic User Interface Example Question 2

Reproduced from National Fire Protection Association, NFPA® 20 Standard for the Installation of Stationary Pumps for Fire Protection. Used with Permission.

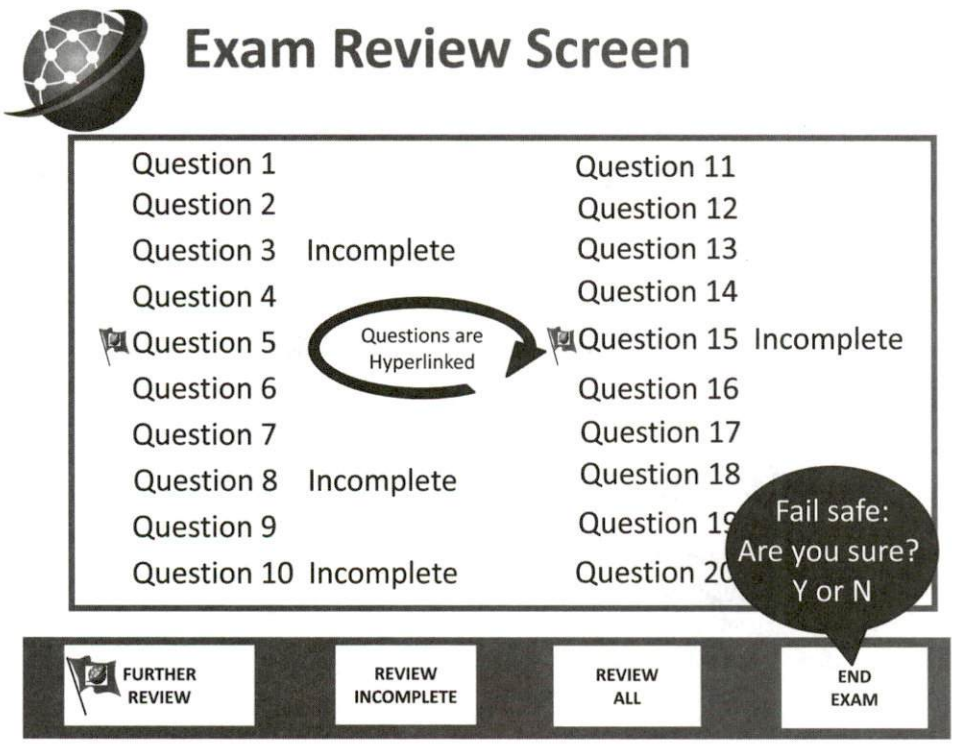
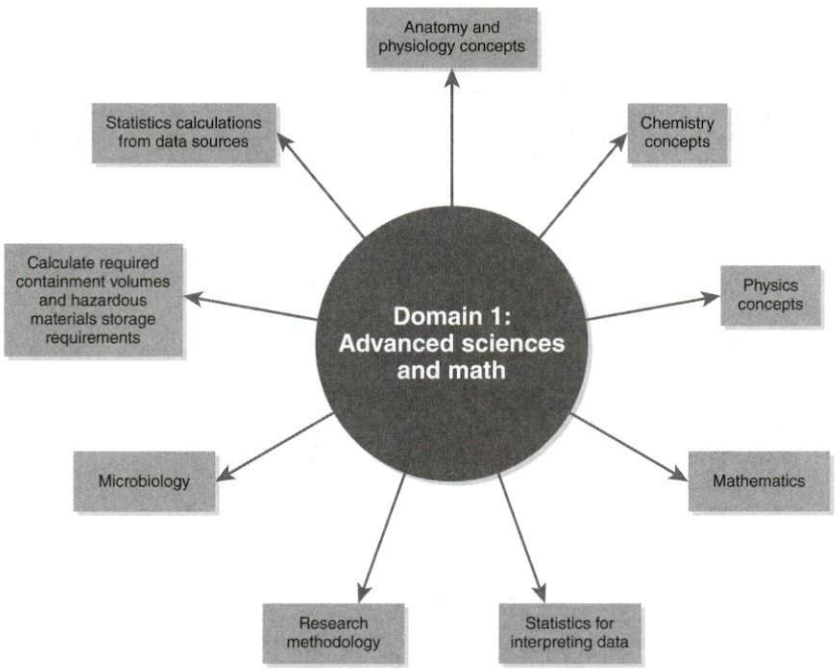


Figure 5 Exam Review Screen Example

Key Consensus, Voluntary, Guidance Standards

- ANSI-ASSE Z10—Occupational Health & Safety Management Systems
- ANSI ASSE Z490—Practices and Criteria for Safety & Health Training
- ANSI/ASSE Z590.2-2003—Criteria for Establishing the Scope and Functions of the Professional Safety Position
- ANSI/Z590.3-2011—Prevention Through Design
- BSI 18001—Safety & Health Managements Systems
- ISO 14000—Environmental Managements Systems
- ISO 31000—Risk Management Principles
- ISO 30010—Risk Management Assessment Techniques
- ISO 19011—Auditing Management Systems
- NFPA 10—Fire Extinguishers
- NFPA 13—Sprinkler Systems
- NFPA 30—Flammable Liquids
- NFPA 70E—Electrical
- NFPA 101—Life Safety Code

Domain 1: Advanced Sciences and Math



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.

Key CSP Blueprint Themes

Blueprint reference

Domain 1: Advanced Science and Math

- Algebra, trigonometry, geometry, calculating area & volume
- Physics, chemistry, biology
  - Chemistry concepts, balancing equations
  - Calculating force, acceleration
  - Anatomy and physiology, target organs, exposure pathways
- Research methods
  - Scientific method (Inductive and deductive)
  - Evidence based, data driven
  - Calculating statistics
  - Interpretation of data

Key CSP Blueprint Themes: Domain 1

ASP-CSP Math Equations

Concentrations of Vapors and Gases Formulas

$$ppm = \frac{mg/m^3 \times 24.45}{MW}$$

ppm = parts per million in concentration
mg/m^3 = milligrams/cubic meter
MW = Molecular Weight of the substance

$$LFL_m = \frac{1}{\frac{f_1}{LFL_1} + \frac{f_2}{LFL_2} + \cdots + \frac{f_n}{LFL_n}}$$

LFL_m = Lower Flammable Limit of a mixture or solvent
f = fraction by weight

$$TWA = \frac{(C_1 \times T_1) + (C_2 \times T_2) + \cdots + (C_n \times T_n)}{(T_1 + T_2 + \cdots + T_n)}$$

TWA = Time Weighted Average
C = Concentration of chemical
T = Time of exposure

$$TLV_m = \frac{1}{\left(\frac{f_1}{TLV_1} + \frac{f_2}{TLV_2} + \cdots + \frac{f_n}{TLV_n}\right)}$$

TLV_m = Threshold Limit Value of a mixture
f = fraction by weight (% expressed as a decimal 0.XX)

$$TLV_{mix} = \frac{C_1}{TLV_1} + \frac{C_2}{TLV_2} + \cdots + \frac{C_n}{TLV_n}$$

Where:
TLV_{mix} = Threshold Limit Value for a mixture of airborne chemicals with additive effects. If the sum is greater than one (1), then an overexposure exists.
C_1 = the measured airborne concentrations of the chemicals.
TLV_1 = published Threshold Limit Value for the respective chemicals.
When two or more hazardous chemicals with similar toxic effects are present in the environment, the combined effect should be evaluated, rather than the individual effect.
NOTE: The units can be either mg/m^3 or ppm, but must be consistent in the equation.

Combined Gas Law (Charles and Boyles Laws)

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P = Pressure (expressed in absolute)
1 atm = 14.7 psi
= 760 mm Hg
= 29.92 in Hg
= 33.90 ft H_2O
= 760 torr
= 101.3 kilopascal
V = Volume
T = Temperature (expressed in absolute)

$$t_{°C} = \frac{(t_{°F} - 32)}{1.8}$$

$t_{°K} = t_{°C} + 273$ $t_{°R} = t_{°F} + 460$

Electrical Formulas

$V = IR$ or $E = IR$ E or V = Voltage I = Current (Amperage) R = Resistance (Ohms)	$P = VI$ or $P = EI$ P = Power (Watts) I = Current (Amperage) E or V = Voltage
$R_{SERIES} = R_1 + R_2 + \cdots + R_N$ R = Resistance (Ohms)	$\frac{1}{R_{PARALLEL}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$ R = Resistance (Ohms)

Radiation Formulas

$I_2 = I_1 \frac{(d_1)^2}{(d_2)^2}$ I = Intensity d = distance	$N = N_o e^{-kt}$ N = radioactivity remaining after time t N_o = radioactivity at a given original time t = elapsed time k = disintegration constant e = second function natural log
$S \cong 6CiEf$ S = Roentgens/hour/foot Ci = Curie strength (whole curies) E = Energy in megaelectron volts (MEV) f = fractional yield	$A = \frac{A_o}{e^{\left(\ln 2 \frac{t}{T_{1/2}}\right)}}$ A = radioactivity remaining after time t A_o = radioactivity at a given original time t = elapsed time $T_{1/2}$ = half-life of the radionuclide ln2 = 0.693 (natural log of 2)
	$T_{1/2} = \frac{\ln 2}{k}$ $T_{1/2}$ = half-life of the radionuclide ln2 = 0.693 (natural log of 2) k = disintegration constant

Structural and Mechanical Calculations

Area and Volume Formulas

Circumference of a circle = $2\pi r$ **or** πd

Area of a circle = πr^2 **or** $\frac{\pi d^2}{4}$

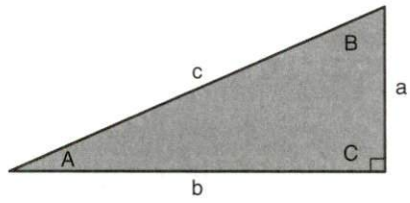
Area of a rectangle = length × width

Area of a triangle = ½ × base × height

Volume of a tank = $\pi r^2 h$ **or** $\frac{\pi d^2 h}{4}$

Volume of a cube = length × width × height

Trigonometry Functions



$a^2 + b^2 + c^2$

$$\sin A = \frac{a}{c}$$

$$\cos A = \frac{b}{c}$$

$$\tan A = \frac{a}{b}$$

$$\text{Angle of a ramp} = \tan^{-1}\left[\frac{\text{rise}}{\text{run}}\right]$$

Sling angle and stress rules of thumb:
15° angle = twice the load
30° angle = the load
45° angle = 70% of load
60° angle = 58% load
90° angle = 50% of load
Load ÷ number of slings ÷ sin A = stress on the sling

Engineering Control Calculations

$Q = AV$ Q = the **Volumetric Flow Rate** in the duct, measured in cubic feet/minute = ft^3/min [cfm] A = the **Cross-Sectional Area** of the duct under consideration, in square feet [ft^2] V = the **Velocity**, or **Duct Velocity**, of the gases moving in the duct, in feet/minute = ft/min [fpm]	$V = 4005\sqrt{VP}$ V = Velocity (lineal feet) VP = Velocity Pressure
$V = 4005C_e\sqrt{SP_h}$ V = average duct velocity (fpm) 4005 = constant, based on the density of standard air C_e = Coefficient of entry (unitless) SP_h = hood static pressure ("wg)	TP = SP + VP TP = Total Pressure ("wg) SP = Static Pressure ("wg) VP = Velocity Pressure ("wg) Velocity Pressure (VP) is always "positive" downstream of the fan. Static Pressure (SP) is always "negative" upstream of the fan.
$Q = \frac{G}{TLV} \times 10^6$ Q = the effective dilution rate (cfm) G = Generation rate of a gas or vapor (cfm) 10^6 = conversion factor from TLV to ppm TLV = the acceptable concentration (ppm)	$Q = \frac{403 \times 10^6 \times SG \times ER \times K}{MW \times C}$ Q = volumetric flow (cfm) SG = Specific Gravity ER = Evaporation Rate (pints/minute) K = K-factor or dilution ventilation safety factor (3–10 unitless) MW = Molecular Weight C = Concentration (TLV)

$$\frac{CFM_1}{CFM_2} = \frac{RPM_1}{RPM_2}$$

CFMi = the **Air Discharge Volume** of the fan when it is operating at the **i**th set of conditions, in cubic feet per minute [cfm];
RPMi = the **i**th operating **Rotational Speed** of the fan, in revolutions per minute [rpm].

Hoods WITHOUT Flanges	Hoods WITH Flanges
$V = \frac{Q}{10x^2 + A}$	$V = \frac{4Q}{3[10x^2 + A]}$
V = the **Capture Velocity**, i.e., the centerline velocity of the air entering the hood under consideration, at a point "**x**" feet directly in front of the face of the hood. This **Capture Velocity** is usually measured in feet per minute [fpm] Q = the **Volumetric Flow Rate** of the hood, measured in cubic feet per minute [cfm] x = the **Distance** from the plane of the hood opening to the point directly in front of it where the **Capture Velocity** is to be determined, measured in feet [ft] A = the **Cross-Sectional Area** of the hood opening, measured in square feet [ft^2]	

Heat Stress Formulas

Indoor Formula (no solar load)	Outdoor Formula (with solar load)
WBGT = 0.7WB + 0.3GT	WBGT = 0.7 WB + 0.2 GT + 0.1DB
WBGT = Wet Bulb Globe Temperature WB = Wet Bulb temperature GT = Globe Temperature	WBGT = Wet Bulb Globe Temperature WB = Wet Bulb temperature GT = Globe Temperature DB = Dry Bulb temperature

Noise Formulas

$L_w = 10 \log_{10} \frac{W}{W_0}$	$L_p = 20 \log_{10} \frac{p}{p_0}$
L_W = sound power level Watts (dB) W = acoustic power in watts W_0 = reference power intensity watts	L_p = sound pressure level (dB) P = final sound pressure (Pa) p_0 = reference sound pressure (Pa) (20 μPa)
$SPL_{Total} = SPL_{Individual} + 10\log n$ SPL_{Total} = combined dB for all sources $SPL_{Individual}$ = dB for one source n = number of noise sources 3-dB rule	$dB_1 = dB_0 + 20 \log_{10}\left(\frac{d_0}{d_1}\right)$ dB_1 = noise level at distance d_1 (dB) dB_0 = noise level at distance d_0 (dB) d = distance from a noise source (any units of length) 6-dB rule

$$T = \frac{8}{2^{\left[(L-90)/5\right]}}$$

T = allowable exposure time
L = exposure (dB)
5-dB rule

$$TWA = 16.61 \log_{10}\left[\frac{D}{100}\right] + 90$$

TWA = Time Weighted Average
D = Dose (%)

$$L_{pt} = 10 \log\left[\sum_{i=1}^{N} 10^{\left(\frac{L_{pi}}{10}\right)}\right]$$

L_{pt} = total sound pressure level generated by N sources (dB)
L_{pi} = individual sound level of each source (dB)
N = number of sound pressure levels

$$L_{pt} = L_{pi} + 10 \log N$$

L_{pt} = total sound pressure level generated by N sources (dB)
L_{pi} = individual sound level of each source (dB)
N = number of sound pressure levels

$$\text{Noise Dose} = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n}$$

C = Calculated exposure time
T = Authorized exposure time

Physics Formulas

Force to Slide
$F = \mu N$
F = Force required
μ = coefficient of friction
N = Normal weight
Force down a ramp (sine function) $N = W \times \sin \angle$
Force perpendicular to a ramp (cosine function)
$N = W \times \cos \angle$

Force to Tip
$F_1 d_1 = F_2 d_2$
F = Force
d = distance

Force
$F = ma$
F = Force required
m = mass
a = acceleration

$W = mg$
W = Weight
m = mass
g = gravity (acceleration)

$v = v_0 + at$
v = final velocity
v_0 = initial velocity
a = acceleration
t = time taken

$$s = v_0 t + \frac{at^2}{2} \text{ or } s = v_0 t + \frac{1}{2} at^2$$

v_0 = initial velocity
s = distance traveled
a = acceleration
t = time taken

$v^2 = v_0^2 + 2as$
v = final velocity
v_0 = initial velocity
s = distance traveled
a = acceleration

$$K.E. = \frac{mv^2}{2}$$

K.E. = Kinetic Energy
m = mass
v = velocity (ft/sec)

$$a = \frac{v - v_0}{t}$$

a = acceleration
v = final velocity
v_0 = initial velocity
t = time taken

Traffic Formulas

Note: These are the formulas that may be provided on the exam. It is recommended that you memorize the simplified traffic formulas provided in the text.

$V_{kph} = \sqrt{255 \times s \times \mu}$

V_{kph} = Velocity in kilometers per hour
S = distance (length of skid mark)
μ = coefficient of friction

$V_{mph} = \sqrt{30 \times s \times \mu}$

V_{mph} = Velocity in miles per hour
S = distance (length of skid mark)
μ = coefficient of friction

$V_{final} = \sqrt{V_1^2 + V_2^2 + \cdots + V_n^2}$

V_{final} = total velocity over multiple coefficients of friction

$V_{mph} = 5.5\sqrt{\frac{K.E.}{W}}$

V_{mph} = Velocity in miles per hour
K.E. = Kinetic Energy
W = Weight

Financial Principles Formulas

$$F = P(1+i)^n \qquad P = F(1+i)^{-n}$$

$$F = A\left(\frac{(1+i)^n - 1}{i}\right) \qquad A = F\left(\frac{i}{(1+i)^n - 1}\right)$$

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right) \qquad P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

Where
i = interest rate for a given interest period (remember to divide the interest by 4 to get quarterly interest)
n = number of interest periods (to get quarters, multiply the years by 4)
P = sum of money at the present time
F = future worth of a present sum of money after n interest periods, or the future worth of a series of equal payments
A = a payment or receipt at the end of an interest period in a series of n equal payments or receipts (if the payment is a yearly payment and the question is based on a quarterly deposit, divide by 4)

Statistics Calculations

$t = \frac{\bar{X} - \mu}{\hat{s}}\sqrt{n}$

t = t-score
$\bar{X}$ = mean
μ = mean
$\hat{S}$ = standard deviation
n = number of data points

$z = \frac{X - \mu}{\mu}$

z = z-score
X = data point
μ = mean
σ = standard deviation

$P(r) = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$

P = Poisson distribution
r = number of observed events or rate
λ = expected number of events or baseline
t = time

$P_f = 1 - R(t)$

P_f = Probability (failure)
R(t) = Reliability (t)

$$r = \frac{N\sum(XY) - (\sum X)(\sum Y)}{\sqrt{\left[N\sum(X^2) - (\sum X)^2\right]\left[N\sum(Y^2) - (\sum Y)^2\right]}}$$

$$x = X - \bar{X}$$
$$y = Y - \bar{Y}$$

r = regression (coefficient of correlation)
N = number of data points
X = independent variable
Y = dependent variable

$R(t) = e^{-\lambda t}$
R(t) = Reliability (t)
e = 2.71828
λ = failure rate (reciprocal of mean time between failure)
t = a specified period of fail-free operation or failure-free operation

$$s = \sqrt{\frac{\sum(x^2)}{N-1}} \qquad \left(x = X - \bar{X}\right) \qquad \sigma = \sqrt{\frac{\sum(x^2)}{N}}$$

s = sample standard deviation
σ = population standard deviation
X = data point
$\bar{X}$ = mean

$$P_k^n = \frac{n!}{(n-k)!} \qquad C_k^n = \frac{n!}{k!(n-k)!}$$

P_k^n = number of combinations possible when taking n things k at a time
C_k^n = number of combinations possible when taking n things k at a time

n = number of things to sample from
k = number of things taken each time

Hydrostatics and Hydraulics Formulas

$$p_v = \frac{Q^2}{891d^4}$$

P_v = Pressure velocity (psi)
Q = flow rate (gpm)
d = internal diameter in inches

$$Q_2 = Q_1\left[\frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}\right]$$

Q = flow (gpm)
S = Static pressure (psi)
R = Residual pressure (psi)

$$\frac{Q_1}{Q_2} = \frac{\sqrt{P_1}}{\sqrt{P_2}}$$

Q = flow (gpm)
P = Pressure differential (S – R)

$$P_d = \frac{4.52\,Q^{1.85}}{C^{1.85}\,d^{4.87}}$$

P_d = Pressure drop – psi/ft
Q = flow (gpm)
C = Coefficient of roughness (pipe)
d = internal diameter in inches

Unit Conversions

1 kg = 2.2 lbs	1000 mm = 1 m
1 kgm = 9.8 Newtons force	1 in = 2.54 cm
1 pound force = 4.45 Newtons	1 micron = 10^{-4} cm
1000 g = 1 kg	1000 m = 1 km
1 lb = 454 g	1 meter = 3.28 feet
7.48 gal = 1 ft^3	1 mile = 1.6 km
16 oz = 454 g	1 ft = 30.48 cm
760 mm Hg = 29.92 in Hg	1 mile = 5280 feet
760 mm Hg = 14.7 lb/in^2	1 mile = 1609 meters

1 liter = 1.06 qt = 61.02 in^3 = 0.03531 ft^3 = 0.26 gal 1 gal = 3.78 liters 1 liter = 1000 mL = 1000 cm^3 (cc)	1 atmosphere (atm) pressure = 14.7 psi = 760 mm Hg = 29.92 in Hg = 33.90 ft H_2O = 760 torr = 101.3 kilopascal
gram-mole @ 0°C and 1 atm = 22.4 liters @ 25°C and 1 atm = 24.45 liters	1 lumen = 1 candela 1 foot-candle = 10.76 candela/m^2 1 foot-candle = 10.76 lux
Water weight density = 62.4 lbs/ft^3 8.34 lbs/gal	1 rad = 10^{-2} gray 1 rem = 10^{-2} sievert 1 gray = 1 sievert

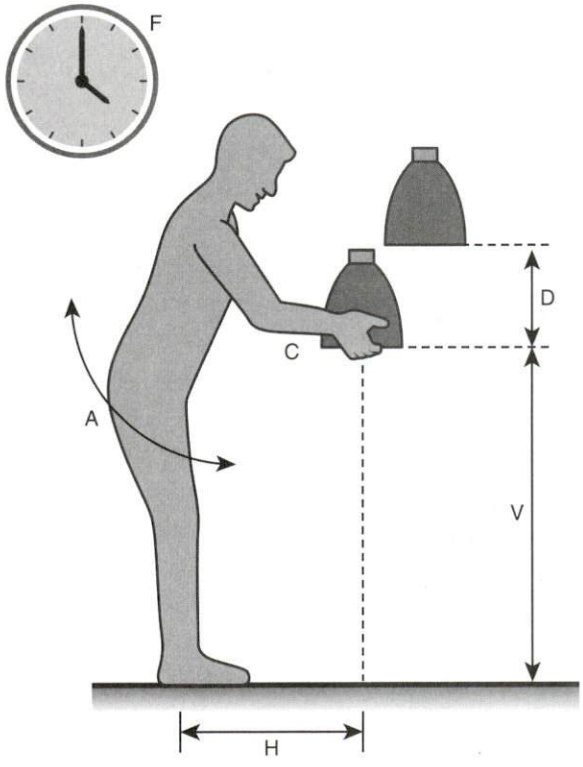
NIOSH Lifting Equation

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

$$RWL(lb) = 51\left(\frac{10}{H}\right)(1 - 0.0075\,|\,V - 30\,|)\left(0.82 + \frac{1.8}{D}\right)\left(1 - (0.0032 \times A)\right)(FM)(CM)$$

$$RWL(kg) = 23\left(\frac{25}{H}\right)(1 - 0.003\,|\,V - 75\,|)\left(0.82 + \frac{4.5}{D}\right)\left(1 - (0.0032 \times A)\right)(FM)(CM)$$

Where
H = horizontal distance of hands from midpoint between the ankles
V = vertical distance of the hand from the floor
D = vertical travel distance between origin and destination
A = angle of asymmetry, the angular displacement of the load from the sagittal plane in degrees
F = average frequency of lift in lifts per minute



Notes and Modifications:

H = must be between 10 and 25 inches
V = must be between 0 and 70 inches
V = is an absolute value indicating the absolute deviation from 30 inches; i.e., if V = 36 the absolute value would be 6, likewise if V = 24 the absolute value would also be 6.
D = must be between 10 inches and (70 − V) inches *if less than 10 inches, D = 10*
F = must be between 0.2 (one lift every five minutes) and 15 lifts per minute – duration ranges up to 8 hours
A = must be between 0° and 135° angular displacement

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

$$RWL(lb) = 51\left(\frac{10}{H}\right)(1 - 0.0075\,|\,V - 30\,|)\left(.82 + \frac{1.8}{D}\right)\left(1 - (0.0032 \times A)\right)(FM)(CM)$$

$$RWL(kg) = 23\left(\frac{25}{H}\right)(1 - 0.003\,|\,V - 75\,|)\left(.82 + \frac{4.5}{D}\right)\left(1 - (0.0032 \times A)\right)(FM)(CM)$$

COUPLING MULTIPLIER		
Coupling Type	V < 30 in (75 cm)	V ≥ 30 in (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

FREQUENCY MULTIPLIER						
Frequency Lifts/min	**Work Duration ≤ 1 hr**		**Work Duration ≤ 2 hr**		**Work Duration ≤ 8 hr**	
(F)	V < 30	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤ 0.2	1.00	1.00	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.80	0.80	0.60	0.60	0.35	0.35
6	0.75	0.75	0.50	0.50	0.27	0.27
7	0.70	0.70	0.42	0.42	0.22	0.22
8	0.60	0.60	0.35	0.35	0.18	0.18
9	0.52	0.52	0.30	0.30	0.00	0.15
10	0.45	0.45	0.26	0.26	0.00	0.13
11	0.41	0.41	0.00	0.23	0.00	0.00
12	0.37	0.37	0.00	0.21	0.00	0.00

FREQUENCY MULTIPLIER						
Frequency Lifts/min	Work Duration ≤ 1 hr		≤ 2 hr		≤ 8 hr	
13	0.00	0.34	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	0.00	0.00	0.00
15	0.00	0.28	0.00	0.00	0.00	0.00
> 15	0.00	0.00	0.00	0.00	0.00	0.00

Lifting Index (LI) = a term that provides a relative estimate of the level of physical stress associated with a particular manual lifting task. The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit (RWL).

$$LI = \frac{\text{Load Weight}}{\text{Recommended Weight Limit}} = \frac{L}{RWL}$$

Select an Approved Calculator

The ASP and CSP exams both require the use of a good scientific calculator. Those taking BCSP examinations will be allowed to bring one or two calculators into the secure examination facility; any calculator brought into the examination must be from the brands and models listed below.

- Casio models FX-100, 200, or 300 series
- Hewlett Packard models HP 10, 12, or 17 series
- Texas Instruments models TI-30 series

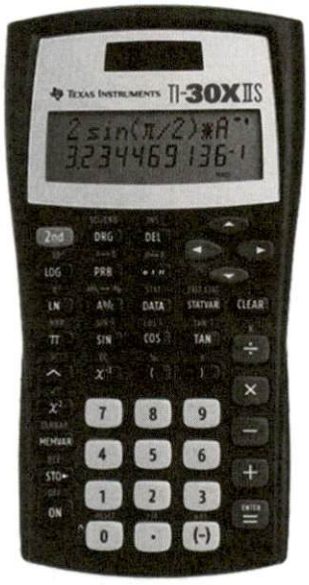
Make sure you know how to use your calculator(s) so you don't waste valuable time trying to understand how to use it once the examination clock starts. It is a good idea to practice working solutions and to be able to recall the correct calculator procedures. Different versions of the above brands and models will be permitted. For example, the TI-30X IIS and HP 30s calculators will be allowed, as they are versions of permitted brands and models.

When purchasing a calculator for this effort, look for the following features:

1. First, and most importantly, the calculator should have a well-illustrated instruction manual. The manual should be large enough to read, not an inch by an inch and a half. It should have examples of problems and answers with illustrations.
2. In addition to suggestions made by the board, the authors believe the calculator should have these functions (in order of importance):
   - A statistical function capable of calculating mean, standard deviation, and correlation.
   - A change sign function for numbers and exponents
   - A universal power functions
   - Scientific notation
   - Combinations, permutations, and factorials
3. Lastly, the calculator should be large enough for each individual's use. Many modern calculators have such small keys that it is nearly impossible to hit just one key at a time. Since test-takers will be doing a considerable amount of work during this study effort, attempt to make it as user-friendly as possible.

Many items on this list are personal preference. Evaluate these suggestions with respect to personal science and math skills to determine which functions are most relevant.

During this course of study, several statistical problems involving the calculation of standard deviation, both population and sample, will be encountered. Determining standard deviation requires, among other things, making a table, determining absolute values, squaring numbers, and significant manipulation. Obviously, solving each problem unassisted would greatly hinder your progress on a five-and-a-half-hour test that allows a minute and a half per question! If a calculator will perform this function with a single key stroke (after data input), there is little doubt which method is recommended.



TI-30X IIS Series Calculator

Reproduced from Texas Instruments Incorporated.

Likewise, coefficient of correlation calculations are very complicated and time consuming to do with x and y tables. Operations that take seconds on a good calculator may require five or more minutes to set up on paper. Undoubtedly, it is wise time management to use a calculator to do much of the work. Additionally, you save a lot of mental effort by not having to be concerned about applying the correct formulas.

The same rationale holds true for scientific notation, combinations, permutations, and factorials. The problems involving probability and reliability all require use of these tools, some more than others. Thus, it is an advantage to search for the **best** possible calculator to assist with these exams.

A selected number of calculators will serve candidates well during the ASP and CSP study effort. SPAN™ International Training Safety Workshops includes the *TI-30X IIS* series calculator as part of the workshop because it has an adequate instruction booklet, performs all required functions, is easy to use and read, and, if one wishes to buy a spare, it can be purchased through SPAN™ for $25.

Calculator Practice

Solve the following using your calculator.

Note: Rounding of numbers for the examination is not a problem. Due to the differences in calculator accuracy, the test will use approximate answers that will not be affected by reasonable rounding errors.

1. Calculate $69.95 − 10% discount = _____
2. Calculate 14×356 _____
3. Calculate $\pi \times 3.6^2$ _____
4. Calculate $\dfrac{\left(\frac{1}{2} \times 6^2\right)}{\sqrt{9}}$ _____
5. Calculate $5^{4.87}$ _____
6. Calculate $\sqrt[4.87]{2535}$ _____

7. Calculate log 15.32 _____

8. Calculate $90 + 16.61 \times \log_{10} 2$ _____

9. Calculate $1 - e^{-2.5}$ _____

10. Calculate 45^{-1} _____

11. Calculate $\frac{1}{45}$ _____

12. Calculate $(64)^{1/2}$ _____

13. Calculate sine 30 _____

14. Calculate arcsine of 0.5 _____

15. Calculate $\frac{(4 \times 5)}{(5 \times 4)}$ _____

16. Calculate $\frac{\frac{70 + 50}{12}}{5 \times 5}$ _____

17. Calculate $\sqrt{4.5 \times 2}$ _____

18. Calculate $\frac{1}{4} \div \frac{1}{2} \div \frac{2}{3} \div \frac{3}{4} \div \frac{7}{8}$ _____

Calculator Solutions

1. Calculate \$69.95 − 10% discount = ... \$62.96
   On the TI: 69.95 − 10% × 69.95

2. Calculate 14×356 4984
   On the TI: 14 × 356 =

3. Calculate $\pi \times 3.6^2$ 40.72
   On the TI: $\pi \times 3.6^2$ =

4. Calculate $\frac{\left(\frac{1}{2} \times 6^2\right)}{\sqrt{9}}$ 6

   On the TI: $(1 \text{ ⌟ } 2 \times 6^2)/(\sqrt{9}) =$

5. Calculate $5^{4.87}$ 2535
   On the TI: 5^4.87 =

6. Calculate $\sqrt[4.87]{2535}$ 5
   On the TI: 4.87 $\text{ }^{x}\sqrt{}$(2535) =

7. Calculate log 15.32 ..... 1.19
   On the TI: log 15.32 =

8. Calculate $90 + 16.61 \times \log_{10} 2$ 95
   On the TI: 90 + 16.61 × log 2 =

9. Calculate $1 - e^{-2.5}$ 0.92
   On the TI: 1 − e^(−2.5) =

10. Calculate 45^{-1} 0.022
    On the TI: 45^ −1 or 45^{-1} =

11. Calculate $\frac{1}{45}$ 0.022
    On the TI: 1 / 45 =

12. Calculate $(64)^{1/2}$ 8
    On the TI: 64^(1 / 2) or 64^1 ⌟ 2 =

13. Calculate sine 30 ..... 0.5
    On the TI: sin30 =

14. Calculate arcsine of 0.5 30
    On the TI: $\sin^{-1}$ 0.5 =

15. Calculate $\frac{(4 \times 5)}{(5 \times 4)}$ 1
    On the TI: (4 × 5) / (5 × 4) =

16. Calculate $\frac{\frac{70 + 50}{12}}{5 \times 5}$ 0.4

    On the TI: ((70 + 50) / 12) / (5 × 5) =

17. Calculate $\sqrt{4.5 \times 2}$ 3
    On the TI: √(4.5 × 2) =

18. Calculate $\frac{1}{4} \div \frac{1}{2} \div \frac{2}{3} \div \frac{3}{4} \div \frac{7}{8}$ 1.143
    On the TI: 1 ⌟ 4 / 1 ⌟ 2 / 2 ⌟ 3 / 3 ⌟ 4 / 7 ⌟ 8 = 1μ 1/7 F◄ ►D ⇒ 1.143

Domain 1 Quiz 1 Questions

1. **High occupational noise levels are prevalent in the occupational safety and health field. With high levels prevalent, occupational hearing loss involves three (3) main hertz ranges and affects specific anatomical parts of the ear. Choose the answer that lists the correct audible level in relation to the affected anatomical ear organ.**

   A. Hearing loss at 3000–6000 hertz range → Sensorineural, affecting the cochlea and semicircular canals
   B. Hearing loss at 2000–4000 hertz range → the inner ear, affecting the cochlea and organ of corti
   C. Hearing loss at 4000–8000 hertz range → The middle ear, affecting the tympanic membrane and cochlea
   D. Hearing loss at 6000–10,000 hertz range → The external ear, affecting the lobule and scapha

2. **In the lungs, oxygen is absorbed into the blood stream by passing through the membrane of the_____ in the lungs.**

   A. pleural cavity
   B. bronchioles
   C. alveoli
   D. trachea

3. **A person's aerobic capacity is *best* defined as:**

   A. the minimum amount of work that can be performed given enough physical strength.
   B. the maximum amount of work that can be performed given enough available lactic acid.
   C. the maximum amount of work that can be performed given enough oxygen supply to the muscles.
   D. the minimum amount of work that can be performed given enough oxygen supply to the muscles.

4. **The movement of a body segment in a lateral plane away from the midline of the body is:**

   A. abduction.
   B. adduction.
   C. flexion.
   D. extension.

5. **Which of the following pass through the carpal tunnel?**

   A. Medial nerve and radial artery
   B. Ulnar nerve and ulnar artery
   C. Ulnar nerve and flexor tendons
   D. Median nerve and flexor tendons

6. **The part of the eye that turns light waves into a signal that is transmitted to the brain by the optic nerve is called the:**

   A. cornea.
   B. lens.
   C. retina.
   D. pupil.

7. **The organ that secretes bile, stores fat and sugar as reserve energy sources, converts harmful substances to less toxic forms, and regulates the amount of blood in the body is called the:**

   A. kidney.
   B. liver.
   C. duodenum.
   D. stomach.

8. The blood vessels and nerves of the skin are found in the:

A. epidermis.
B. hypodermis.
C. stratum corneum.
D. dermis.

9. A 110-foot telecommunications tower casts a shadow at an angle of 32 degrees with the ground. The length of the shadow is:

A. 110 feet.
B. 176 feet.
C. 198.6 feet.
D. 229 feet.

$$\sin A = \frac{a}{c} \quad \cos A = \frac{b}{c} \quad \tan A = \frac{a}{b}$$

10. Which of the following correctly evaluates the Boolean expression shown below?

A. A and not-A or A and B equals A and B.
B. A plus not-A and A plus B equals A plus B.
C. A plus A BAR and A plus B equals A plus B.
D. A or not-A and A or B equals A or B.

$$(A + \overline{A}) \bullet (A + B) = A + B$$

11. Two tank farms are located on plant property. Tank farm number one contains one fuel storage tank 132 feet in diameter and 42 feet high. This tank farm has no diking. Tank farm number two is completely diked and contains four fuel storage tanks. Tank number one is 100 feet in diameter and 35 feet high. Tanks two and three are 50 feet in diameter and 15 feet high. Tank number four is 40 feet in diameter and 15 feet high. The area enclosed by diking is 220 feet by 330 feet. Calculate the storage capacity of the fuel tank located in tank farm number one.

A. 4,300,000 gallons
B. 2,500,000 gallons
C. 6,800,000 gallons
D. 555,456 gallons

$$V = \frac{\pi d^2 \times h}{4}$$

12. The pressure in a 5-L compressed gas cylinder is 101.3 kpa at a temperature of 298K. The cylinder is allowed to heat while stored and reaches a pressure of 106.4 kpa because the commercial transportation van is exposed to the sun. What is the new temperature of the cylinder in Celsius?

A. 55°C
B. 40°C
C. 20°C
D. 75°C

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

13. A car is traveling at 70 mph. The operator's reaction time is 0.75 seconds. How far will the car travel during the driver's reaction time?

A. 48.6 feet
B. 63 feet
C. 77 feet
D. 91.0 feet

14. A 175-pound worker equipped with a fall arrest system slips and falls 6 feet. The total arresting force placed on the restraining anchor fixture is 950 pounds. How many additional "G" forces did this worker experience?

A. 2.2
B. 3.3
C. 4.4
D. 6.0

15. In a cargo terminal, a cotton bale having a mass of 227 kilograms of mass (kgm) hangs from a device traveling in a straight line.The velocity of the cotton bale increases from 10.0 m/s to 20.0 m/s in 5 s. Determine the magnitude of the force acting on the cotton.

A. 454 N
B. 325 N
C. 906 N
D. 650 N

$$a = \frac{v - v_0}{t} \qquad F = ma$$

16. How many moles of oxygen are there in 10 grams of the element? Note: The atomic weight of oxygen is 16.

A. 6.3 moles
B. 0.68 moles
C. 0.63 moles
D. 63 moles

17. Which of the following equations is balanced?

A. $N_2H_4 + 2H_2O_2 \rightarrow 4H_2O + N_2$
B. $N_2H_4 + 2H_2O_2 \rightarrow 6H_2O + N_2$
C. $N_2H_4 + 2H_2O_2 \rightarrow 4H_2O + 2N_2$
D. $N_2H_4 + 2H_2O_2 \rightarrow 4H_2O + 4N_2$

18. The process of collecting organic materials on a surface of an activated carbon filter is:

A. adsorption.
B. absorption.
C. desorption.
D. permeation.

19. A key characteristic of an organic chemical is that:

A. it is only found in living things like plants and animals.
B. it decomposes rapidly.
C. it contains carbon.
D. it is pure and comprised of only a single element.

20. Any substance with a pH reading of 1.8 is:

A. neutral.
B. acidic.
C. caustic.
D. basic.

Domain 1 Quiz 1 Answers

1. Answer: **B**. Habitual exposure to noise above 85 dB will cause a gradual hearing loss in a significant number of individuals, and louder noises will accelerate this damage. Noise-induced hearing loss can be temporary or permanent. Noise (defined as unwanted sound) is a pervasive, insidious cause of hearing loss. It causes no particular pain unless it is as loud as a rifle blast. Chemical-induced hearing loss involves **ototoxic chemicals** (and examples) include:

   - organic solvents (styrene, trichloroethylene, mixtures)
   - heavy metals (mercury, lead, trimethyltin)
   - asphyxiates (carbon monoxide, hydrogen cyanide)

   The ears have considerable comeback power from brief exposure to intense noise and ordinarily recover within 14 hours or so (this is called a temporary threshold shift (TTS), typically most prominent at 4000 Hz).

However, prolonged exposure to intense noise gradually damages the cochlear hair cells of the inner ear, resulting in a prominent threshold shift (PTS) across multiple frequencies (Plog 2012).

- **The average measured hearing range of an unimpaired person is 20–20,000 Hz. Below 20 Hz is subaudible; above 20,000 is ultrasonic.**
- **Human speech ranges from 300 to 4000 Hz.**
- **Generally, noise-induced hearing loss occurs at a pitch of about 2000–4000 Hz.**

The external portion of the ear (auricle/pinna) collects sound waves from the air and funnels them into the ear canal. They are transported to the tympanic membrane (eardrum). The collected sound waves cause the eardrum to move back and forth in a vibrating mechanical motion that is passed on to the bones of the middle ear.

- The outer ear consists of the pinna, external auditory canal, and ear drum.
- The middle ear consists of the hammer, anvil, and eustachian tube.
- The inner ear consists of the semicircular canals, cochlea, organ of corti, and cochlear nerve.

The hearing conservation program requires employers to monitor noise exposure levels in a way that accurately identifies employees exposed to noise at or above 85 decibels (dB) averaged over 8 working hours, or an 8-hour time-weighted average (TWA). Employers must monitor all employees whose noise exposure is equivalent to or greater than a noise exposure received in 8 hours where the noise level is constantly 85 dB. Employers need to worry about noise exposure when threshold shifts are large at one frequency, when they are moderate at two or more adjacent frequencies, or when even small successive shifts occur consistently over a period of years. OSHA's current definition of a shift to worry about, a significant or "standard" threshold shift, is an average shift of 10 dB or greater at 2000, 3000, and 4000 Hz in either ear (*Hearing Conservation Manual*, 4th edition).

NIOSH establishes Recommended Exposure Limits (REL) for noise based on the best available science and practice. The NIOSH REL for noise is 85 decibels, using the A-weighting frequency response (often written as dBA) over an 8-hour average, usually referred to as Time-Weighted Average (TWA). Exposures at or above this level are considered hazardous. OSHA sets legal limits on noise exposure in the workplace. These limits are based on a worker's time-weighted average over an 8-hour day. With noise, OSHA's permissible exposure limit (PEL) is 90 dBA for all workers for an 8-hour day.

Occupational standards specify a maximum allowable daily noise dose, expressed in percentages. For example, a person exposed to 85 dBA per NIOSH or 90 dBA per OSHA over an 8-hour work shift, will reach 100% of their daily noise dose. Any noise above 140 dB is not permitted. The noise dose is based on both the sound exposure level and how long it lasts (duration), so for each increase or 3-dB (NIOSH) or 5-dB (OSHA) in noise levels, the duration of the exposure should be cut in half (this is what's referred to as exchange rates in standards). **Table 4** illustrates the relationship between sound exposure levels and durations for both NIOSH and OSHA.

Table 4 Monitoring Noise Exposure Levels

Time to Reach 100% Noise Dose	Exposure Level per NIOSH REL	Exposure Level per OSHA PEL
8 hours	85 dBA	90 dBA
4 hours	88 dBA	95 dBA
2 hours	91 dBA	100 dBA
1 hour	94 dBA	105 dBA
30 minutes	97 dBA	110 dBA
15 minutes	100 dBA	115 dBA

2. Answer: **C**. An **alveolus** (plural: **alveoli**) is an anatomical structure that has the form of a hollow cavity. Found in the lung parenchyma, the pulmonary alveoli are the terminal ends of the respiratory tree, which outcrop from either alveolar sacs or alveolar ducts, which are both sites of gas exchange with the blood as well. The alveolar membrane is the gas-exchange surface. Carbon dioxide–rich blood is pumped from the rest of the body into the alveolar blood vessels where, through diffusion, it releases its carbon dioxide and absorbs oxygen.

   The **pleural cavity** is the thin fluid-filled space between the two pulmonary pleurae (visceral and parietal) of each lung. The outer pleura (parietal pleura) is attached to the chest wall. The inner pleura (visceral pleura) covers the lungs and adjoining structures, including blood vessels, bronchi, and nerves.

   The **bronchioles,** or **bronchiole,** are the passageways by which air passes through the nose or mouth to the alveoli (air sacs) of the lungs, in which branches no longer contain cartilage or glands in their submucosa. They are branches of the bronchi and are part of the conducting zone of the respiratory system. The bronchioles divide further into smaller **terminal** bronchioles that are still in the conducting zone, and these then divide into the smaller **respiratory** bronchioles that mark the beginning of the respiratory region.

   The **trachea**, colloquially called the **windpipe**, is a cartilaginous tube that connects the pharynx and larynx to the lungs, allowing the passage of air.

3. Answer: **C**. *Aerobic capacity* refers to the *maximum* amount of oxygen consumed by the body during intense exercises, in a given time frame. It is a function both of cardiorespiratory performance and the *maximum* ability to remove and use oxygen from circulating blood. Maximum aerobic work capacity is often referred to physical work, endurance, or capacity.

4. Answer: **A**. **Abduction** is defined as movement away from the central axis of the body—away from the median plane. **Flexion** is movement that decreases the angle between two adjacent bones. **Extension** is movement that increases the angle between two adjacent bones. **Adduction** is defined as movement toward the central axis or midline—the opposite of abduction.

5. Answer: **D.** The carpal tunnel, or carpal canal, is the passageway on the palmar side of the wrist that connects the forearm to the middle compartment of the palm. The tunnel consists of bones and connective tissue. Several tendons and the median nerve pass through it.

6. Answer: **C**. When light enters the **eye**, it first passes through the **cornea**. Its main function is to refract, or bend, light. The **lens** focuses light rays onto the **light sensitive retina**, where it is changed into a signal that is transmitted to the brain by the **optic nerve**. The signal is received and interpreted by the brain as a visual image. The **pupil** is the opening of the iris. The pupil may appear to open (dilate) and close (constrict), but it is really the iris that is the prime mover; the **pupil** is merely the absence of iris. The **pupil** determines how much light is let into the **eye**.

7. Answer: **B**. The ***liver*** secretes bile, stores fat and sugar as reserve energy sources, converts harmful substances to less toxic forms, and regulates the amount of blood in the body. The ***kidneys*** remove waste products from the blood and produce urine. As blood flows through the *kidneys*, the *kidneys* filter waste products, chemicals, and unneeded water from the blood. The **duodenum** is the first and shortest segment of the small intestine. It receives partially digested food (*chyme*) from the stomach and plays a vital role in the chemical digestion of chyme in preparation for absorption in the small intestine. Many chemical secretions from the pancreas, liver, and gallbladder mix with the chyme in the duodenum to facilitate chemical digestion. The **stomach** receives chewed food from the esophagus. Tiny glands in the *stomach's* lining secrete gastric juice, which contains acids, mucus, and enzymes.

8. Answer: **D**. The skin consists of three layers:

   - Epidermis: thin outer layer and produces melanin
   - Dermis: thick underlying layer that stores much of the body's supply of water, regulates temperature, and contains glands, nerves, and blood vessels for the skin.
   - Hypodermis: fatty layer for insulation and shock absorption.

9. Answer: **B**.

$$\tan A = \frac{a}{b}$$

$$b = \frac{a}{\tan A}$$

$$b = \frac{110}{\tan 32}$$

$$b = 176 \text{ ft}$$

10. Answer: **D**. When evaluating Boolean Logic and applications, the sign + is read "or" (i.e., A + B becomes A or B.) The sign "·" is read "and"; thus, A · B is stated A and B. The "A-bar" symbol is read "not-A."

The expression $(A + \overline{A}) \bullet (A + B) = A + B$ is read:

A or not-A and A or B equals A or B.

The expression $A \times (B + C) = (A \times B) + (A \times C)$, also described as a union of one subset with two others, can also be expressed as the union of their intersections.

11. Answer: **A**.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{3.14 \times (132)^2 \times 42}{4}$$

$$V = 574{,}760 \text{ cu ft}$$

$574{,}760 \times 7.48$ gal per cu ft = 4,299,200 gallons

12. Answer: **B**. P = Pressure (expressed in absolute, gauge pressure must be converted to absolute by adding 1 atm pressure to the gauge reading)

1 atm = 14.7 psi
= 760 mm Hg
= 29.92 in Hg
= 33.90 ft H_2O
= 760 torr
= 101.3 kilopascal

V = Volume
T = Temperature (expressed in absolute on the Kelvin scale for Celsius and Rankin scale for Fahrenheit)

$$t_{°C} = \frac{(t_{°F} - 32)}{1.8}$$

$$t_{°K} = t_{°C} + 273 \qquad t_{°R} = t_{°F} + 460$$

P_1 = 101.3 kilopascals (kpa)
T_1 = 298°K
P_2 = 106.4 kpa
T_2 = ? Celsius

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2} \qquad \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{101.3}{298} = \frac{106.4}{T_2} \qquad T_2 = \frac{(106.4 \times 298)}{101.3} = 313°K$$

313°K – 273 = 40°C

13. Answer: **C**.

$$\text{Distance} = \text{Speed} \times \text{Time}.$$

$$70 \text{ mph} \times 1.47 \frac{\text{fps}}{\text{mph}} \times 0.75 \text{ sec} = 77.12 \text{ ft}$$

14. Answer: **C**. The workers weight is a function of gravity. The worker's weight is 175 pounds in the gravity of earth; so, at rest (stationary) the worker is experiencing 1 "G" force. 950 – 175 = 775 pounds additional force; 175 lb = 1 G. Therefore, 775/175 = 4.4 G. Remember in the measurement of G forces, positive or negative, **always** measure from the baseline of +1 G (one gravity).

15. Answer: **A**. The mass of the cotton bail, m, is given as 227 kgm. The initial velocity, v_0, is given as 10.0 m/s. The final velocity, v, is given as 20.0 m/s. The time elapsed, t, is given as 5 s.

    Step 1: Solve for acceleration.

$$a = \frac{v - v_0}{t}$$

$$a = \frac{20 \text{ m/s} - 10 \text{ m/s}}{5 \text{ s}} = 2 \text{ m/s}^2$$

    Step 2: Solve for force.

$$F = ma$$

$$F = (227 \text{ kgm})(2 \text{ m/s}^2) = 454 \text{ N}$$

    1-N Force = 1.0 kilogram of mass (kgm) × 1.0 m/s^2 constant acceleration

16. Answer: **C**. The atomic weight of oxygen is 16, which means that one mole of oxygen weighs 16 grams. So, 10 grams divided by 16 = 0.63 moles of oxygen.

17. Answer: **A**. Only the first equation is balanced and represents the mixture of two substances, which explode on contact. The **hypergolic** reaction shown is that of hydrazine and hydrogen peroxide.

18. Answer: **A**. **Adsorption** is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. This process creates a film of the *adsorbate* on the surface of the *adsorbent*. This process differs from **absorption**, in which a fluid (the *absorbate*) is dissolved by or permeates a liquid or solid (the *absorbent*), respectively. Adsorption is a surface-based process while absorption involves the whole volume of the material. The term "sorption" encompasses both processes, while ***desorption*** is the reverse of it. Adsorption is a *surface phenomenon*.

19. Answer: **C**. **Organic chemistry** is a chemistry subdiscipline involving the scientific study of the structure, properties, and reactions of organic compounds and organic materials (i.e., *matter in its various forms that contain **carbon** atoms*). Examples of organic compounds include table sugar, methane (hydrocarbons), DNA, proteins, nucleic acids, and enzymes. Organic molecules and compounds are generally associated with living organisms. **Inorganic chemistry** deals with the synthesis and behavior of inorganic and organometallic compounds. Some examples of inorganic compounds are table salt, diamonds, ammonium chromate, carbon dioxide, carbon monoxide, hydrogen fluoride and silver oxide. Inorganic compounds almost always lack carbon.

20. Answer: **B**. The pH scale ranges from 0 to 14. It measures the acidity or basicity of a solution. A pH of 7 means it is a neutral solution. Pure water has a pH of 7. A pH of less than 7 means the solution is acidic. A pH of more than 7 means the solution is basic. The less pH, the more acidic the solution is. The more pH, the more basic the solution is. pH stands for the power of H, or the amount of H^+ ions, acids or bases take or contribute in solution. pH equals the negative log of the concentration of H^+ (**Figure 6**). $pH = -\log[H^+]$

    When the concentration of H^+ ions in a solution is 10^{-14}, the pH is 14. In pure water, the average concentration of H^+ ions is 10^{-7}.

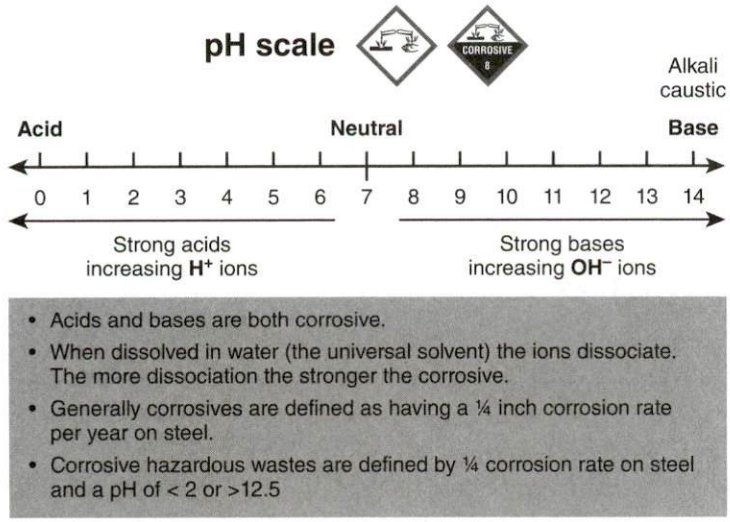


Figure 6 pH Scale

Snyder, D.J. *The Hazardous Materials Management Desk Reference*, 3rd ed. Bethesda, MD: Alliance of Hazardous Materials Professionals, 2014.

Domain 1 Quiz 2 Questions

1. A small overhead crane is reeved with a block and 10-part line and is being used to lift a load of 20 tons. Discounting the block friction, what is the force required to lift the load?

A. 20 tons
B. 20,000 pounds
C. 2 tons
D. 2000 pounds

2. There is a 2000-gallon tank filled with brine water (s.g. 1.8). What will be the weight of a full tank?

A. 16,800 pounds
B. 26,900 pounds
C. 30,000 pounds
D. 40,000 pounds

3. Management has proposed to install a new manufacturing unit on the second floor of one of the buildings. The unit is 12 feet by 12 feet square and weighs 18,000 pounds total. When you are doing your initial evaluation of the proposal, you find engineering drawings that state, "The maximum floor loading for the proposed location is 150 PSF." Can the unit be installed safely?

A. No, the loading is over maximum by 10 PSF.
B. No, the loading is over maximum by 25 PSF.
C. Yes, the loading is under maximum by 10 PSF.
D. Yes, the loading is under maximum by 25 PSF.

4. If a light source has an illumination reading of 600 foot-candles at 1 foot, what is the illumination at 10 feet?

A. 2 foot-candles
B. 4 foot-candles
C. 6 foot-candles
D. 9 foot-candles

$$I_2 = I_1 \frac{(d_1)^2}{(d_2)^2}$$

5. A radioisotope has a half-life of 1 year. How many years will it take to decrease initial activity to less than 10%?

A. 3
B. 4
C. 5
D. 6

6. What radiation reading would result from an unshielded 5 millicurie source of cesium-137 at a distance of 1 foot, given an MEV of 0.662 and a 0.9 gamma-radiation per second disintegration?

A. 4.37 R/hr/1ft
B. 0.047 R/hr/1ft
C. 0.018 R/hr/1ft
D. 36.7 mR/hr/1ft

$S \approx 6\ CiEf$

7. What radioactivity would remain from 1 Ci (curie) of Co-60 (5.24 years half-life) after a 20-year period?

A. 0.0071
B. 0.071
C. 0.71
D. 7.1

$$A = \frac{A_o}{e^{\left(1n2\ \frac{t}{T_{1/2}}\right)}}$$

8. In the following set of numbers, what is the median value?

A. 12
B. 8
C. 12.14
D. 11

8, 8, 10, 12, 13, 15, 19

9. Airflow readings were taken for a newly installed laboratory fume hood and found to be acceptable and released to operations. Several months later, a scientist from the research and development division has set up an experiment in the fume hood that has modified the space configuration. To meet the manufacturer's specifications for airflow, each section in the plane must be within +/– 20% of the mean. Given the new airflow readings, what can you interpret from this data?

A. The airflow readings are not acceptable in two sections.
B. The airflow is acceptable because it was evaluated and released to operations.
C. The airflow is acceptable based on the new readings in each section.
D. The airflow readings are not acceptable in three sections.

64	81	82	108
69	75	87	102
72	89	98	98

10. The mean plus or minus 1 standard deviation estimates what percentage of the distribution in a *normal* distribution?

A. 95.45%
B. 99.73%
C. 68%
D. 50%

11. If mean accidents are 10 and standard deviation is 3, what is the probability of less than 7 accidents at a location?

A. 2.5%
B. 5%
C. 16%
D. 32%

12. What is the standard deviation of the following complete set of data points?

100 ppm	124 ppm	115 ppm	93 ppm	85 ppm	102 ppm	109 ppm	111 ppm	114 ppm	102 ppm	104 ppm

A. 5.5
B. 10.4
C. 12.6
D. 15.1

$$s = \sqrt{\frac{\sum(X^2)}{N-1}} \quad \left(x = X - \overline{X}\right) \quad \sigma = \sqrt{\frac{\sum(X^2)}{N}}$$

13. As the safety director for a large organization, you have implemented a new training initiative. Supervisors in some of your plants will test a new self-study safety educational package. These supervisors reported each week to a training center where they checked out self-study safety material. The time each supervisor spent reviewing the material was tabulated by training department personnel, and when the supervisors felt they were ready, they were administered a final written examination. You are also planning to give these same supervisors an additional test after six months to determine retention. Using this data, *compute* the Pearson Product Moment Coefficient of Correlation between the two sets of data to indicate a relationship between hours of study and test score.

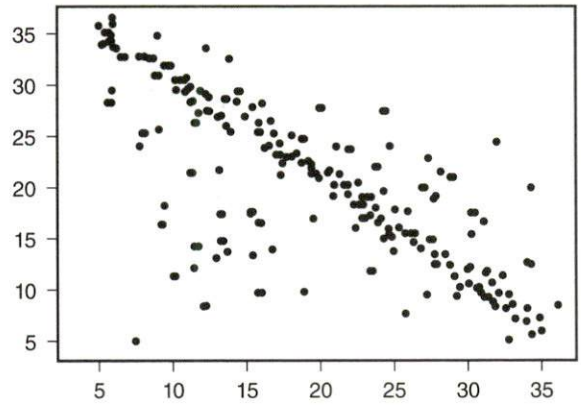
Supervisor	Hours	Scores	Supervisor	Hours	Scores
A	24	75	G	16	71
B	23	83	H	15	68
C	19.5	98	I	14.5	59
D	18	80	J	14	62
E	17	74	K	13.5	70
F	16.5	69	L	10	54

A. 0.31
B. 0.86
C. 0.67
D. 0.72

$$r = \frac{N\sum(XY) - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{\left[N\left(\sum X^2\right) - \left(\sum X\right)^2\right]\left[N\left(\sum Y^2\right) - \left(\sum Y\right)^2\right]}}$$

14. Which of the following coefficient of correlation best describes the relationships shown in this chart?

A. +0.90
B. −0.90
C. +0.05
D. −0.05



15. Assuming the data follows a normal distribution with a mean of 1800 and a standard deviation of 250, what is the probability of the component performing without failure if operated until 2400 hours?

Z	0	1	2	3	4	5	6	7	8	9
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936

A. 8.02%
B. 0.82%
C. 1.04%
D. 1.82%

$$R_t = 1 - P_f \quad z = \frac{X - \mu}{\sigma}$$

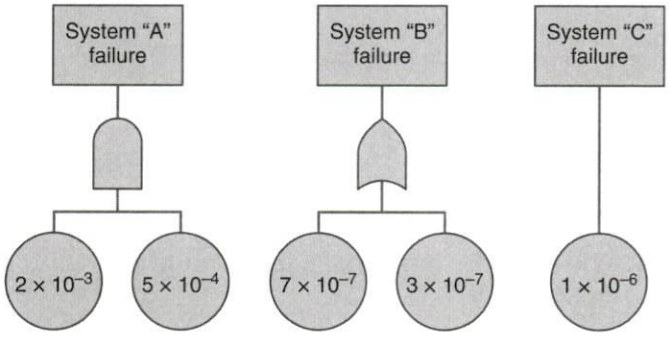
16. The CEO of the company has asked you to calculate statistics on the accidents at one of your plants. The safety manager at the plant indicates that the total average number of accidents that occur during a given month is 5. What is the probability that there will be exactly four accidents in the upcoming month?

A. 0.0067
B. 0.0033
C. 0.0842
D. 0.1755

$$p(r) = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$$

17. To select a system from among three potential safety design candidates, a Safety & Health Consultant must recognize that system failure will result in a loss, regardless of choice. An elementary design for each system showing probability of failure is shown below using standard "fault tree" symbols. Which system has the lowest overall failure probability?

A. System A has lower probability and offers redundancy.
B. System B has lower probability but has two potential single point failures.
C. System C is the simplest and has lowest probability.
D. The probability is the same for all three systems.



18. A company has an aggressive safety awards program for over-the-road transport drivers. Twenty drivers are semifinalists for three monetary awards each $1,500 in value. How many ways can awards be given?

A. 1140
B. 6840
C. 60
D. 6.6

$$nC_r = \frac{n!}{(n-r)!r!}$$

$$nP_r = \frac{n!}{(n-r)!}$$

19. In a recognition program with 20 workers, 3 awards are given; $2,000 for first place, $1,500 for second place, and $1,000 for third place. How many ways could the awards be given?

A. 1140
B. 6840
C. 60
D. 6.6

$$nC_r = \frac{n!}{(n-r)!r!}$$

$$nP_r = \frac{n!}{(n-r)!}$$

20. You are a CSP and a member of a skydiving club. You have been asked by the club president to assess last year's fatality data for the industry and provide the club members some insight/recommendations. According to the data, which potential error has the greatest probability of failure and highest priority based on reducing the risk of failure by 50%?

Potential Error	Probability of Failure	Safety Factor Reduces Risk of Failure by 50%
Malfunctions	0.95×10^{-7}	Well planned and rehearsed emergency procedures
Landing Problems	60×10^{-9}	Adequate training and jumper mental state
Collisions	0.035×10^{-6}	Adequate separation during breakoff
Reserve Problems	2.5×10^{-8}	Adequate safeguards and use of protocols

A. Malfunctions
B. Landing Problems
C. Collisions
D. Reserve Problems

21. Which of the following is true concerning the 95% confidence level when conducting hypothesis testing?

A. There is a 95% chance of being correct.
B. There is a 95% chance of being incorrect.
C. One will be wrong 1 time out of every 20 decisions.
D. One will be right 19 times out of every 20 decisions.

22. A safety survey is designed, and the company CEO wants to change confidence intervals from 90 to 95%. What is *best* way to achieve this?

A. Increase sample size.
B. Decrease number of survey questions making it more concise.
C. Increase number of survey questions.
D. Decrease sample size.

23. Which *best* describes the intent of a "competent person"?

A. The person capable of identifying existing and predictable hazards in surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees and who has authorization to take prompt corrective measures to eliminate them.
B. The person required to be on-site at confined space entry, hoisting and rigging, and excavation and trenching operations.
C. A supervisor with the ability to identify existing and future job site hazards and who reports directly to the person who has responsible charge of the operation.
D. The person who is required to shut down the operation anytime the risk analysis indicates that worker exposure to a hazard is reasonably acceptable.

24. Define the term for knowing the value of one variable allowing exact prediction of the value of another variable or when two sets of data are tested and there is no statistical difference between the data sets.

A. Lack of variance
B. Statistical significance
C. Coefficient interval
D. Perfect correlation

25. A recent perception survey shows a significant difference in scores from labor and management on the topic of discipline. All other survey responses indicated perception alignment between management and labor. What actions should be taken based on this data?

A. Change the company disciplinary policy to be fair and impartial.
B. Conduct training on the company's discipline policy.
C. Management should further investigate the cause of the discrepancy in the data.
D. No action is required; labor receives the discipline and perceives it differently than managers.

Domain 1 Quiz 2 Answers

1. Answer: **C**. The 10-part line on the crane referred to in this question provides a mechanical advantage of 10 to 1. 20 tons/10 = 2 tons. Note: 2000 pounds = 1 ton. The term reeved refers to the method of routing the wire ropes through the blocks used to develop the mechanical advantage.

2. Answer: **C**. Brine is a solution of water and salt. It can be salt water, pickling water, sea water, etc. All forms of brine are heavier than water.

   Step 1: Use conversion for calculating weight of tank containing water. $2000 \text{ gal} \times 8.34 \text{ lbs/gal} = 16{,}680 \text{ lbs}$

   Step 2: Convert from water to brine using specific gravity. $16{,}680 \text{ lbs} \times 1.8 = 30{,}024 \text{ lbs}$

3. Answer: **D**.

$$\text{Total ft}^2 \text{ of Unit} = 12 \text{ ft} \times 12 \text{ ft} = 144 \text{ ft}^2$$

$$\text{PSF for Unit} = \frac{18{,}000 \text{ lbs}}{144 \text{ ft}^2} = 125 \text{ PSF}$$

   Therefore, the PSF of the unit is 25 PSF under the maximum of 150 PSF.

4. Answer: **C**. Sound, radiation, and light are energy sources that follow the inverse square law, which states: "The propagation of energy through space is inversely proportional to the square of the distance it must travel." Consequently,

   Where:

   $I_1 = 600$

   $d_1 = 1$ ft

   $d_2 = 10$ ft

   $I_2 = ?$

$$I_2 = I_1 \times \frac{(d_1)^2}{(d_2)^2}$$

$$I_2 = 600 \times \frac{(1)^2}{(10)^2}$$

$$I_2 = 600 \times \frac{1}{100}$$

$$I_2 = 6 \text{ ftc}$$

5. Answer: **B.** The activity after 3 years will be 12.5% of the initial activity. After 4 years, activity will be 6.25% of initial activity.

6. Answer: **C**. The formula depicted on the exam may be of S ≅ 6CE, which is a "shortcut" formula for cobalt-60, since the "f" value for cobalt-60 is one. For cesium-137:

   Ci = 5 millicurie = 0.005 whole curies (the formula requires whole curie units)

   E = 0.662 MEV

   f = 0.9 gamma radiation disintegration

7. Answer: **B**.

   A = radioactivity remaining after time t

   A_o = radioactivity at a given original time

   t = elapsed time

   $T_{1/2}$ = half-life of the radio-nuclide

   ln 2 = 0.693 (natural log)

$$A = \frac{A_o}{e^{\frac{\ln 2 t}{T\frac{1}{2}}}}$$

$$A = \frac{1 \text{ Ci}}{e^{\frac{(0.693\,[20 \text{ yr}])}{5.24 \text{ yr}}}} = \frac{1 \text{ Ci}}{e^{2.645}} = \frac{1 \text{ Ci}}{14.08} = 0.071 \text{ Ci}$$

8. Answer: **A**. The median value of a series of numbers is the middle value. 12 is the middle or median value for this set of numbers. The mode is 8, which was selection "B." The average value, or the "mean," for the set is 12.14, which was answer "C," and the range is 11 (19 – 8), which was answer "D." The mean is derived by adding up the data points, which is 85 and dividing by the number of data points (7), which equals 12.1429 (**Figure 7**).

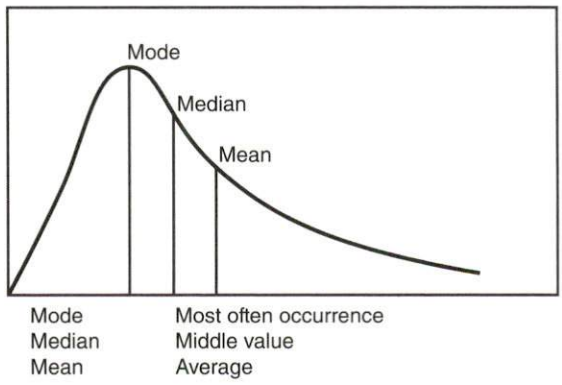


Figure 7 Measurements of Central Tendency

9. Answer: **A**. The mean, average of all 12 data points, is 85.42 cfm. If the mean is 85.42 cfm and acceptable conditions are +/– 20% of the mean, the acceptable range for each quadrant is 68.3–102.5 cfm. (85.42 × 0.20 = 17.08)

   Two sections fall outside of the acceptable range of 68.3–102.5 cfm.

10. Answer: **C**. The mean +/– 1 standard deviation will estimate the point at which 68% of the observations will fall (**Figure 8**).

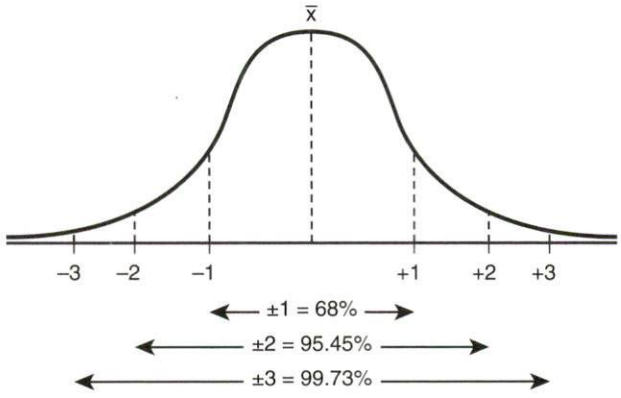


Figure 8 Standard Deviation Definitions

11. Answer: **C**. There is a 16% chance of being less than 7 or more than 13 (**Figure 9**).

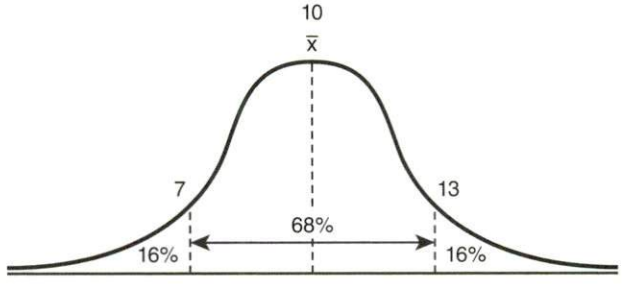


Figure 9 Probability of Less than 7 Accidents at a Location

12. Answer: **B**. There are simply too many failure points in the long-hand method. On the TI 30X IIS:

X	$\bar{X}$	$(X - \bar{X})$	$(X - \bar{X})^2$
100	105.4	5.4	29.2
124	105.4	18.6	345.96
115	105.4	9.6	92.16
93	105.4	−12.4	153.76
85	105.4	−20.4	416.16
102	105.4	−3.4	11.56
109	105.4	3.6	12.96
111	105.4	5.6	31.36
114	105.4	8.6	73.96
102	105.4	−3.4	11.56
104	105.4	−1.4	1.96
$\sum X = 1159$		$\sum (X - \bar{X})^2 = 1181$	

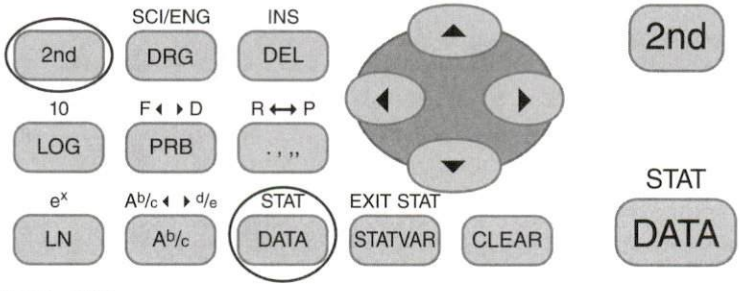
$$\sigma = \sqrt{\frac{\sum (x^2)}{n}} \text{ WHERE } (x = X - \bar{X})$$

$$\sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{n}}$$

$$\sigma = \sqrt{\frac{1181}{11}}$$

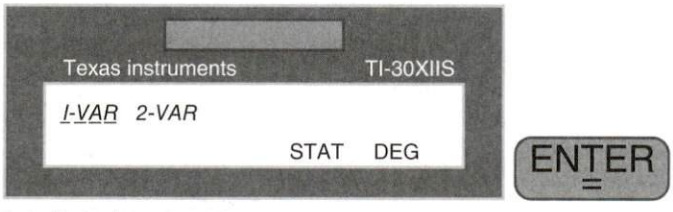
$$\sigma = 10.36$$

Set to STAT Mode using the second function of DATA key.



Modified from TI 30X IIS.

Select *1-VAR* and enter.

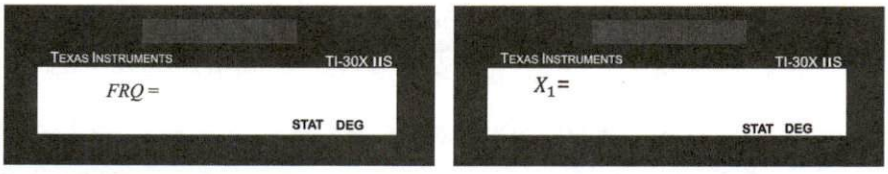


Reproduced from Texas Instruments Incorporated.

Press DATA key.



Enter $X_1 = 100$ down arrow FRQ = 1 down arrow; $X_2 = 124$ down arrow FRQ = 1 down arrow; $X_3 = 115$ down arrow FRQ = 1 down arrow; $X_4 = 93$ down arrow FRQ = 1 down arrow; $X_5 = 85$ down arrow FRQ = 1 down arrow, continue until all 11 numbers are entered.

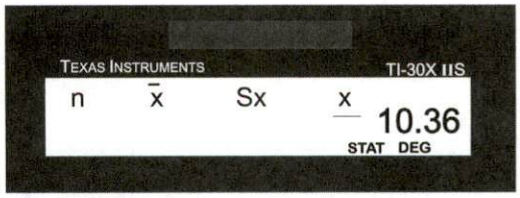


Reproduced from Texas Instruments Incorporated.

Press STATVAR.



Select $\sigma x = 10.36$.



Reproduced from Texas Instruments Incorporated.

13. Answer: **D**.

Step 1: Build a table.

Supervisor	X	Y	X^2	Y^2	XY
A	24	75	576.00	5625.00	1800.00
B	23	83	529.00	6889.00	1909.00
C	19.5	98	380.25	9604.00	1911.00
D	18	80	324.00	6400.00	1440.00
E	17	74	289.00	5476.00	1258.00
F	16.5	69	272.25	4761.00	1138.50
G	16	71	256.00	5041.00	1136.00
H	15	68	225.00	4624.00	1020.00
I	14.5	59	210.25	3481.00	855.50
J	14	62	196.00	3844.00	868.00
K	13.5	70	182.25	4900.00	945.00
L	10	54	100.00	2916.00	540.00
N = 12	$\sum X = 201$	$\sum Y = 863$	$\sum X^2 = 3540$	$\sum Y^2 = 63,561$	$\sum XY = 14,821$

Step 2: Apply the formula.

$$r = \frac{N\sum(XY) - (\sum X)(\sum Y)}{\sqrt{N\sum(X^2) - (\sum X)^2}\ \sqrt{N\sum(Y^2) - (\sum Y)^2}}$$

$$r = \frac{12\,(14,821) - (201)(863)}{\sqrt{12\,(3540) - (201)^2}\ \sqrt{12\,(63,561) - (863)^2}}$$

$$r = \frac{177,852 - 173,463}{\sqrt{42,480 - 40,401}\ \sqrt{762,732 - 744,769}}$$

$$r = \frac{4389}{\sqrt{2079}\ \sqrt{17,963}} = \frac{4389}{6111} = 0.72$$

On the TI 30X IIS:

Similar to the steps for solving question 4. Set to STAT Mode then select 2-VAR and enter: Press DATA $X_1 =$ 24 down arrow $Y_1 = 75$ down arrow $X_2 = 23$ down arrow $Y_2 = 83$ down arrow $X_3 = 19.5$ down arrow $Y_3 = 98$ down arrow $X_4 = 18$ down arrow $Y_4 = 80$ down arrow $X_5 = 17$ down arrow $Y_5 = 74$ down arrow, continue until done, then press STATVAT and select $r = 0.72$.

14. Answer: **B**. The statistical term for the amount of association between two variables is correlation. The coefficient of correlation is an expression of the correlation as a number between 0 and 1. Thus a perfect coefficient of correlation is 1; on the other hand, 0 represents no correlation. In the scatter diagram shown in this question, it is obvious that there is a strong correlation between the "Y" and "X" data; however, the correlation is not perfect, and there are many dots that seem to have no correlation. It is also evident by inspection, that the correlation is inverse or negative; that is, with every increase in "Y" value, there is a decrease in "X" value. The two sets of data are inversely related. The only selection that offers a strong negative correlation is "B." If the data had a strong positive correlation, it could be represented by the chart shown here, in which case selection "A" would be the best choice. Answer "C" and "D" show almost no correlation, and the scatter diagram depicting that condition would show a very random pattern (**Figure 10**).

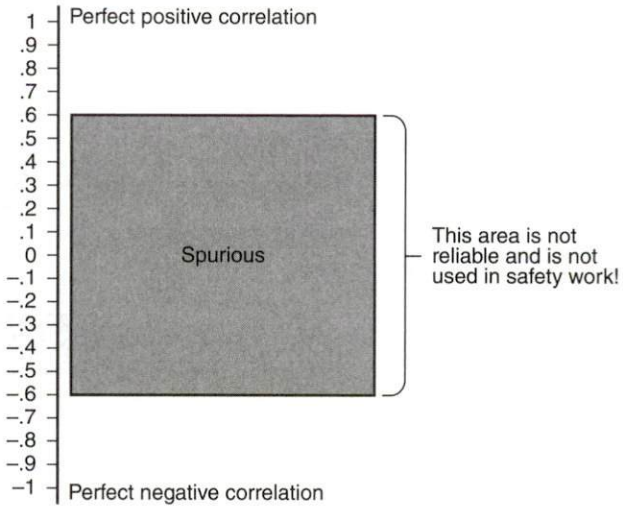


Figure 10 Correlation

15. Answer: **B**.

$$z = \frac{X - \mu}{\sigma}$$

$$z = \frac{2400 - 1800}{250}$$

$$z = \frac{600}{250} = 2.4$$

Area: 2.4 = 0.4918

$P_f = 0.5 + 0.4918 = 0.9918$

$R_t = 1 - P_f$

$R_t = 1 - 0.9918 = 0.0082 = 0.82\%$

16. Answer: **D**.

$$P(r) = \frac{e^{-\lambda t}(\lambda t)^r}{r!}$$

$$P_4 = \frac{e^{-5}5^4}{4!}$$

$$P_4 = \frac{(0.00674) \times (625)}{4 \times 3 \times 2 \times 1}$$

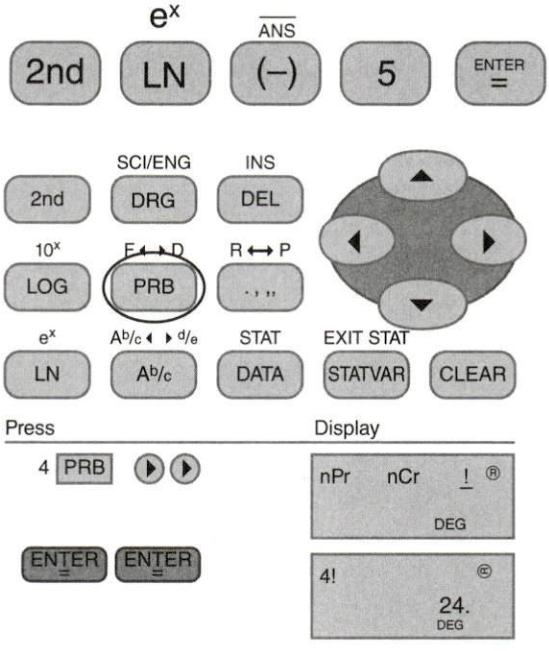
$$P_4 = \frac{4.2125}{24} = 0.1755$$

$t = 1$

$\lambda = 5$

$r = 4$

Note: Find the probability of "exactly" four accidents alerts us to use the Poisson distribution.



17. Answer: **D**. System "A" is a parallel system in which both the first **AND** the second components must fail to produce a system failure. To determine probability for a parallel system, individual probabilities are multiplied.

$$(2 \times 10^{-3}) \times (5 \times 10^{-4}) = 1 \times 10^{-6}$$

System "B" is a series system; that is, if either the first **OR** the second components fail, a system failure will occur. For components in series, the total failure rate is the sum of individual components' failure rates.

$$(7 \times 10^{-7}) + (3 \times 10^{-7}) = 1 \times 10^{-6}$$

System "C" has only one component. Thus, the probability of system failure is the same as single component probability of failure.

$$1 \times 10^{-6}$$

Since the severity and probability for each system is the same, the loss risk is also the same. Given this situation, the selection process would consider overall system cost, deliverability, quality, longevity, human factors, etc. (**Figures 11** and **12**).

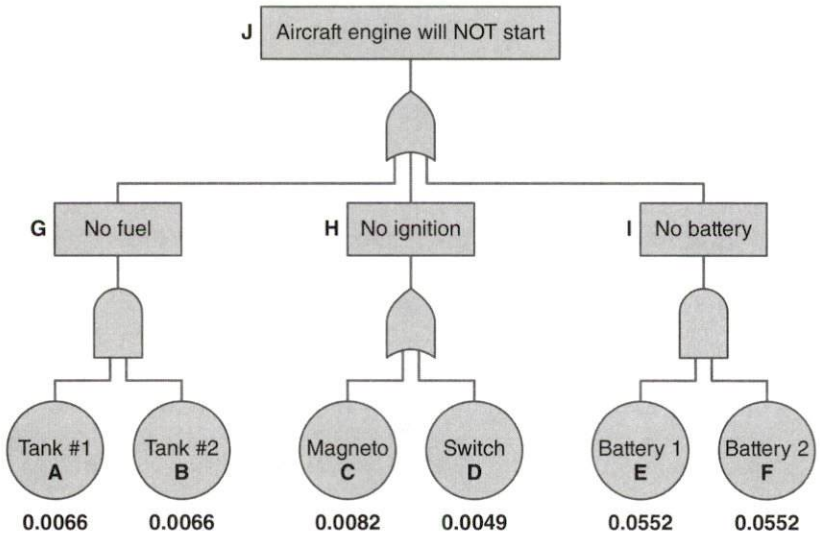


Figure 11 Fault Tree Analysis (FTA) Example 1

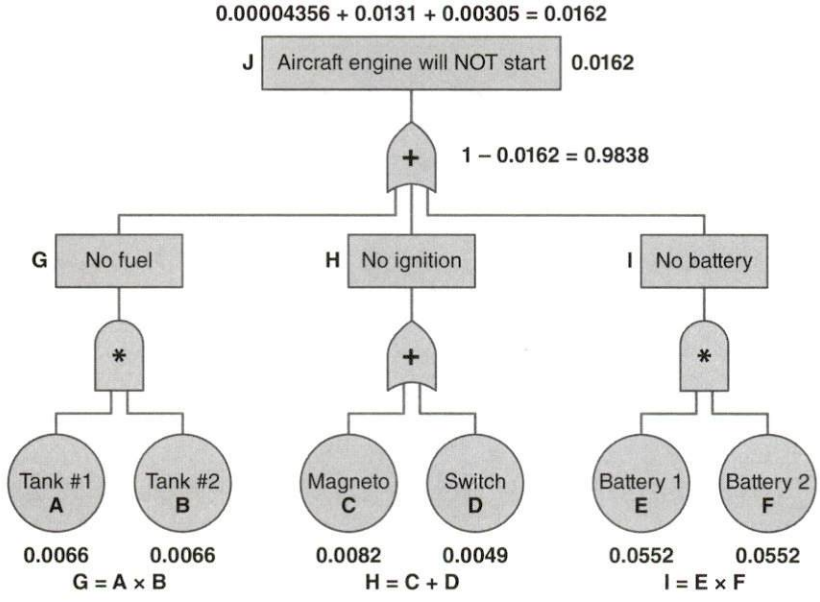
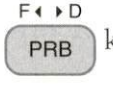


Figure 12 Fault Tree Analysis (FTA) Example 2

18. Answer: **A**. Recall formula and solve. That is, the number of combinations of n things taken r at a time.

Note: This is accomplished very easily on most scientific calculators that follow the standard notation. Enter n first, then keystroke nCr, enter r, then = (on the TI 30X-IIS, the nCr function is on PRB  key).

$$_{n}C_{r} = \frac{n!}{(n-r)!r!}$$

$$_{20}C_{3} = \frac{20!}{(20-3)!3!}$$

$$_{20}C_{3} = \frac{20!}{(17!3!)}$$

$$_{20}C_{3} = \frac{2.43 \times 10^{18}}{\left((3.56 \times 10^{14})(6)\right)}$$

$$20C_{3} = 1140$$

19. Answer: **B**. Recall formula and solve. In the preceding question, the order in which awards are given didn't matter since each was \$1500. However, order matters in this question since one person will get \$2000, another will get \$1500, and the last one will get \$1000. So, for this question, use the equation for permutations.

$$ {}_nP_r = \frac{n!}{(n-r)!} $$

$$ {}_{20}P_3 = \frac{20!}{(20-3)!} $$

$$ {}_{20}P_3 = \frac{2.43 \times 10^{18}}{3.56 \times 10^{14}} = 6840 $$

Note: This is accomplished very easily on most scientific calculators that follow the standard notation. Enter *n* first, then keystroke nPr, enter *r*, then = (on the TI 30X-IIS, the nPr function is on the PRB 

key).

20. Answer: **A**. The latest information on actual skydiving fatalities from the USPA (US Parachute Association) shows in 2016 that there were 21 fatalities in 4 million jumps with the following breakouts:

Malfunctions	(8 in 21, or 38%) which is probability of failure of 9.5×10^{-8}
Landing Problems	(5 in 21, or 24%) which is probability of failure of 6.0×10^{-8}
Collisions	(3 in 21, or 14%) which is probability of failure of 3.5×10^{-8}
Reserve Problems	(2 in 21, or 10%) which is probability of failure of 2.5×10^{-8}
Other	(3 in 21, or 14%) which is probability of failure of 3.5×10^{-8}

Data pulled from http://www.uspa.org/facts-faqs/safety and http://parachutistonline.com

Therefore, malfunctions result in the most fatalities of the four options given.

Malfunctions	$0.95 \times 10^{-7} =$	0.000000095
Landing Problems	$60 \times 10^{-9} =$	0.000000060
Collisions	$0.035 \times 10^{-6} =$	0.000000035
Reserve Problems	$2.5 \times 10^{-8} =$	0.000000025

Data pulled from http://www.uspa.org/facts-faqs/safety and http://parachutistonline.com

21. Answer: **A**. Pure chance will occasionally give test results, which cause us to reject or accept a hypothesis when we should not have. This error factor is called a "confidence factor." It does not mean that we will be wrong or right 95% of the time, it simply means there is a 5% possibility of error due to pure chance. For example, if a hypothesis test rejected at the 5% significance level, we would be 95% confident in the results of the test. There would still remain, however, a 5% chance that we could be making a Type I error (rejecting a fair value). If answer D said, "It had a **chance** of being right 19 times out of 20," it would be a valid answer.

22. Answer: **A**. In statistical inference, one wishes to estimate population parameters using observed sample data. As we increase the confidence level of our estimates—from 90 to 95, for example—our confidence interval gets larger. In other words, in order to be more confident that our interval actually contains the population mean, we have to increase the size of the interval (i.e., we have to be less precise). How can we mitigate that tradeoff between level of confidence and the precision of our interval? We do this primarily by increasing our sample size. The methods used to influence the precision of confidence intervals include:

- Increasing the sample size. Often, the most practical way to decrease the margin of error is to increase the sample size.
- Reducing variability. The less that your data varies, the more precisely you can estimate a population parameter.
- Using a one-sided confidence interval.
- Lowering the confidence level.

In applied practice, confidence intervals are typically stated at the 95% confidence level. However, when presented graphically, confidence intervals can be shown at several confidence levels, for example 90%, 95%, and 99%. In statistics, a **confidence interval** (**CI**) is a type of interval estimate of a population parameter. How frequently the observed interval contains the true parameter if the experiment is repeated is called the **confidence level**. In other words, if confidence intervals are constructed in separate experiments on the same population following the same process, the proportion of such intervals that contain the true value of the parameter will match the given confidence level. Whereas two-sided confidence limits form a confidence interval, and one-sided limits are referred to as **lower/upper confidence bounds (or limits)**.

23. Answer: **A**. OSHA defines a competent person as "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees and who has authorization to take prompt corrective measures to eliminate them." Additionally, the competent person should be a person who has extensive knowledge/experience in a particular activity or job function.

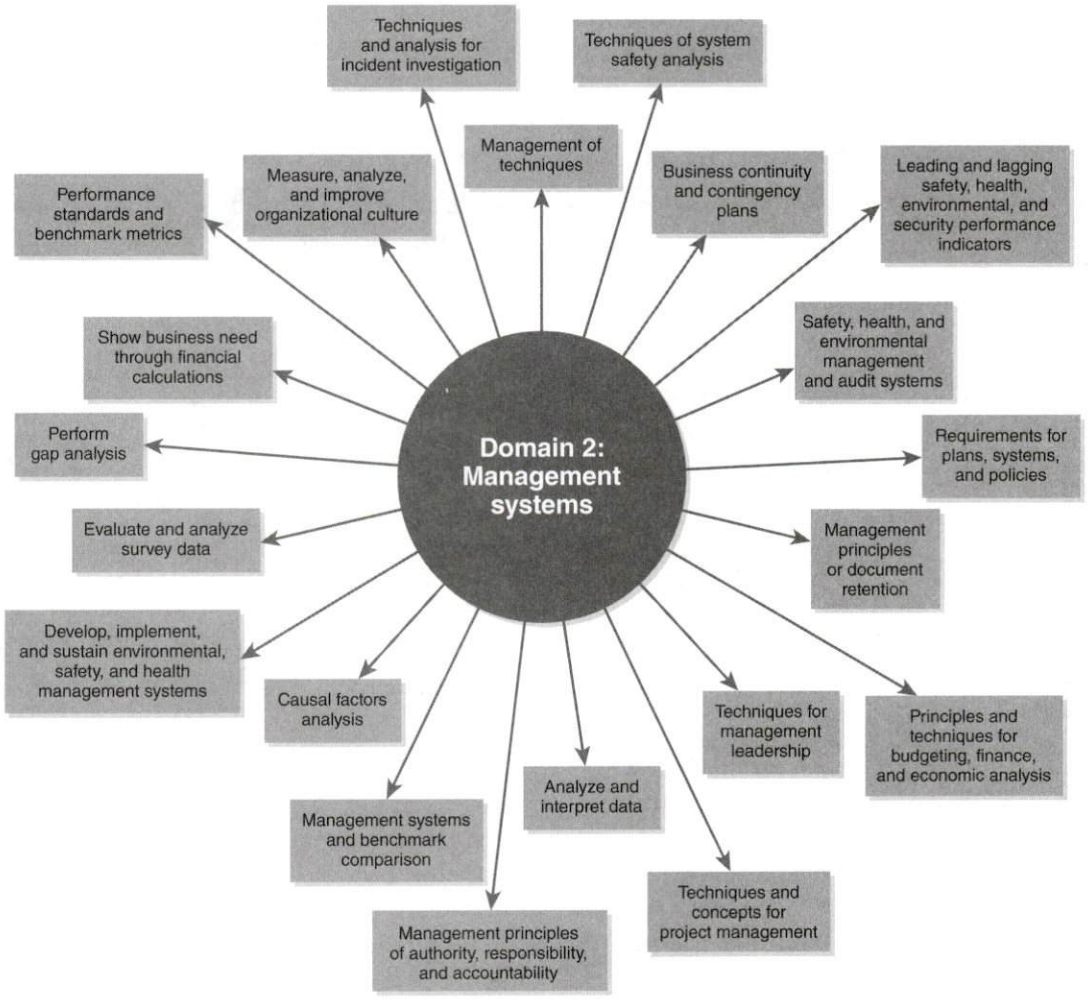
24. Answer: **D**. The definition of correlation is a statistical technique that measures the degree of relationship between two variables. It measures the tendency of one set of data to vary with another set of data. It does not imply a causal relationship between variables. Two sets of data that have no variation are said to have perfect correlation.

25. Answer: **C**. Perception surveys are most often used when one is trying to find out how people understand or feel about their situations or environments. They are used to assess needs, answer questions, solve problems, establish baselines, analyze trends, and select goals. Surveys reveal what exists, in what amount, and in what context. The two main reasons why companies conduct surveys are to get feedback on past/current performance and/or to obtain information for future direction. However, they can be used far beyond just a way to gather information. They can:

    - Identify gaps and provide recommendations to rectify between what is said and what is actually practiced.
    - Highlight differences between management and employees, realizing that the larger the gap, the greater the problem.
    - Provide an opportunity to connect and interact with employees.
    - Identify gaps between company's goals and its actual policies.
    - Serve as internal benchmarks, a measurable and quite useful means for companies to follow its own trends and progress.
    - Determine where current programs work and where they fall short.
    - Be an operational tool because responses from employees can really drive action.
    - Make employees feel that management does care what they have to say.
    - Encourage employees to provide feedback to management, thereby getting a sense of their role as part of the business aspects of organizations.
    - Encourage open communication among various organizational layers.

    Since almost all major companies and industries are conducting surveys, it is all the more important that companies be confident that the survey chosen will provide responses that will be useful to its operation. In other words, the survey must be reliable and validated. To influence everyone to think and talk about safety in the same way, it is necessary that perception surveys be conducted at all levels in a company. That is the only way true communication can begin. Administration and conduction of the survey is crucial. Confidentiality and anonymity must be absolutely guaranteed. Otherwise, respondents will not be honest, and the survey results will be essentially useless. It is only with the assurance of anonymity and confidentiality that employees will feel safe responding to questions truthfully. The perception survey results, with evidence-based recommendations, will give management a blueprint for action.

Domain 2: Management Systems



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Themes

Blueprint reference

Domain 2: Management Systems

- Demonstrated safety leadership
  - Effective communication
  - 3 E's of Safety: Engineering, Education, Enforcement (Empowerment)
  - Front line leadership (supervisor) accountability
  - Project management, scope of work, safety plans
  - Cost benefit analysis, business acumen
- Incident investigation
  - Fact finding
  - Root causes are management system errors
  - Prevention is primary purpose
- Continuous improvement
  - Auditing
  - Observation
  - Feedback
  - Gap analysis



Elements of an Effective Occupational Health & Safety Management System (OHSMS)

Increase knowledge

- Demonstrated Management leadership
- Employee involvement
- Occupational safety & Health programs
- Hazard identification and risk control
- Operational control
- Emergency preparedness and response
- Employee training
- Management review
- Continuous system evaluation and improvement

Relevant Consensus Standards

- ISO 9001 (INT)
- ISO14001(INT)
- ISO45001(INT)
- ISO19001(INT)
- OHSAS 18001(INT)
- ANSI Z10 (US)
- OSHA VPP (US)
- CSA Z1000 (CAN)
- ILO Guidelines for OH&S management systems (INT)
- Safety MAP (AUS)
- Home grown/in-house developed OHSMS

Key CSP Blueprints: Domain 2

Domain 2 Quiz 1 Questions

1. Given the five-year historical data for serious injury and illnesses illustrated in the chart, calculate the lost workday case incident rate for year 4.

Year	Total Serious Injury/ Illness Cases	Lost Workdays	Lost Workday Cases	Days Away from Work	Days of Restricted Work Activity	Hours Worked per Year
1	92	1932	67	1565	367	1,398,765
2	88	2002	81	1622	380	1,456,732
3	119	1821	98	1384	137	1,129,565
4	118	1754	90	1316	438	1,623,451
5	122	1234	98	740	494	1,834,225

A. 11.1
B. 21.8
C. 17.4
D. 9.01

2. Given the five-year historical data illustrated in the chart, calculate the combined serious injury and illnesses case incident rate for years 3, 4, and 5.

A. 15.7
B. 12.8
C. 21.8
D. 2.76

3. The time value of money is a financial concept that illustrates:

A. that the value of a safety investment is determined when costs are incurred and benefits accrue.
B. the need to involve financial professionals when planning capital budget safety projects.
C. that return on investment and cost–benefit analysis are equivalent metrics.
D. that a dollar today is equivalent to a dollar in the future.

4. Which types of questions are important for an interviewer to use during an incident investigation?

A. Reflective
B. Open ended
C. Guided
D. Close ended

5. Safety sampling is a management tool for making the workplace safer by studying how processes and people operate. These sampling statistics measure:

A. accidental injury/illness performance.
B. effectiveness of line manager's safety activities.
C. risk potential for accidental injury/illness.
D. job safety analysis.

6. The definition of benchmarking is stated as:

A. developing predictions based on past performance.
B. process of comparing business processes and performance metrics to industry best practices.
C. setting standards to predict profits.
D. setting standards for rest of industry so that operation can be considered superior.

7. Immediately following an incident investigation, the investigator prints the digital pictures taken at the scene and makes notes on the pictures describing the context, orientation of the photographer, lighting, date, time, and other information that may be helpful later in the investigation. What does this process describe?

A. Chain of custody procedures
B. Spoiled evidence protocols
C. Forensic quality procedures
D. Evidentiary preservation regulations

8. The following table provides an example of a _____ report.

Line Item #	Line Item Description	Actual YTD	Budget YTD	Difference YTD
1	External safety consultants-sampling & analysis	$112,250	$100,000	($12,250)
2	Monitoring hardware maintenance	$28,150	$25,000	($3150)
3	Fire Protection system maintenance	$15,000	$15,000	-0-
4	External safety consultants—other	$12,000	$25,000	$13,000

Line Item 1: Emergency required the use of external resources more than expected
Line Item 2: Required replacement of damaged portable gas detector
Line Item 4: Timing difference—expect to use external consultants more next quarter.

A. slack
B. budget exception
C. budget variance
D. resource timing delivery

9. All the following are valid reasons for an accident (mishap) investigation *except:*

A. prevent reoccurrence of similar events.
B. establish causal factors.
C. provide vehicle for discipline.
D. provide data for trend analysis.

10. In formulating realistic predictions of performance, examples of leading and lagging data indicators include:

A. trend analysis and operational history.
B. benchmarking and trend analysis.
C. historical trends and severity rates.
D. benchmarking and gap analysis.

11. A new operations safety manager has been asked to develop an incident data collection system. The *first* step in this process is to:

A. identify existing data sources and codify the data.
B. establish incident reporting procedures.
C. define the subsequent use of the data.
D. define investigation team parameters.

12. A manufacturing operation is experiencing above-average incident and accident occurrences at specific location. The *first* step for implementation of actions to reduce these occurrences is to:

A. survey the facility to determine the probable cause of the injuries.
B. bring a safety committee online to handle the problems.
C. train all line supervisors in accident/incident prevention.
D. schedule a meeting with upper management to discuss the situation.

13. The advantages of department level self-audits over corporate health and safety staff audits include:

A. department auditors being more objective.
B. department auditors being incentivized to reflect positively on their performance.
C. department auditors better assessing problems they are most familiar with and develop feasible solutions.
D. corporate staff deferring to department self-audits and recuse themselves minimizing corporate bias.

14. The *best* illustration of a safety performance benchmark is:

A. a thorough root cause analysis.
B. an incident rate below the industrial average.
C. an increased injury trends.
D. employee involvement.

15. The Critical Incident Technique method employed during an incident investigation is:

A. a technique to identify mechanical reliability issues in chemical process machinery.
B. an open-ended retrospective method of interviews that identify the critical aspects of an incident.
C. a prescribed dialogue as part of pre-emergency planning exercises.
D. a sampling of individual behaviors through observations.

16. A manufacturing business has purchased a machine that is belt driven. The machine presents a serious hazard if the belt is not guarded. There are four situations that could contribute to an accident or injury. Which Boolean expression could result in an injury to the machinist?

A. $B \bullet D + C \bullet D$
B. $A \bullet B + A \bullet C$
C. $C \bullet D + B \bullet D$
D. $(A + B) \bullet D \bullet (B + C)$

A = The belt guard is not in position.
B = The belt severs.
C = The belt is compromised by an external source.
D = The belt guard will protect the machinist.

17. In assessing a company's loss control performance, several key performance indicators (KPI) are collected and analyzed. One of these is "number of lost time cases experienced during the previous year." This dimension is an example of a/an:

A. leading indicator.
B. lagging indicator.
C. optional indicator.
D. occupational indicator.

18. How is a supervisor's safety performance activity measure *best* described?

A. Reporting incidents to management
B. Classifying the financial impacts of losses associated with incidents
C. Initiating accident investigation on reported incidents
D. Performing safe work observations of employees and discussing observations with them

19. If an organization's occupational health and safety management system is to succeed, as described in *ANSI/ASSE* Z10, there are two critical components—top management leadership and:

A. supervisor accountability.
B. employee participation.
C. OHS written policy.
D. sustainable safety observation program.

20. Auditing conformance with ISO 14001 and OHSAS 18001 management systems is important for companies. Which of the following best provides minimally suitable verification that the company is reviewing proposed or new legal requirements as they apply to the organization?

A. A document identifying the date of any review of new or proposed legal requirements and a statement determining applicability
B. A certified letter from the legal department stating that the company complies with all legal requirements
C. An electronic message from a legal update review service, signifying that new legal requirements are routinely conveyed to the company
D. A signed CSPs report outlining legal requirements applicable to the organization

Domain 2 Quiz 1 Answers

1. Answer: **A**.

$$\text{Rate} = \frac{\text{LWD cases} \times 200{,}000}{\text{Total hours worked}}$$

$$\text{Rate} = \frac{90 \times 200{,}000}{1{,}623{,}451} = 11.1$$

The incidence rate for lost workday cases is the most meaningful performance indicator for a safety program.

2. Answer: **A**.

Step 1: Total the number of accidents for period in question.

$$\begin{array}{r} 119 \\ 118 \\ \underline{122} \\ 359 \end{array}$$

Step 2: Total man-hours for same period.

$$\begin{array}{r} 1{,}129{,}565 \\ 1{,}623{,}451 \\ 1{,}834{,}225 \\ \hline 4{,}587{,}241 \end{array}$$

Step 3: Apply formula and compute cumulative accident rate.

$$\text{Rate} = \frac{\text{Serious Cases} \times 200{,}000}{\text{Total hours worked}}$$

$$\begin{array}{ll} 119 & 1{,}129{,}565 \\ 118 & 1{,}623{,}451 \\ 122 & 1{,}834{,}225 \\ \hline 359 & 4{,}587{,}241 \end{array}$$

$$\text{Rate} = \frac{359 \times 200{,}000}{4{,}587{,}241} = 15.7$$

3. Answer: **A**. Calculating the present value of future benefits is useful when considering alternative projects on a limited budget. Present-value calculations compare the cost of implementation against the dollar value of the benefit. For example, a safety manager is considering committing $10,000 to a project that will save approximately $17,000. However, the savings will not be realized for five years. Should the company commit? Can the safety manager convince management that this is a worthwhile investment? If financial considerations are a primary concern, it must be determined whether the benefit the company will receive later will be greater than the investment.

4. Answer: **B**. According to the *Root Cause Analysis Handbook*, 2005 Edition, to gather data from people, the analyst must be a skilled interviewer. During the interview the interviewer must ask open-ended questions that require the interviewee to respond with a long, descriptive answer.

5. Answer: **B**. Safety sampling measures the effectiveness of the line manager's safety activities, but not in terms of accidents. It measures effectiveness by conducting periodic samplings of how safely the employees are working. Safety sampling is based on the quality control principle of random sampling inspection. The degree of accuracy is dictated by the number of samples taken.

6. Answer: **B**. Benchmarking (also "best practice benchmarking" or "process benchmarking") is a process used in management and particularly strategic management, in which companies evaluate various aspects of their business processes in relation to best practice, usually within their own industry. Benchmarking is researching other organizations methods, selecting the best techniques and applying them to your organization. This then allows companies to develop plans on how to adopt such best practice.

   Benchmarking may be a one-off event but is often treated as a continuous process in which companies continually seek to challenge their practices. A safety performance benchmark is similar to a goal. An example would be one year with no lost time injuries or illnesses at a particular work site. A benchmark is based on research conducted on other similar organizations and applied to your organization. Incident rates are lagging indicators (sometimes referred to as business metrics) of safety performance. Overall safety performance cannot be evaluated by historical data such as these rates and are typically poor performance indicators.

7. Answer: **A**. In the book *Root Cause Analysis Handbook, An Effective Guide to Incident Investigation* chain of custody procedures for photographs start with the photographer fully documenting the context, source, and relevant information related to the photograph.

8. Answer: **C**. This table is a type of budget variance report.

9. Answer: **C**. Accident investigation has as its primary purpose the prevention of similar occurrences and the discovery of hazards. The intent is not to place blame or administer discipline but rather to determine how responsibilities may be defined or clarified and to reduce error producing situations. Accident investigation should improve the safety of operations, if accident investigation is used for punitive measures, the tool has the reverse effect.

   Management system problems are unifying characteristics of root causes of incidents or accidents. Human errors and equipment malfunctions are the causal factors from which the root causes are derived.

10. Answer: **B**. A **benchmark** is defined as a standard or point of reference used for measuring or judging quality, value, efficiency, etc. Benchmarking takes into consideration what is the standard for the industry and compares the current status of your company in relation to reference point or data.

    Trend analysis is the process of examining past performance for trends and then using these trends, or tendencies, to make a prediction of what will take place under certain circumstances (e.g., changes, modifications, presumed improvements).

11. Answer: **C**. In the book *Safety Culture and Effective Safety Management,* author Swartz (2000) explains that before collecting data and developing a system to collect and manipulate the data, it is essential to define how the data will be used.

12. Answer: **A**. You must always base your findings and recommendations on facts, which means that your first action should always be to survey the situation and collect the facts that may impact the situation.

13. Answer: **C**. The advantages of departmental auditing are involvement in the process and ownership of the solutions. Motivations for developing a management system audit program range from the desire to measure compliance with specific regulations, standards, or conformance with internal policies to the goal of risk management. In practice auditing programs are designed to meet a broad range of objectives, depending on the needs of their various stakeholders. Companies have established auditing programs to:

    - determine and document compliance status.
    - improve overall safety, health, and environmental performance at operating facilities assist facility management.
    - increase the overall level of safety, health, and environmental awareness.
    - accelerate the overall development of S/H/E management control systems.
    - improve the safety, health, and environmental risk management system.
    - protect the company from potential liabilities.
    - develop a basis for optimizing safety, health, and environmental resources.
    - assess facility management's ability to achieve OHS goals.

14. Answer: **B**. According to author Dan Peterson in *Safety by Objectives*, a safety performance benchmark is similar to a goal. A benchmark is based on research conducted on other similar organizations and applied to one's own organization.

15. Answer: **B**. The **Critical Incident Technique** (or **CIT**) is a set of procedures used for collecting firsthand observations of human behavior that have critical significance and meet methodically defined criteria. A critical incident can be described as one that makes a significant contribution—either positively or negatively—to an activity or phenomenon and to understand the relationship between competencies and reasons for accidents. Critical incidents can be gathered in various ways, but typically respondents are asked to tell a story about an experience they have had.

    Through the use of the critical incident technique, one may collect specific and significant behavioral facts, providing a sound basis for making inferences as to requirements for measures of typical performance (criteria), measures of proficiency (standard samples), training, selection and classification, job design, operating procedures, equipment design, motivation and leadership (attitudes), and individual behavior.

    Critical incidents can be gathered in various ways, but typically respondents are asked to tell a story about an experience they have had. CIT is a flexible method that usually relies on five major areas. The first is

determining and reviewing the incident, then fact-finding, which involves collecting the details of the incident from the participants.

When all facts are collected, the next step is to identify the issues. Afterwards a decision can be made on how to resolve the issues based on various possible solutions. The final and most important aspect is the evaluation, which will determine if the solution that was selected will solve the situation's root cause and will cause no further problems.

16. Answer: **B**. This may be easier to see in a small fault tree. Determine the condition that could result in an injury; in this case, A and B or A and C have to exist, and either situation will produce an injury—therefore an OR gate (**Figure 13**).

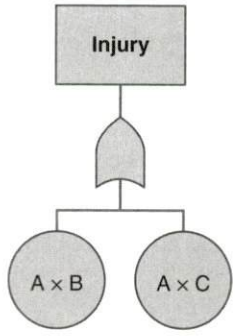


Figure 13 Fault Tree Analysis, Question 16

17. Answer: **B**. Lagging indicators (such as historical statistics) provide data on how well the loss control system has performed and is useful for understanding how well a management system change affected loss control performance. However, lagging indicators are not as useful for predicting future loss control performance.
18. Answer: **D**. Author Dan Petersen (2003) explains that activity measures are leading (proactive) measures a line supervisor should do as part of his or her normal responsibilities as being accountable for the safety of employees.
19. Answer: **B**. According to *ANSI/ASSE Z10*, top management leadership and employee participation are the main divisions in the scope of this standard.
20. Answer: **A**. A member of the management team must certify that such reviews were conducted and must include date of review and findings of applicability. This type of written certification is common practice in auditing methods because it is not practical for auditors to observe and verify that **all** management processes were conducted.

Domain 2 Quiz 2 Questions

1. **British Standard OHSAS 18001 states that a successful management system should be based on all the following *except:***

   A. a generic occupational health and safety policy.
   B. identification of occupational health and safety risks and legal requirements.
   C. objectives, targets, and programs that guarantee continuing improvement.
   D. management activities that manage occupational health and safety risks.

2. **In 3 years, $400,000 will be required for EPA modifications to your plant. How much money should you invest at 10% to have the required amount when needed?**

   A. $310,789
   B. $300,526
   C. $287,565
   D. $293,824

$$F = P(1 + i)^n \qquad P = F(1 + i)^{-n}$$

3. **It is anticipated that in 5 years from now a new piece of instrumentation will be needed. Assuming that the device can be purchased for $30,000 and that money is worth 15%, how much must be deposited yearly in an investment account to have the required amount?**

   A. $5449
   B. $4549
   C. $3957
   D. $4449

$$F = A\left(\frac{(1 + i)^n - 1}{i}\right) \qquad A = F\left(\frac{i}{(1 + i)^n - 1}\right)$$

4. What is the uniform annual payment that will amortize a loan of $400,000 in 8 years with a 14% interest rate?

A. $84,356
B. $86,228
C. $87,459
D. $85,765

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right) \qquad P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

5. Professionals dedicated to the science that studies harmful, or toxic, properties of substances are:

A. industrial hygienists.
B. industrial toxicologists.
C. health physicists.
D. medical pathologists.

6. To ensure the safety and health of employees, an employer must:

A. maintain the workplace in a cost-effective way.
B. ensure that external fire doors are held open always.
C. maintain the workplace in a safe condition.
D. ensure that fire doors are kept locked.

7. The primary purpose of ISO 19011 is to provide guidance on:

A. designing and developing S&H systems.
B. improving environmental control systems.
C. implementation of an SH&E management system.
D. managing and conducting quality and environmental management system audits.

8. Which of the following is the *least important* purpose of a Safety, Health, and Environmental audit?

A. Gathering data for manager's performance reports
B. Determining and document compliance status
C. Developing a basis for optimizing SH&E resources
D. Improving overall SH&E performance

9. In the history of chemical and petroleum industries, causal factors for major events have often related to inadequacies in these four management processes:

A. maintenance of mechanical integrity, action items follow-up, management of change, process safety training and competency.
B. near-miss reports, accident trends analysis, incident investigation reports, management of change.
C. training assessment, near miss reports, leading indicators, lagging indicators.
D. leading indicators, accident reports, balanced score cards, behavior-based observations.

10. The OHSAS 18001 specification requires only minimal documentation. It is important that documented OH&S procedures are developed and adequately controlled. A compilation of documents that form the basis for the management system is normally called a:

A. list of documents.
B. safety policy manual.
C. master list.
D. document inventory index.

11. A determination of the extent to which program operations have contributed to achieving an objective related to accident or injury reduction is called a(n):

A. effectiveness evaluation.
B. general evaluation.
C. procedural evaluation.
D. administrative evaluation.

12. When implementing a JSA program, which of the following is the first item to be analyzed?

A. Order of jobs according to product flow moving through each department
B. Jobs generating most complaints from supervisors
C. Jobs contributing to highest incident rates
D. Jobs exposing most workers

13. A characteristic of a root cause for an event or incident is:

A. human error.
B. a management system problem.
C. an error made by a manager or supervisor.
D. intentional unsafe act performed by an employee or work team.

14. Which of the following would be *most unsuitable* for a supervisor when evaluating a subordinate during an annual employee performance report cycle?

A. Offering advice about safety performance
B. Counseling about personal hygiene habits that affect job performance
C. Rating performance based on measurable objective criteria
D. Providing definitive comments about the worker's potential to fail in industry or business

15. One key to success when implementing a safety change initiative in a global organization is:

A. frequent audits to ensure conformance with corporate policies and procedures.
B. document all conversations in case of disputes during the implementation.
C. focus more on outcomes and less on processes used to achieve them.
D. embed senior corporate managers in all foreign facilities.

16. A company operating as a machine shop performs contract jobs for their customers. The company has 67 employees with an average salary of $41,500. These data place the company in worker's compensation Class 3650 with a manual rate of $12.50. The company has a current experience modification factor on workers' compensation insurance of 1.2. Next year it will drop to 0.80. What is the company's estimated worker's compensation premium for next year?

A. $195,643
B. $278,100
C. $103,700
D. $118,678

17. To effectively oversee a safety & health management system, safety directors should _____ as many levels of management as possible.

A. report to
B. acquire access to
C. cite violations of standards to
D. have budgets approved by

18. All the following are included in ANSI/ASSE Z10 *except:*

A. S&H policy development.
B. employee participation.
C. management review.
D. evaluation and corrective action.

19. Which of the following is the *least* accurate description of change analysis?

A. Change analysis in safety should reflect the multiple succession realities rather than rely on possibly one-dimensional detection–correction of a single contributory change.
B. If a system has been operating in a stable manner but is now experiencing difficulties, change is probably not the basis of the problem.
C. Sensitivity to approaching or plausible change is a key component in the work of a good, experienced manager or safety professional.
D. In multifaceted systems, consideration must be given to accumulation of change, for example adjustments made two years ago combined with a modification made a month ago may produce the undesired event.

20. When ANSI standards are developed or revised, what must be identified?

A. The stakeholders that are impacted by the standard
B. The cost of implementation on the stakeholders
C. The impact of the environmental life cycle
D. The regulatory requirements for compliance with the standard

Domain 2 Quiz 2 Answers

1. Answer: **A**. OHSAS 18001 is an *Occupation Health and Safety Assessment Series* for health and safety management systems. It is intended to help an organization to control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which to be certified and assessed. OHSAS 18001 will measure a company's managements system regarding several dimensions. The extent of application will depend on such factors as the occupational health and safety policy of the organization, the nature of its activities, and conditions under which it operates. A successful management system should be based on the following:

- An occupational health and safety policy appropriate for the company.
- Identification of occupational health and safety risks and legal requirements.
- Objectives, targets, and programs that ensure continual improvements.
- Management activities that control the occupational health and safety risks.
- Monitoring of the occupational health and safety system performance.
- Continual reviews, evaluation, and system improvement.

Ten OHSMS Strategies

1. Define safety responsibilities for all levels of the organization (e.g., safety is a line management function).
2. Develop upstream measures (e.g., number of reports of hazards/suggestions, number of committee projects/successes, etc.).
3. Align management and supervisors by establishing a shared vision of safety and health goals and objectives vs. production.
4. Implement a process that holds managers and supervisors accountable for visibly being involved, setting the proper example, and leading a positive safety and health culture.
5. Evaluate effectiveness of recognition and disciplinary systems for safety and health.
6. Ensure the safety committee is functioning appropriately (e.g., membership, responsibilities/functions, authority, meeting management skills).
7. Provide multiple paths for employees to bring forward suggestions, concerns, or problems. One mechanism should use the chain of command and ensure no repercussions. Hold supervisors and middle managers accountable for being responsive.
8. Develop a system that tracks and ensures timeliness in hazard correction. Many sites have been successful in building this in with an already existing work order system.

9. Ensure reporting of injuries, first aid cases, and the near misses. Educate employees about the accident pyramid and importance of reporting minor incidents. Prepare management for an initial increase in incidents and a rise in rates. This will occur if underreporting exists in the organization. It will level off, then decline as the system changes take hold.
10. Evaluate and rebuild the incident investigation system as necessary to ensure that investigations are timely, complete, and effective. They should get to the root causes and avoid blaming workers.

2. Answer: **B**.

$$i = 0.10 \quad n = 3 \quad F = \$400{,}000 \quad P = ?$$

$$P = F(1+i)^{-n}$$

$$P = 400{,}000 \times (1.1)^{-3}$$

$$P = \$300{,}526$$

Keystrokes for the TI-30X IIS calculator: 400 000 × 1/1.10^3 = 300,526

Keystrokes for the HP10BII

1. 400000 (FV KEY)
2. 10 (I/YR KEY)
3. 3 (N KEY)
4. (PV KEY) for the answer

$$i = .15 \quad n = 5 \quad F = \$30{,}000 \quad A = ?$$

$$A = F\left(\frac{i}{(1+i)^n - 1}\right)$$

$$A = 30{,}000 \times \left(\frac{.15}{(1+.15)^5 - 1}\right) = \$4449$$

3. Answer: **D**.

Keystrokes for the TI-30X IIS: 30 000 ×.15/(1.15^5-1) = 4449

Keystrokes for the HP10BII

1. 30 000 (FV KEY)
2. 15 (I/YR KEY)
3. 5 (N KEY)
4. (PMT KEY) for the answer

4. Answer: **B**.

$$i = .14 \quad n = 8 \quad P = \$400{,}000 \quad A = ?$$

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right)$$

$$A = 400{,}000 \times \left(\frac{.14 \times 1.14^8}{(1.14)^8 - 1}\right) = \$86{,}228$$

Keystrokes for the TI-30X IIS calculator: 400 000 × (.14 × 1.14^8)/(1.14^8 –1) = 86 228
Keystrokes for the HP10BII

1. 400000 (PV KEY)
2. 14 (I/YR KEY)
3. 8 (N KEY)
4. (PMT KEY) for the answer

5. Answer: **B**. According to the Fundamental of Industrial Hygiene, an **industrial toxicologist** is one who studies the harmful, or toxic, properties of substances and determines dose thresholds. An **industrial hygienist** is one devoted to the art and science of anticipation, recognition, evaluation, and control of those environmental factors in the workplace that may cause sickness, impaired health, and well-being. A **health physicist** studies the field of science concerned with radiation physics and radiation biology with the goal of providing technical information and proper techniques regarding safe use of ionizing radiation. **Pathologists** are physicians who diagnose and characterize disease in living patients by examining biopsies or bodily fluid. Pathologists may also conduct autopsies to investigate causes of death.

6. Answer: **C**. According to ANSI/ASSE/IEC/ISO 31010 (Z690.3-2011) Risk Assessment Techniques National Adoption of: IEC/ISO 31010:2009, the purpose of risk assessment is to provide evidence-based information and analysis to make informed decisions on how to treat particular risks and how to select between options.

   Some of the principal benefits of performing risk assessment include:

   - understanding the risk and its potential impact upon objectives;
   - providing information for decision-makers; contributing to the understanding of risks, in order to assist in selection of treatment options;
   - identifying the important contributors to risks and weak links in systems and organizations;
   - comparing of risks in alternative systems, technologies, or approaches;
   - communicating risks and uncertainties;
   - assisting with establishing priorities;
   - contributing towards incident prevention based upon postincident investigation;
   - selecting different forms of risk treatment;
   - meeting regulatory requirements;
   - providing information that will help evaluate whether the risk should be accepted when compared with predefined criteria; and
   - assessing risks for end-of-life disposal.

   These processes are what keep the employees and workplace safe.

7. Answer: **D**.

   ISO 19011 is an international standard that sets forth guidelines for:

   - quality management systems auditing.
   - environmental management systems auditing.

8. Answer: **A**. According to the National Safety Council, SH&E audits are performed for the following reasons (listed in order of importance):

   - determine and document compliance status;
   - improve overall SH&E performance;
   - assist facility management;
   - increase the overall level of SH&E awareness;
   - accelerate overall development of SH&E management control systems;
   - improve SH&E risk management system;
   - protect company from potential liabilities;
   - develop a basis for optimizing SH&E resources; and
   - assess facility management's ability to achieve SH&E goals

9. Answer: **A**. The publication *Process Safety Leading and Lagging Metrics,* published by the Center for Chemical Process Safety (2007) gives specifically related guidance on determining and applying leading and lagging indicators in the practice of safety. Three types of process safety performance metrics are described and the text on their selection and application is extensive. The metrics are lagging metrics, leading metrics, and near miss and other internal lagging metrics. The metrics pertain only to chemical process incidents and near misses to the exclusion of types of incidents that are not process related. The leading process safety metrics given particular attention are maintenance of mechanical integrity; action items follow-up; management of

change; process safety training and competency (and training competency assessment). Companies should identify which of these components are most important for ensuring the safety of their facilities and should select the most meaningful leading metrics from the examples [above], and where significant performance improvement potentially exists. Other leading metrics may be defined as well if applicable.

10. Answer: **C**. According to author Joe Kausek of OHSAS 18001 *Designing and Implementing an Effective Health and Safety Management System*, clause 4.4.4 requires electronic or hard copy of the information that provides an overall description of the main elements of the HSMS, how these elements interact, and reference to any documents that describe these activities in more detail. Normally, the first step in establishing control is to develop a master listing of the procedures, instructions, forms, and other documents that form the basis for the management system. This is normally called the Master List. A Safety Policy Manual may serve as the master list but is not specifically mentioned nor therefore required.

11. Answer: **A**. An effectiveness evaluation is defined as "a determination of the extent to which program operations have contributed to achieving an objective related to accident or injury reduction. It involves (a) determining the change achieved in accident or injury involvement, (b) relating program operations to the achieved change, and (c) relating the program cost to the benefit derived from what the program accomplished.

12. Answer: **C**. In the NSC *Accident Prevention Manual for Business and Industry: Administration and Programs,* 12th Edition, the jobs selected for job safety analyses should not be selected at random. The order of analysis should be guided by the following factors:

    - frequency of incidents;
    - rate of disabling injuries;
    - severity potential; and
    - new jobs

13. Answer: **B**. As described in *Root Cause Analysis Handbook, An Effective Guide to Incident Investigation. 2005* Edition, management system problems are unifying characteristics of root causes of incidents. Human errors and equipment malfunction are example of causal factors driving the root causes.

14. Answer: **D**. The annual performance evaluation provides an excellent opportunity to train, counsel, and encourage employees. However, correcting employee shortcomings or encouraging superior performance should occur during normal daily supervision. The employee annual performance evaluations should always be based on sound, measurable objective criteria that is fully understood by both the supervisor and employee.

    The meeting should **never** be used as a way for the supervisor to express his or her personal feelings about the lack of potential of a worker. Providing negative comments about the potential for success or failure is an extremely poor practice and is, in the authors' opinion, the most inappropriate.

15. Answer: **C**. Implementing a safety change initiative in a global organization can be difficult because of how different cultures view safety and risk management. It is important to incorporate cultural elements into the management system (Global Solutions, Inc. 2011).

    A successful strategy for assessing the management of risk at local in-country facilities is to:

    - focus on outcomes: What is the risk? How is it managed? Is the risk adequately controlled?
    - allow for cultural, technological, legal, regulatory, health care, social system, and other differences in developing solutions to risk control challenges, findings, and other implementation strategies.
    - ask a lot of questions before mandating risk-control solutions for your global facilities, which is the best advice.

16. Answer: **B**. Estimated premium is calculated in this case by determining the estimated payroll, dividing it by $100 (since rates are based on $100 of payroll), multiplying that number by the rate for machine shops and the experience modifier for the new year.

    $$\text{Estimated Premium} = [(\#\ \text{Employees} \times \text{Average Salary})/\$100] \times \text{Manual Rate} \times \text{Experience Modifier}$$

    $$\text{EP} = [(67 \times \$41{,}500)/\$100] \times \$12.50 \times 0.80$$

    $$\text{EP} = \$278{,}050$$

17. Answer: **B**. Access to managers throughout an organization will assist the safety director in developing an accepted, consistent, effective safety management system. It is critical that top management understand and support the safety & health management system. If the safety function reports at a high level in a company that does not value safety, the level of reporting is irrelevant.

18. Answer: **A**. ANSI/ASSE Z10 provides the blueprint for widespread benefits in health and safety, as well as in productivity, financial, performance, quality, and other organizational and business objectives. The seven sections include Management Leadership, Employee Participation, Planning, Implementation and Operation, Evaluation, Corrective Action, and Management Review (American Industrial Hygiene Association ANSI/AIHA Z10-2005. Fairfax, VA: American Industrial Hygiene Association, 2005 Aug:1-66).

19. Answer: **B**. In William G. Johnson's book *MORT Safety Assurance Systems*, he states that "change is the mother of trouble," referencing the following areas of concern:
    - Change analysis in safety should reflect the multiple sequence realities rather than rely on possibly simplistic detection-correction of a single causative change.
    - If a system has been operating in a stable manner but now experiencing difficulties, change is probably the cause of the problem.
    - Sensitivity to impending or probable change is a key component in the work of a good, experienced manage or safety professional.
    - In complex systems, attention must be given to the compounding of change. For example, a change made two years ago combined with a change made a month ago may produce the undesired event.

20. Answer: **A**. According to ANSI Essential Requirements: Due process requirements for American National Standards (2019) protocols section 2.5.1 Project Initiation Notification (PINS), at the initiation of a project to develop or revise an American National Standard, notification shall be transmitted to ANSI using the Project Initiation Notification System (PINS) form, or its equivalent, for announcement in *Standards Action*. A statement shall be submitted and published as part of the PINS announcement that shall include:
    a. an explanation of the need for the project, including, if it is the case, a statement of intent to submit the standard for consideration as an ISO, IEC, or ISO/IEC JTC-1 standard; and
    b. identification of the stakeholders (e.g., telecom, consumer, medical, environmental, etc.) likely to be directly impacted by the standard.

Domain 2 Quiz 3 Questions

1. A company has adopted OHSAS 18001 to maintain continuous improvement in their safety and health management system. Based on the OHSAS 18001 guidelines that the management system should be suitable, adequate, and effective, which of the following should indicate that a management appraisal should be performed?

A. Earnings are down from the preceding year.
B. SH&S Director position has been held by three different individuals during the past 18 months.
C. A company's environmental performance has been questioned by the local "green" group.
D. The safety performance of a company is 43% lower than the previous year.

2. Which of the following is *not* integral to the development of an effective safety culture?

A. Safety managers must directly control worker behavior.
B. Front-line supervisors initiate corrective measures for unsafe behaviors.
C. Employees' desire to be safe and work as a team
D. Unions take responsibility for ensuring safety as part of their role in protecting members.

3. In project management, work that must be performed to deliver a product, service, or result with the specified features and functions is called the:

A. project schedule.
B. project scope.
C. project scope statement.
D. project scope management plan.

4. The Management Grid® by Robert Blake and Jane Mouton, illustrates management styles by drawing a grid that has on the "Y" axis Concern for People and the "X" axis Concern for Production. Thus a 9,1 supervisor could be called a:

A. country club manager.
B. dictator.
C. workaholic.
D. company man.

5. According to current safety philosophy, which would have the *most impact* on modifying safety performance?

A. A sign stating, "Wear Your Eye Protection."
B. Turning off all machines when finished.
C. Complimenting an employee for wearing eye protection.
D. A free meal for a safe month on the plant floor.

6. Which of the following factors is a hygiene factor as opposed to a motivation factor, according to the work of Frederick Herzberg?

A. Money
B. Recognition
C. Responsibility
D. Achievement

7. A new safety director was hired by a company that traditionally has had a "paper safety program." The director has a staff of three and reports to one of three vice presidents. The rates for the company are much higher than the industrial average. The initial assessment is that there is very little interest in safety at any level. The safety director has been given authority to increase the safety staff and a sizable increase in department budget. After having hired new staff and reorganizing the department, the next step should be to:

A. increase the safety training effort for all employees.
B. organize a safety committee and get management to appoint members.
C. start an inspection program to identify areas that need attention.
D. integrate safety accountability into job descriptions, appraisals, and objectives.

8. When applying TQM techniques, the concept of empowering the worker frequently surfaces as a foundational issue. Which of the following is *not* considered to be a strategy of empowerment?

A. Allow employees ownership of a tasking.
B. Demand teams own the problem.
C. Delegate authority to the lowest possible level.
D. Develop rigorous procedure for multilevel review of team recommendations.

9. The behavioral management safety concept is often criticized as dealing exclusively with behavioral modification. The major flaw in this view of behavioral based safety management is that it overlooks the fact that behavioral safety also plays a key role in:

A. securing management involvement.
B. establishing employee participation in the planning process.
C. identifying behavioral aspects of design and engineering for facilities, tools, and equipment.
D. establishing a response loop for observers to report the status of safe and unsafe actions.

10. Recently, numerous tools have been left behind after maintenance has been completed. What is the *best* way to increase tool accountability and improve or eliminate the problem?

A. Associate employee number to tool usage.
B. Develop a remotely monitored system.
C. Implement an automated bar-coding system.
D. Install a computerized system.

11. A "standard bureaucratic model" has all the following attributes *except:*

A. specialized jobs.
B. homogenous departments.
C. decentralized authority.
D. narrow span of control.

12. Which ISO standard series covers environmental management?

A. 45001
B. 19011
C. 31001
D. 14001

13. The steps for the continuous improvement safety process are the same as in the continuous quality improvement process. These include all the following *except:*

A. specify standards.
B. measure compliance.
C. track procedures.
D. provide feedback on improvement.

14. In project management, a deliverable-oriented hierarchical decomposition of work to be executed by the project team to accomplish project objectives and create the required deliverables is called the:

A. work authorization scheme.
B. work package.
C. WBS dictionary.
D. work breakdown structure.

15. A staff safety engineer is given authority by the general manager to stop operations on a construction site whenever an imminent danger situation becomes evident. Which of the following correctly identifies the authority granted by the general manager?

A. Staff authority
B. Staff to line authority
C. Authority of delegation
D. Functional authority

16. Which of the following needs are at the *lowest* level in Maslow's hierarchy of human needs?

A. Esteem
B. Social
C. Physiological
D. Safety

17. When calculating the total case incident rate, the numerator of the formula is:

A. the number of lost workdays multiplied by 100 employees working 200 hours per year.
B. the number of cases involving days away from work, transfer, and work restriction multiplied by 200,000.
C. the actual hours worked multiplied by the total number of cases.
D. the number of cases multiplied by 100 employees working 2000 hours per year.

18. Organizations with effective safety management systems firmly assign accountability for safety to:

A. hourly worker level.
B. line managers at every level.
C. the senior executive level.
D. the company owner level.

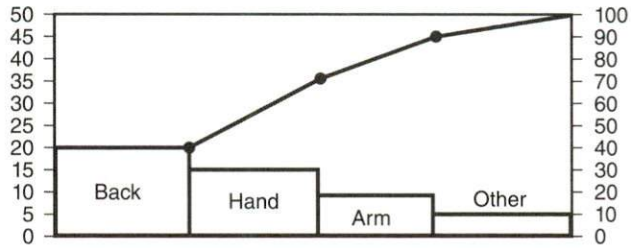
19. Leadership styles can be dependent on the situation or team being led. In a situation where the leader is highly accountable for a task but has a distant relationship with the team performing the task, the BEST situational leadership style is:

A. selling.
B. participating.
C. telling.
D. delegating.

20. A safety culture is:

A. the common and generally accepted way people behave in the workplace as it relates to safe practices.
B. defined by printed safety rules and posted signs.
C. described in negotiated agreements between unionized workers and management.
D. determined by the attitude that workers display each day.

21. Which of the following is the correct interpretation of this Pareto diagram?



A. Backs represent 20% of injuries.
B. The combined number of hand and arm injuries equals 30.
C. Knee injuries account for 10% of injuries.
D. Back and hand injuries account for 70% of all injuries.

22. During an incident investigation, chain-of-custody evidence collection protocols is *least likely* to include:

A. procedures for restocking medical supplies.
B. evidence tracking procedures.
C. documentation of evidence possession.
D. methods for collecting and preserving evidence.

Domain 2 Quiz 3 Answers

1. Answer: **D**. The purpose of adopting OHSAS 18001 health and safety management system is to maintain continuous improvement. If the management system finds a significant reduction in the company's safety performance, it should indicate a comprehensive management review of specified items causing the reduction.
2. Answer: **A**. According to the National Safety Council, some of the elements of an effective safety culture are:
   - The CEO has to express support for safety and show it by their actions and decisions.
   - The management team has to consistently support safe work conditions and obtain safer materials/machines.
   - The front-line supervisors need to correct behaviors as well as obtain the right equipment.
   - The workers must want to be safe and work as a team.
   - The union must make safety part of its role in protecting the members.

   A total safety culture requires continual attention in the domains of environment, person factors, and behavior. In an effective organization, line management is responsible and accountable for enforcing SH&E policies.
3. Answer: **B**. This is the definition of a **project scope**.
   Specific Scope of Work Objectives
   - Objectives should meet targets, ANSI Z-10 using the example of "SMART" criteria:
     - Specific—Clearly defined desired outcome
     - Measurable—Concrete metric for success
     - Actionable—Written as a concrete action plan
     - Realistic—Practical in its scope
     - Time-bounded—A specific timeframe is set
   - Plan through the project life cycle
4. Answer: **B**. The 9, 1 supervisor would be one who is interested more in production than in the interests of their employees and thus would be labeled a dictator or organizational manager. Conversely, a 1, 9 manager might be referred to as a country club manager (**Figure 14**).
5. Answer: **C**. Most experts agree that there are two primary actions that influence behavior change the most: positive reinforcement and reinforcing the behavior as close to time of action as possible. The first step in improving behavior in an organization is to establish an ethics program to address the organization's culture issues.
6. Answer: **A**. Frederick Herzberg in his book *Work and the Nature of Man* develops a motivation–hygiene theory. The theory attempts to explain how persons are satisfied by certain job factors while being motivated by other factors that are quite peripheral to the job being performed. Two-factor theory distinguishes between:

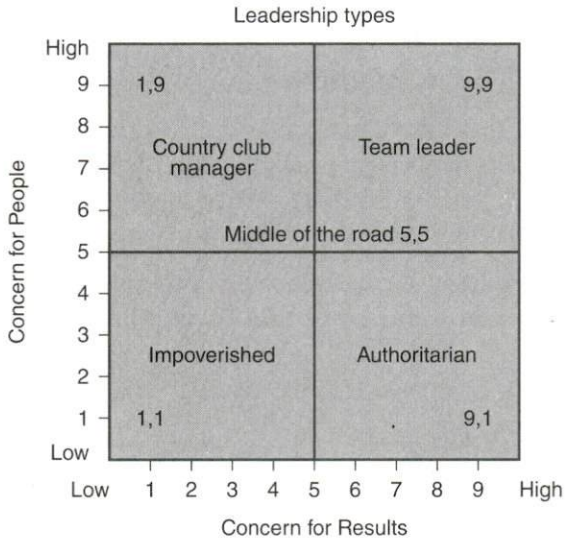


Figure 14 The Management Grid® by Robert Blake and Jane Mouton

Satisfaction is influenced by:	Motivation is influenced by:
Money	Achievement
Status	Recognition
Relationships with boss	Enjoyment of work
Company policies	Possibility of promotion
Work rules	Responsibility
Working conditions	Chance for growth

Modified from Herzberg, F. *Work and the Nature of Man*, World Pub. Co., 1966.

Motivators (e.g., challenging work, recognition, responsibility) that give positive satisfaction, arising from intrinsic conditions of the job itself, such as recognition, achievement, or personal growth.

Hygiene factors (e.g., status, job security, salary, fringe benefits, work conditions) that do not give positive satisfaction, though dissatisfaction results from their absence. These are extrinsic to the work itself and include aspects such as company policies, supervisory practices, or wages/salary.

7. Answer: **D**. According to Dr. Roger L. Brauer (2006), making safety part of a supervisor's or manager's daily responsibilities and including it in their appraisals, job descriptions, and applying it to possible promotions and salary increases is the primary requirement for a successful safety program. When determining the staffing level at given locations, areas to consider are the injury rate, the number of recognized hazards, and the workers' compensation costs per employee. The number of employees will impact the final decision but is not as important as the previous three considerations.

8. Answer: **D**. The key concepts in empowerment strategies generally include:

   - Ownership, which implies trust and should come with delegation of authority commensurate with the tasking. No self-directed work team is truly productive until the team members hold themselves mutually accountable.
   - All contributions are valuable. It is important to value all input and, in many cases, a "try it you will like it" attitude is in order. Every idea is important to the originator.
   - Everyone has value. All jobs have dignity; treat everyone with respect.
   - Listen to the smallest voice. Contributions come from all corners; often the greatest offering will come from the lowest stature employee.
   - Delegate authority to the lowest possible level. If employees are competent, then let them do their job. No one knows more about the particulars of a job than the person doing it.
   - Teams must own the problem. Teams must be given autonomy. If management does not trust the team, then management is the problem. Management, within reason, cannot change recommendations that come from teams.

   A typical bureaucratic review process that will kill the initiative of a team because it burdens them with extensive justification at many levels. Ownership is a simple concept but hard to accomplish. Any attempt at nitpicking, over supervision, rephrasing, rearranging, etc. will undermine the empowerment through ownership strategy.

9. Answer: **C**. Some safety engineering professionals question the lack of design and engineering influence on the accident causation model advanced by management theorists (based on behavioral aspects). However, understanding motivations for people's actions, as well as realizing how they act, affords the ability to design better and safer facilities, equipment, and tools.

10. Answer: **C**. The bar-coding system would be the best choice for tool accountability. In this type of system, tools entering an area would be scanned prior to an employee entering. When work was completed, tools would be scanned as the employee left the area. If a tool were left inside, the final scan list would show that a tool had entered and was not scanned as having left the area. This type of system is widely used in industries where an errant tool left in an area could cause damage or result in other severe consequences. Associating employee numbers to tools checked out from a tool crib would aid in accounting for who was using certain tools. However, just checking out the tool would not be sufficient for accounting as to the location of the tool (i.e., tool bag, left behind).

11. Answer: **C**. Bureaucratic organizations, formally, are defined by these main features:

    - Hierarchy of control (i.e., decisions are made one or more levels above where the work is done)
    - Specialization of function (resulting in some efficiencies but also in noncommunicating subcultures within their "silos" or "chimneys")
    - Centralization of information and control (resulting in underutilizing the knowledge and creativity of most workers and managers)
    - Formal rules, policies, and procedures govern behavior (resulting in greater consistency but creating structures that are very hard to change when it becomes necessary
    - Strict separation of the private life from official role of all employees

The OHS manager should give attention to outside influences such as the external environment, community interests, and other external concerns. The **Contingency Management Style** is the primary style that reacts to outside influences. When choosing an appropriate organizational model, a manager should understand that there are multiple arrangements that will produce the best result with minimum difficulty in the situation in which the organization operates. Given individual discretion and the fact that some configurations appear to influence employee performance and satisfaction, managers should consider carefully the behavioral implications when making structural decisions.

12. Answer: **D**.

    ISO 45001 "Health & Safety management systems"

    ISO 31001 "Risk management systems"

    ISO 9001 "Quality management systems"

    ISO 14001 "Environmental management systems"

    ISO 19011 "Auditing management systems"

13. Answer: **C**. Most of the Behavior Based Safety experts define the "continuous improvement safety process as consisting of:

    - specifying standards.
    - measuring compliance.
    - providing feedback on improvements.

14. Answer: **D**. This is the definition of a **work breakdown structure (WBS)**. The WBS also organizes and defines the total scope of the project. Each descending level represents an increasingly detailed definition of project work. The WBS is decomposed into work packages. The deliverable orientation of the hierarchy includes both internal and external deliverables.

15. Answer: **D**. The operational control delegated the safety engineer to shut down dangerous jobs by the general manager is functional or line authority. This authority, or lack of it, is hotly debated by safety and health professionals. One position calls the delegation of such power unnecessary.

    This opinion states that even the threat of a shutdown is most certainly going to be a confrontational issue. This is an issue that will eventually have to be resolved by higher authority and that often leads to long-lasting negative relations between staff and operations. The other side of this debate believes they need the reserve strength over line managers because of the conflict between organizational demands and safety concerns. They further advance the argument by noting that the act of delegation of authority is in itself a strong commitment by senior management to the safety process.

    In many studies the authority of the safety professional has been linked to accident experience. Since the job is usually of a staff nature, the authority is often subtle. It is most effectively derived if the safety professional enjoys the confidence of a major executive. Another term that is used is "extensio," which is Latin for the state of being extended or the general manager's authority has been extended to the safety professional.

16. Answer: **C**. In the basic study of behavioral science, the theory of human needs by Abraham Maslow is often cited. In Maslow's theory, a need is a deficiency a person feels the compulsion to satisfy. Central to this theory is the progressive principle, that is, the needs are arranged in a hierarchy whereby only after a lower-level need is satisfied can the next highest level become active. At the bottom of Maslow's "Hierarchy of Human Needs" are the physiological or survival needs of food, water, and physical well-being. According to the *progression principle*, as soon as these survival needs are met, one attempts to satisfy the next level of needs; those of, security, protection, and stability in day-to-day life activities. If these are met, one moves on to social needs. The first three needs in the model are called lower-order needs and are concerns for a person's desire for social and physical well-being. The top two needs in the pyramid are the high-order needs that satisfy psychological development and growth. Maslow's needs are often used as the most elementary model in the complex study of man's needs and desires. The chart (**Figure 15**) shows how needs are satisfied in life and in business.

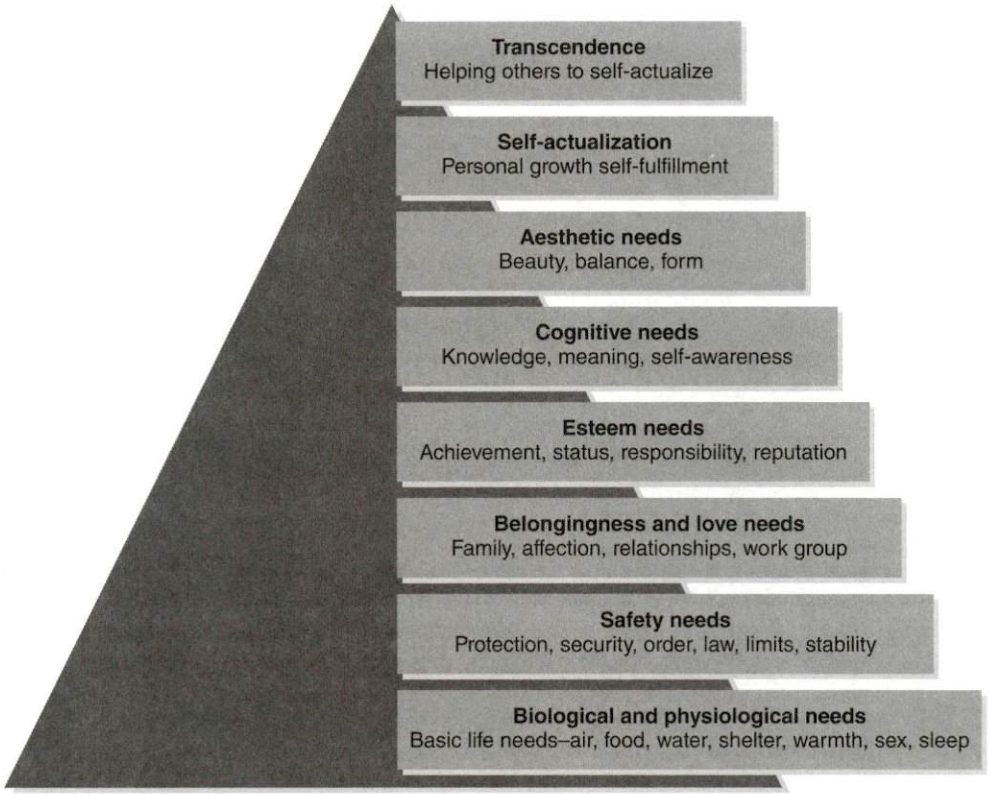


Figure 15 Maslow's Hierarchy of Human Needs

Modified from Maslow. *A Theory of Human Motivation*. Eastford, CT: Martino Fine Books, 2013.

17. Answer: **D**. An incidence rate of injuries and illnesses may be computed from the following formula:

$$\text{Incident Rate} = \frac{\#\text{ of Incidents} \times 200{,}000}{\text{Total Hours Worked}}$$

The 200,000 hours in the formula represents the equivalent of 100 employees working 40 hours per week, 50 weeks per year, and provides the standard base for the incidence rates. You can use the same formula to compute incidence rates for:

- Injury and illness cases with days away from work
- Injury and illness cases with job transfer or restriction
- Injury and illness cases with days away from work, job transfer or restriction, or both (DART)
- Other recordable injury and illness cases
- Injury-only cases
- Illness-only cases

"Hours worked" should not include any nonwork time, even though paid, such as vacation, sick leave, holidays, etc. If actual hours worked are not available for employees paid on commission, by salary, or by the mile, etc., hours worked may be estimated on the basis of scheduled hours or 8 hours per workday.

Vehicle accidents are generally measured per million miles, whereas injury rates are figured per 200,000 work hours or 100 workers working one year.

$$\text{Fleet Incident Rate} = \frac{\#\text{ of Incidents} \times 1{,}000{,}000}{\text{Miles Driven}}$$

$$\text{Fleet Incident Rate} = \frac{\#\text{ of Incidents} \times 1{,}600{,}000}{\text{Kilometers Driven}}$$

18. Answer: **B**. Accountability for safety performance in the superior performing companies is clearly established with line management at every level. Safety performance is one of the elements scored in the overall performance measurement system. Favorable or unfavorable results influence salaries, bonuses, and promotion potential. One of the principal indicators of management commitment to safety is the inclusion of safety performance in the performance review system. Management commitment to safety is questionable if the accountability system does not include safety performance measures that impact financially and on the promotion potential of those responsible for results (Swartz 2000).

19. Answer: **C**. The concept of situational leadership is leaders changing and adjusting their style to fit the situation and the people involved. Situational leadership is a well-established model built around the concept that each situation requires the application of a combination of two possible behavior dimensions-task or directive behavior and relationship or supportive behavior. In each case, a leader has to determine which combination is required by the situation and then correctly apply the appropriate behavior to properly manage the situation. They use four situations to describe the fundamentals of their model:

    - Situation 1 (S1): High task, low relationship leader assumes telling role
    - Situation 2 (S2): High task, high relationship leader assumes selling role
    - Situation 3 (S3): High relationship, low task leader assumes participating role
    - Situation 4 (S4): Low relationship, low task leader assumes delegating role

    In an S1 situation, subordinates are usually new to a task and do not know how to do it. At this stage they don't know what they don't know. They need to be told what the task is and how to do it. They don't necessarily need a close relationship with the leader. In an S2 situation, workers are thought to be developing some competence, and now at least they know what they don't know. Because of this, they begin to develop more of an interest but still must rely on the leader for guidance, so the need for a closer relationship is there. Developing workers want to know what the leader knows. In an S3 situation, workers have developed confidence and competence. They can handle the situation or task without input (task direction is not necessary); however, it is, figuratively speaking, the first time on their own, so they would like input and feedback about their performance and need a close (or high) relationship with the leader. In S4 situations, workers are fully developed and know how to handle the situation or perform the task without input and do not need feedback. Task-direction need and relationship with the leader are both low. A leader must be able to constantly assess this very dynamic process and correctly determine in which of these four categories workers or situations are (Haight 2012a).

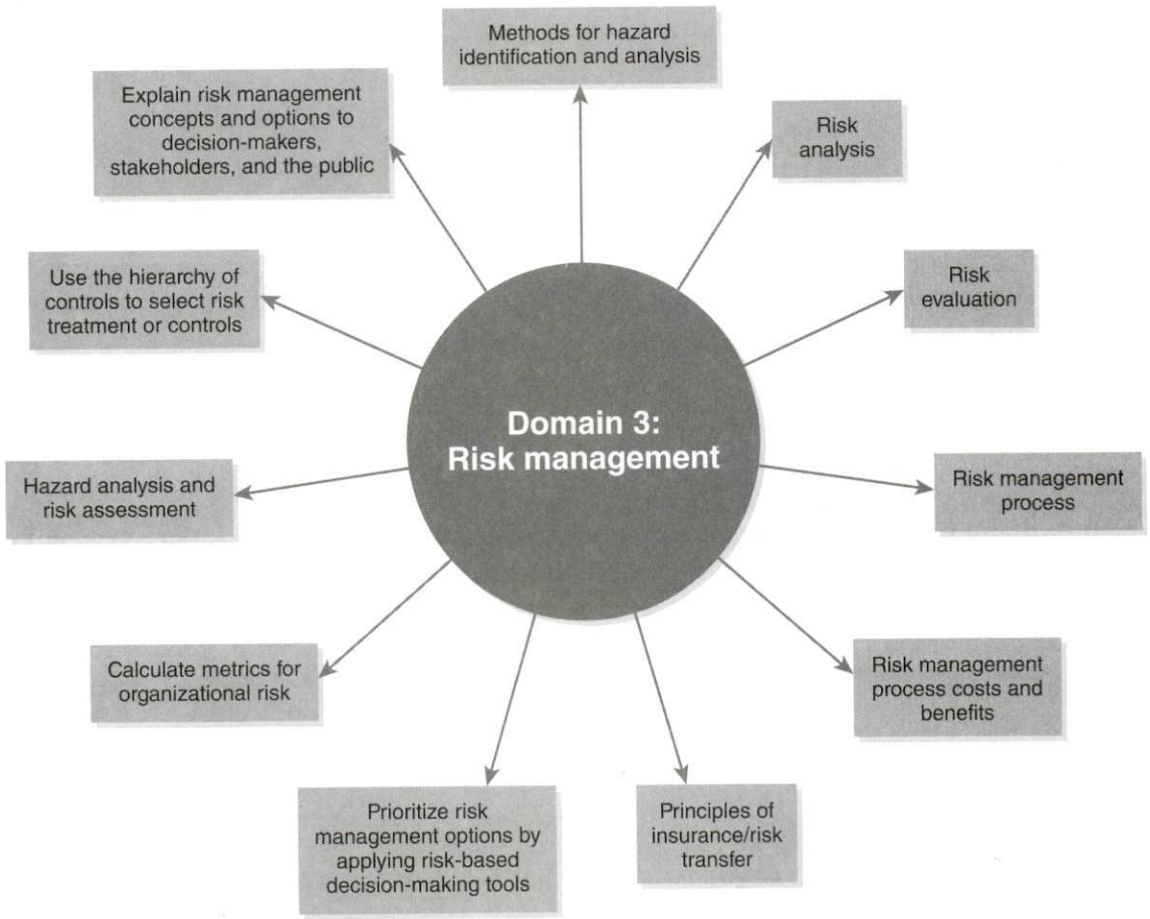
20. Answer: **A**. Making a safety culture successful is a real challenge for which the safety professional will need to invest time and energy. A culture is the way a group of people ordinarily behave, a common practice, like a culture of wearing casual clothes or dresses and suits. A safety culture means, in simplest terms, the common and generally accepted way people behave in the workplace, as it relates to safe behavior. The culture is a group's feeling that everyone has to cooperate for safety and that everyone in the group will try to behave in a way that protects the safety of each other. If the workers believe in safety for themselves and others and then they act like safety matters in their everyday work, that is a workplace that has an active "safety culture" (Hagan, Montgomery, and O'Reilly 2009).

21. Answer: **D**. The analysis of a Pareto diagram evaluates categories that represent the greatest frequency of cases. It evaluates the greatest number of incidents, not necessarily severity. In this example from *Safety Metrics: Tools and Techniques for Measuring Safety Performance* 2nd Edition, the frequency of injuries was classified according to the body part affected. Over this period, backs accounted for 40% of all injuries, hands 30%, arms 20%, and all others were 10%.

    To construct a Pareto diagram, the category that accounted for the greatest percentage of cases is placed to the left of the diagram and remaining categories are arranged in descending order of overall percentage of injuries. A line is constructed that indicates the cumulative injuries. In this chart, back and hand injuries account for 70%, while back, hand, and arm account for 90%.

22. Answer: **A**. As a link in the chain of custody, that is a person with a duty to preserve and protect evidence or someone with a vested interest in the outcome of the accident investigation, it is essential that from the moment the event occurs you identify, track, and log movement of your evidence. An example of chain of custody would be taking photos, printing photos, making notes, describing the angles that the photo was taken, lighting, date/time, and any other information that could be helpful later in the process.

Domain 3: Risk Management



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Themes

Blueprint reference

Domain 3: Risk Management

- Evidence-based risk assessment practices (ISO 31001)
  - Qualitative and Quantitative hazard analysis and risk assessment methods
  - FTA, FMEA, What-if, checklist, HAZOP, JSA, Observations, Behavior based safety
- Prioritized risk-based decision making
  - Risk matrixes, risk scores, business acumen
- Effectively communicating risk management options to decision makers and stakeholders

Key CSP Blueprint Themes: Domain 3

Domain 3 Quiz 1 Questions

1. **A company decides to reflect the worker's compensation losses in terms of profits. The profit margin is 2.5% on each unit sold. What is the gross sales volume needed to offset $90,000 of worker's compensation costs?**

   A. $600,000
   B. $3,000,000
   C. $3,600,000
   D. $30,000,000

2. **A steel manufacturing plant has a $1,400,000 payroll that suffers workers' compensation losses of $97,000. The experience modification factor for this plant is 1.6 and the manual premium is $88,000. What is the loss ratio for this manufacturing firm?**

   A. 98%
   B. 38%
   C. 59%
   D. 69%

3. **Accepted probabilistic risk assessment methodology used for assessing workplace system failures is called _____ analysis.**

   A. environmental
   B. fault tree
   C. job safety
   D. safety and health

4. **The loss ratio is defined as:**

   A. $\text{Loss Ratio} = \dfrac{\text{Losses}}{(\text{Experience Modifier} \times 100)}$

   B. $\text{Loss Ratio} = \dfrac{\text{Losses}}{(100{,}000 \times \text{Experience Modification})}$

   C. $\text{Loss Ratio} = \dfrac{\text{Losses}}{(\text{Manual Premium} \times \text{Experience Modification})}$

   D. $\text{Loss Ratio} = \dfrac{\text{Losses}}{\text{Premium}}$

5. **In conducting a safety and health audit, a CSP asks for workers compensation cost data and finds the location's experience modification rate to be 0.55. The rating for this location's safety and health performance based upon this value is:**

   A. good.
   B. average.
   C. cost neutral.
   D. poor.

6. Software analysts can predict software errors using selected statistical models. The following information estimates error rates versus project development phases of a system.

ERROR RATE VERSUS PROJECT DEVELOPMENT PHASES	
Phase	**Errors/100 Object Instructions**
Validation/Acceptance	0.597
Integration	0.899
Operational Demo	0.234
Pre-Op Exercise	0.433

Based on this information, the mean error rate is:

A. one error rate in 100 instructions.
B. one error rate in 200 instructions.
C. one error rate in 400 instructions.
D. one error rate in 800 instructions.

7. Accident costs and probability for the past year are reflected in the following table. What is the expected value of accident costs?

Accident Costs	Probability
0	0.1
$5000	0.5
$10,000	0.3
$15,000	0.4

A. $6000
B. $11,500
C. $9000
D. $0

8. An industry had 38 serious incidents including one fatality in the past 15 years. Four incidents involved forklifts. Determine the probability that the next serious accident will involve a forklift.

A. 13%
B. A determination is not possible.
C. 8%
D. 10.5%

9. Which of the following scenarios has the higher annual financial risk?

Scenario A: Minor employee injuries occur about twice per month and cost the company about $3500 in lost work productivity and $2500 in medical and insurance compensation per incident.

Scenario B: Catastrophic incidents occur about once every 30 years and cost the company about $1,200,000 in lost work productivity and equipment damage, along with $2,500,000 in legal fees and other compensation.

A. Scenario A has the higher risk.
B. Scenario B has the higher risk.
C. Scenarios A and B both have the same approximate risk.
D. Risk value for these scenarios show a frequency ratio of 1:2.

10. A company has a process that uses a highly toxic chemical. An industrial hygienist has proposed installation of gas detectors as a safety measure. The cost–benefit ratio is defined as the cost in dollars associated with cost of each fatality reduced by installing the detectors. Calculate the cost reduction per fatality if the detector is installed.

A. $1,000,000/fatality
B. $4,000,000/fatality
C. $12,000,000/fatality
D. $8,000,000/fatality

Detector installation cost	$200,000
Projected fatalities if not installed	0.05
Projected fatalities if installed	0.025

Domain 3 Quiz 1 Answers

1. Answer: **C**. $3,600,000 in gross sales at a 2.5% profit margin is required to offset $90,000 in worker's compensation losses.

$$90{,}000 \div .025 = 3{,}600{,}000$$

2. Answer: **D**.

$$\text{Loss ratio} = \frac{\text{losses}}{\text{E- Mod} \times \text{Manual Premium}}$$

$$L_R = \frac{97{,}000}{1.6 \times 88{,}000}$$

$$L_R = 0.6889$$

3. Answer: **B**. Fault tree analysis is a commonly used method for assessing system reliability. It starts with a top-level fault and works down, identifying the events that make that top event occur and using component probabilities to calculate ultimate probability the event may occur. A system is analyzed in the context of its work environment and actual operation to find all credible ways in which the system can fail.

4. Answer: **C**.

$$\text{Loss Ratio} = \frac{\text{Losses}}{(\text{Manual Premium} \times \text{Experience Modification})}$$

5. Answer: **A**. The experience modification is developed from the location's injury/illness frequency and severity rate and the industry rate. If the plant had the same experience as the industry as a whole, the experience modification rate would be 1. Since this plant had an experience modification rate of 0.55, it would be considered very good.

6. Answer: **B.**

Errors per 100 instructions	Instructions
0.597	100
0.899	100
0.234	100
0.433	100
2.163	400

If you have 2.163 errors per 400 instructions, then you have approximately 1 error per 200 instructions.

7. Answer: **B**. Risk can be expressed as the frequency of an event multiplied by the consequence of the event. Usually, consequence is expressed in units of monetary value used as a comparison of financial risk across different areas. The expected value of accident costs is the sum of the costs times the probability of each occurrence.

Accident Cost		Probability		Expected Losses
0	×	0.1	=	$ 0
$5000	×	0.5	=	$ 2500
$10,000	×	0.3	=	$ 3000
$15,000	×	0.4	=	$ 6000
				$11,500

8. Answer: **D**. Probability is the number of forklift accidents divided by the number of total accidents.

$$P = \frac{4}{38} = 0.105 = 10.5\%$$

9. Answer: **A**.

Calculate the cost of minor incidents per year.

$3500 indirect + $2500 direct = $6000/minor incident

$6000 × 24 incidents/year = $144,000/year

Annual risk exposure for minor incidents is $144,000 annually.

Calculate the cost of major incidents per year.

$1.2M indirect + $2.5M direct = $3,700,000/Catastrophic incident $3,700,000/30 years = $123,333/year.

Annual risk exposure for the catastrophic incident is $123,333/year.

Minor incidents represent a great annual financial risk. These are essentially equivalent; however, Scenario A is a slightly higher risk. Risk can be expressed as the frequency of an event multiplied by the consequence of the event. Usually, consequence is expressed in units of monetary value used as a comparison of financial risk across different areas.

10. Answer: **D**. The difference between the risk reductions is 0.05 – 0.025 for a net benefit of 0.025. To calculate cost to benefit ratio, divide cost by net benefit.

$200,000 ÷ 0.025 = $8,000,000

Domain 3 Quiz 2 Questions

1. **Catastrophe insurance is a low-probability, high-cost insurance against events that are generally excluded from standard hazard insurance. These policies for insurers are *most closely* related to:**

   A. general liability.
   B. business interruption.
   C. reinsurance.
   D. disaster liability.

2. **The following are all criteria for evaluating cost-benefit analysis *except:***

   A. the cost–benefit ratio.
   B. gross benefits.
   C. rate of return.
   D. payback period.

3. Any action that reduces losses incurred, by definition, is

A. loss control.
B. loss transfer.
C. risk management.
D. loss reduction.

4. Which of the following is *most important* for conducting a successful hazard and operability (HAZOP) study?

A. Numerous labor and management representatives knowledgeable of safety procedures
B. A study director familiar with the process being considered
C. A conversant process safety engineer familiar with process safety regulations
D. Multiple subject-matter experts knowledgeable about the process being studied

5. A business has decided to implement a behavior-based safety program. What is the *first* step a safety professional needs to initiate in the process?

A. Establish the data collection process.
B. Develop the questions to be asked during the collection process.
C. Decide how to codify the data once it is collected.
D. Define the subsequent use of the data.

6. A systematic process for calculating and comparing benefits and costs of a project, decision, or abatement actions is known as:

A. cost analysis.
B. risk management.
C. cost–benefit analysis.
D. prime cost assessment.

7. What is the term for the ratio of risk exposure to venture or project cost?

A. Expenditure ratio
B. Loss/profit ratio
C. Risk exposure ratio
D. Threat ratio

8. The stages in the risk analysis and management of a project include all the following *except:*

A. identification.
B. estimation.
C. response.
D. intervention.

9. Risk assessment should be carried out by a/an:

A. supervisor.
B. enforcement officer.
C. competent person.
D. safety representative.

10. A method used to reduce risk is known as a:

A. hazard.
B. control measure.
C. hazard report.
D. safety analysis.

11. An example of a human factor that could result in an accident is:

A. high noise levels.
B. a dusty workplace.
C. inexperience.
D. poor lighting.

12. Risk assessment must be carried out in:

A. all workplaces.
B. some workplaces.
C. only large workplaces.
D. only high-risk workplaces.

13. Which analysis method *most commonly* applies deductive reasoning?

A. Failure Mode and Effect Analysis (FMEA)
B. Fault Tree Analysis (FTA)
C. Preliminary Hazard Analysis (PHA)
D. Operational Hazard Analysis (OHA)

14. Which is the *best* definition of hazard?

A. A condition, set of circumstances, or inherent property that can cause injury, illness, or death.
B. An event in which a work-related injury or illness or fatality occurred or could have occurred.
C. A set of interrelated elements that establish and support occupational safety and health objectives.
D. An estimate of the combination of the likelihood of an occurrence of a hazardous event or exposure and the severity of the injury.

15. Risk is defined as a combination of:

A. frequency of episodes of an adverse event and probability of occurrence of the adverse event.
B. probability that an adverse event will occur and consequences of the adverse event.
C. probability that a hazardous condition exists and consequences of the hazard.
D. exposure and consequences to a hazard.

16. Which of the following is the *most likely* next step after completing a risk assessment associated with machining tools?

A. Probability of occurrence
B. Severity of harm
C. Cost–benefit ratio of risk reduction options
D. Exposure to hazard

17. Which is considered a *direct* cost when defining hidden costs of an accident?

A. Time lost from work by injured
B. Time lost by fellow workers
C. Payment and benefits for lost time
D. Loss of production

18. A *semi-quantitative* method of risk assessment characterized by the blended use of qualitative process hazard analysis and quantitative risk analysis methods is a:

A. hazard operability study.
B. layer of protection analysis.
C. failure modes effects analysis.
D. what-if/checklist study.

19. Which is an *unlikely* loss reduction strategy?

A. Providing a CPR/first aid certified individual on every work team.
B. Installing a modernized fire suppression system.
C. Doing emergency planning (what-if) scenarios.
D. Storing back up files at an offsite location.

20. What is the *primary* function of a loss control system?

A. Assess risk, establish effective risk control measures, and elimination of risk.
B. Establish effective risk control measures for hazardous conditions, establish effective control measures, elimination of risk.
C. Identify hazardous conditions, assess their risks, and establish effective risk control measures.
D. Assure compliance with applicable regulatory requirements and eliminate residual risk

Domain 3 Quiz 2 Answers

1. Answer: **C**. **Insurance** protects businesses and residences against natural disasters such as earthquakes, floods and hurricanes, and against man-made disasters such as terrorist attacks. These low-probability, high-cost events are generally excluded from standard hazard insurance policies, and so catastrophe insurance is required.

   Catastrophe insurance is different from other types of insurance in that it is difficult to estimate the total potential cost of an insured loss and a catastrophic event results in an extremely large number of claims being filed at the same time. This makes it difficult for catastrophe insurance issuers to effectively manage risk. Reinsurance and retrocession are used along with catastrophe insurance to manage catastrophe risk.

   Reinsurance (insurance for insurers) for catastrophic losses allows the insurance industry the ability to absorb the multibillion dollar losses caused by natural and man-made disasters such as hurricanes, earthquakes, and terrorist attacks because losses are spread among thousands of companies including catastrophe reinsurers who operate on a global basis. Insurers' ability and willingness to sell insurance fluctuates with the availability and cost of catastrophe reinsurance.

   Retrocession is the practice of one reinsurance company essentially insuring another reinsurance company by accepting business that the other company had agreed to underwrite. When one reinsurance company has other reinsurance companies partially underwrite some of its reinsurance risk, it essentially diversifies its risk portfolio and limits its potential losses because of a catastrophe.

2. Answer: **B**. The criteria for evaluating cost and benefits are:

   - the cost–benefit ratio;
   - net benefits, benefits minus cost;
   - rate of return; and
   - payback period.

   Not all costs and benefits can be converted to quantitative terms, some may only be expressed in qualitative terms. This can be the most difficult part of the formula.

   A major objective of applying cost–benefit analysis to safety is to provide a systemic analytical approach to dealing with complex issues of cost and benefit, assessing trade-offs in hazard control methods.

   Additionally, cost–benefit analysis is a tool to help management prioritize corrective actions. Though formal risk analysis identifies actions to reduce risk, a financial analysis is essential so managers have the information to make judgments on how to spend money and expend efforts needed to reduce the identified risks by implementing corrective actions.

3. Answer: **D**. **Loss reduction** means any **action** that reduces the losses incurred. The reduction may be by decrease of the physical destruction (as by reducing the amount of material burned or the number of persons injured) or by reducing the operational loss from a given amount of destruction (as having standby equipment

or more effective medical care for the injured). It includes the concepts of loss prevention and control as well as the concept of risk avoidance—the refusal to accept a given risk. Planning actions are not generally considered part of loss reduction. The four steps required in an effective loss control program are problem identification, selection of corrective measures, implementation and feedback, and control.

4. Answer: **D**. As referenced in by the Center for Chemical Process Safety *Guidelines for Hazard Evaluation Procedures,* 3rd Edition, subject-matter experts familiar with the process and sections of the process being studied are essential. A process hazard analysis leader familiar with the analytical method is important, but it is not essential for the study leader to be personally familiar with the actual process being studied.
5. Answer: **D**. The first step you must always take when collecting data is to determine the use of the data and restrict it to only that use.
6. Answer: **C**. Cost–benefit analysis is a generic process of evaluating competing courses of action by examining the dollar costs of certain abatement actions versus the dollar value of benefits received.
7. Answer: **C**. Risk exposure ratio is the ratio of the risk exposure to the project cost.
8. Answer: **D**. There are five stages in risk analysis and management: (1) identification, (2) estimation, (3) evaluation, (4) response, and (5) monitoring.

   Identification techniques include individual consultation and group discussion. Individual consultations are one-on-one meetings are arranged as a preliminary exercise to initially identify the risks. This process involves key participants in the project in question. The purpose of this stage is to allow the interviewee to contemplate what he/she thinks are the main risks attached to either the project as a whole, as individual stages of the project, or both. As the participants are from different disciplines, their viewpoints about the project are influenced by the specialized nature of their field. Group discussion is a process by which potential sources of risk are identified with a clear set of rules and a timetable. This technique should be carried out with the project team. One person should be the coordinator who chairs the meetings. The discussion process should have two distinct stages: a creative stage and an assessment stage. The creative stage permits any one member of the team, one at a time, to "throw" in potential risks or sources of risk. Individual team members are not restricted to their own knowledge domain and outlandish ideas are encouraged. The assessment stage then follows. Estimation includes interviewing and brainstorming with personal and corporate experience. The analysis, and/or estimation, stage is more extensive in nature than in the identification stage. All the ideas are analyzed individually, and a final draft of the risks is assembled. The idea of the analysis stage is to categorize or rank the risks by using the one-on-one situation in interviewing, or the group discussions from brainstorming. Therefore, the result from this stage is to prioritize the risks so as to know which of them are to be forwarded to the quantitative analysis. At this point, this threshold level or cut-off point must also be decided. The notion being the risks below this level, and thus those not to be analyzed quantitatively, are covered by project contingent reserves. The ones above would not be, hence, requiring further analysis.

   If there are employees with experience, then this property should be used. Experience enables the main risks in a project to be identified. Obviously, one looks at the more senior officers to excel in this department. However, there is always a chance that certain risks never encountered before are overlooked. If the project is not equivalent to a previous project, then the policies of the company or engineering judgment decides on a contingency percentage. Factors of safety are used extensively in the construction industry and is based on this method.

   Response strategies include:

   Risk Avoidance

   - Avoiding risk can be as simple as a contractor not placing a bid or even the owner not proceeding with project funding. Other ways are: tendering at a very high bid, placing conditions on the bid, and not bidding on the high-risk portion of the contract.

   Risk Transfer

   - Risk transfer can take two basic forms:

- The property or activity responsible for the risk may be transferred (e.g., hire a subcontractor to work on a hazardous process); and
- The property or activity may be retained, but the financial risk transferred (e.g., insurance or client takes the costs of risk by contract).

Risk Retention

- This is the method of responding to risks by the body who controls them. The risks, foreseen or unforeseen, are controlled and financed by the company or contractor that is fulfilling the terms of contract. There are two retention methods: active and passive. Active retention, sometimes referred to as self-insurance, is a deliberate management strategy after a conscious evaluation of the possible losses and costs of alternative ways of handling risks. Passive retention (sometimes called noninsurance), on the other hand, occurs through neglect, ignorance, or absence of decision (e.g., a risk has not been identified and responding to the consequences of that risk must be borne by the contractor performing the work).

Risk Reduction

- Loss prevention is one of the ways of risk reduction. Loss prevention can be classified into four basic categories:
  - Preconditions for a loss (i.e., faults in the premises, for example, badly insulated wire);
  - Prevention of loss; devices designed to prevent preconditions for loss (e.g., cut-off switches);
  - Early discovery of loss producing events (e.g., sprinkler system); and
  - Limitation of loss (e.g., fire doors, compartmentalization).

9. Answer: **C**. The term "competent person" is used in many OSHA standards and documents. An OSHA "competent person" is defined as "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them" (29 CFR 1926.32(f)). By way of training and/or experience, a competent person is knowledgeable of applicable standards, can identify workplace hazards relating to the specific operation, and has the authority to correct them. Some standards add additional specific requirements that must be met by the competent person. Another definition is a person with the appropriate combination of skill, knowledge, qualifications, and experience should conduct the risk assessment.

10. Answer: **B**. **Risk management** is the identification, assessment, and prioritization of risks (defined in ISO 31000 as *the effect of uncertainty on objectives*) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Once risks have been identified and assessed, all techniques to manage the risk fall into one or more of these control measures:

    - Avoidance (eliminate, withdraw from, or not become involved)
    - Reduction (optimize—mitigate)
    - Sharing (transfer—outsource or insure)
    - Retention (accept and budget)

    Ideal use of these strategies may not be possible. Some of them may involve trade-offs that are not acceptable to the organization or person making the risk management decisions.

11. Answer: **C**. Not understanding properly how something works or an error in diagnosis or planning can be due to inexperience. Increasing the knowledge and experience of employees will result in greater competence and reduce accidents.

12. Answer: **A**. According to the International Organization for Standardization (2011b), organizations of all types and sizes face internal and external factors and influences that make it uncertain whether and when they will achieve their objectives. The effect this uncertainty has on an organization's objectives is "risk." All activities of an organization involve risk. Organizations manage risk by identifying it, analyzing it, and then evaluating whether the risk should be modified by risk treatment in order to satisfy their risk criteria. Throughout this process, they communicate and consult with stakeholders and monitor and review the risk and the controls

that are modifying the risk to ensure that no further risk treatment is required. This standard describes this systematic and logical process in detail.

13. Answer: **B**. Deductive analysis involves reasoning from the general to the specific. Of the choices listed only fault tree analysis involves this technique.

14. Answer: **A**.

    Hazard: A condition, set of circumstances, or inherent property that can cause injury, illness, or death.

    Incident: An event in which a work-related injury or illness or fatality occurred or could have occurred.

    Occupational Health and Safety Management System (OHSMS): A set of interrelated elements that establish and support occupational safety and health objectives.

    Risk: An estimate of the combination of the likelihood of an occurrence of a hazardous event or exposure and the severity of the injury.

15. Answer: **B**. Risk is defined as the probability that a substance or situation will produce harm under specified conditions. Risk is a combination of two factors: (1) the probability that an adverse event will occur, and (2) the consequences of the adverse event. Risk encompasses impacts on public health and environment and arises from exposure and hazard. Risk does not exist if exposure to a harmful substance or situation does not or will not occur. Hazard is determined by whether a substance or situation has the potential to cause harmful effects. Risk is the probability of a specific outcome, generally adverse, given a set of conditions.

16. Answer: **C**. Risk assessment was introduced and specifically addressed by the American National Standards Institute in ANSI B11.TR3:2000 entitled *Risk Assessment and Risk Reduction–A Guide to Estimate, Evaluate, and Reduce Risks Associated with Machine Tools*. The ANSI B11.TR3 explored three major premises of risks:

    - probability of occurrence—very likely, likely, unlikely, or remote
    - severity of harm—catastrophic, serious, moderate, or minor
    - exposure to hazard—frequency and duration, extent of exposure, or number of people exposed

    ANSI B11.TR3 explains that zero risk does not exist and is therefore unattainable. Some amount of residual risk remains even after the application of machine safeguarding. Cost benefit is not part of a risk assessment. The common primary objective in both ANSI B11.TR3 and ANSI B11-2008 is that reasonably foreseeable hazards must be identified and dealt with.

    Both standards contain scoring/rating systems to establish various risk reduction categories. The European Machinery Standard EN1050 (now ISO 14121) follows the same general format and addresses risk assessment in the same manner. However, it utilizes terms and phrases that are common to European standards.

17. Answer: **C**. The direct costs are medical and compensation. The indirect, or hidden, costs are: time lost from work by the injured, loss in earning power, economic loss to the injured family, lost time by fellow workers, loss of efficiency due to break-up of crew, lost time by supervision, cost of breaking in a new worker, damage to tools and equipment, time-damaged equipment is out of service, spoiled work, loss of production, spoilage, failure to fill orders, overhead costs, and miscellaneous.

18. Answer: **B**. Layer of Protection Analysis (LOPA) is a useful tool often used to assess the risk of major accidents. It is most commonly used within the process industries; however, the general approach is applicable for any type of risk assessment. LOPA is a semi-quantitative method meaning that an "order of magnitude" approximation approach is used to derive frequency estimates, and therefore risk, for event consequences. The estimates of risk are limited to the single event being studied and will deal only with credible worst-case consequences of the event. As a risk assessment tool, LOPA fits in between simplified qualitative techniques (such as simple risk matrix) and complete quantitative assessment (QRA). LOPA would be a good choice as a risk assessment approach where a higher degree of risk quantification is required due to the potential severity of the consequences, but where there is no need for a full quantitative assessment. The time and cost to complete a LOPA is greater than a simplified qualitative analysis but far less than QRA. LOPA also provides very clear linkages between causes, controls, and outcomes, considers the effectiveness of individual controls, and can be used to demonstrate that the controls are adequate using simple risk criteria.

These are key requirements of any major hazard's safety case so the benefit of this tool for major hazard risk assessment is obvious. The scenario risk determined through the LOPA may also be plotted onto the company risk matrix which helps to communicate the results to employees who are already familiar with the risk matrix. A key aspect of the LOPA methodology involves identifying the "preventative" controls that prevent the hazard leading to an accident (the "loss of control" event) and the "mitigating" controls that help to reduce the magnitude or severity of an incident once it has occurred. These are referred to as the "layers of protection." The layers of protection are identified explicitly and assigned probabilities of failure based on estimates of effectiveness and reliability (**Figure 16**). The estimated initiating event frequency and control failure probabilities may then be combined to generate the frequency estimates for accident outcomes. These frequency estimates may then be compared to "target" risk criteria and plotted onto a risk matrix if desired.

According to *Layers of Protection Analysis: Simplified Process Risk Assessment*, Center for Chemical Process Safety, American Institute of Chemical Engineers (2001), layers of protection analysis (LOPA) is a powerful analytical tool for assessing the adequacy of protection layers used to mitigate process risk. LOPA builds upon well-known process hazards analysis techniques, applying semi-quantitative measures to the evaluation of the frequency of potential incidents and the probability of failure of the protection layers. Beginning with an identified accident scenario, LOPA uses simplifying rules to evaluate initiating event frequency, independent layers of protection, and consequences to provide an order-of-magnitude estimate of risk. LOPA has also proven an excellent approach for determining the safety integrity level necessary for an instrumented safety system, an approach endorsed in instrument standards, such as ISA S84 and IEC 61511.

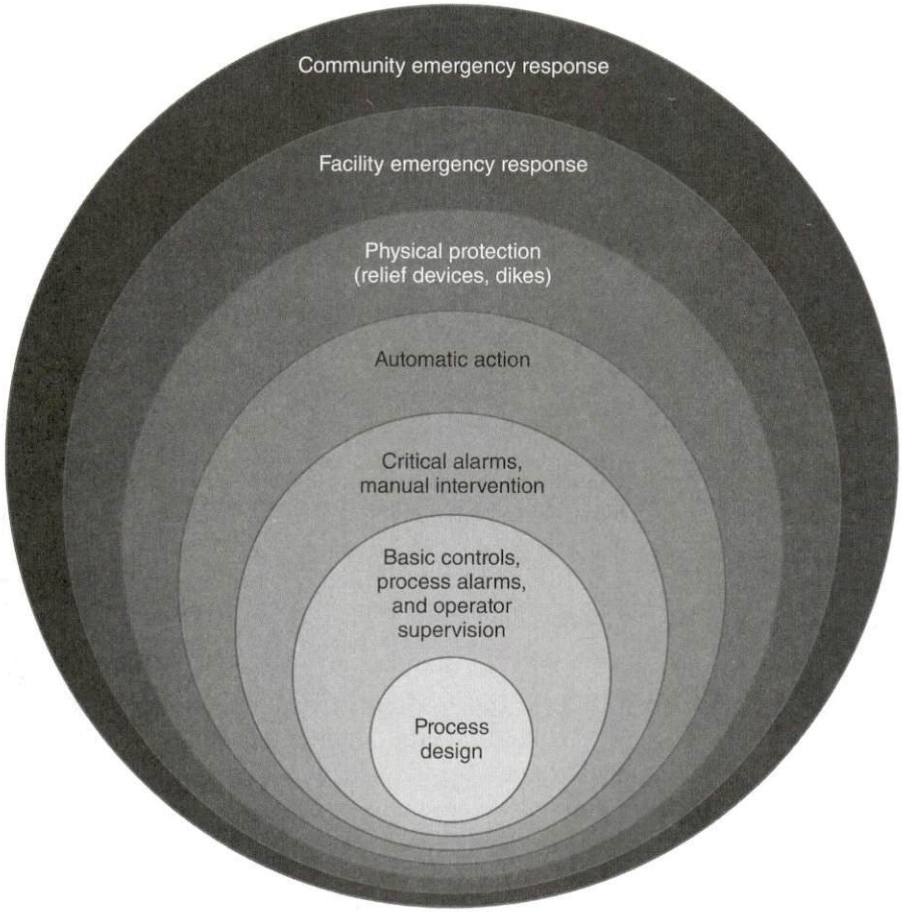


Figure 16 Layers of Protection Analysis (LOPA)

Center for Chemical Process Safety. *Layer of Protection Analysis: Simplified Process Risk Assessment*. New York, NY: Wiley-AIChe, 2001.

19. Answer: **D**. Storing back up files at an offsite location would be considered loss prevention and not loss reduction. Other examples of loss prevention strategies are replacing physical guards on saws, installing GFCIs or performing HAZCOM training. An example of loss reduction would be to equip and train a fire brigade.

    Loss reduction has several approaches. Risk management control procedures emphasize safety management. The human approach believes the safety attitudes of individuals determine the safety precautions they take. The engineering approach places emphasis on physical features of the workplace as a potential cause of injuries. Another approach is reducing operational loss from a given amount of destruction (e.g., by having standby equipment or more effective medical care for the injured).

20. Answer: **C**. As described in *Assurance Technologies*, a loss control system must be able to identify the hazardous conditions as well as understand the real risks associated with those hazardous conditions. A loss control system is incomplete if it solely identifies hazardous conditions and does not act to understand the risks. Therefore, the actions taken are relative to the risks associated with the hazardous conditions.

Domain 3 Quiz 3 Questions

1. **According to current machine tools risk evaluation models, the *most important* concept of "zero risk":**

   A. is achievable given the correct task analysis was performed.
   B. does not virtually exist.
   C. can occur with the appropriate safety customs.
   D. is the definitive goal of any safety program.

2. **The risk remaining after preventive measures have been taken is called:**

   A. acceptable risk.
   B. allowable risk.
   C. unacceptable risk.
   D. residual risk.

3. **A study method that requires a multidisciplinary team, guided by an experienced leader and uses specific guide words (such as "no," "increase," "decrease," "reverse") that are systematically applied to parameters (e.g., temperature, pressure, flow) to identify the consequences of deviations (e.g., reduced flow) from design intent for various processes and operations is called a(n):**

   A. FTA.
   B. ETA.
   C. HAZOP.
   D. FMEA.

4. **In a business or industrial setting, there are powerful reasons to focus on behavior before attitudes. These include all the following *except:***

   A. a change in behavior can influence a change in attitude.
   B. a change in behavior does not influence a change in attitude.
   C. behavior can be measured and therefore managed.
   D. attitudes present measurement challenges.

5. **A manager responsible for the safety and health function in a company has access to all cost data relevant to insurance, medical, wages, and operations. How is the total cost of an incident determined?**

   A. Merge insurance costs for medical and compensation paid to claimant.
   B. Sum the insured and noninsured costs.
   C. Ascertain direct costs and multiply by a factor of 10.
   D. Establish direct cost and then add 50%.

6. Basic principles of loss control include all the following *except:*

A. "An unsafe act, an unsafe condition, and an accident are all symptomatic of something flawed in the management system."
B. Certain sets of circumstances that will produce severe injuries can be predicted. These circumstances can be identified and controlled."
C. "The key to effective line safety performance is management procedures that attach accountability."
D. "Safety must be managed as a separate company function apart from the normal planning processes to assure management's commitment to safety and make it unmistakably evident to employees."

7. Reinforcement of desired behaviors is *best* accomplished by:

A. cash incentives.
B. negative reinforcement at the work shift end.
C. positive reinforcement as soon as possible.
D. It is not required as employees will change their behaviors only if they aspire to do so.

8. Which of the following has the *greatest* impact or influences on behavior?

A. Activators
B. Consequences
C. Discipline
D. Feedback

9. Safety professionals demonstrate business acumen skills by incorporating the concept of cost effectiveness when advising management for risk-based decision-making. Which is a risk management principle applied when defining acceptable risk levels for machinery hazards?

A. As low as reasonably achievable (ALARA)
B. As low as reasonably practical (ALARP)
C. Best Available Control Technology (BACT)
D. Maximum Achievable Control Technology (MACT)

10. Safety professionals sometimes incorrectly use the terms *risk* and *hazard* interchangeably. Risk is *best* defined as:

A. conditions of things.
B. actions or inactions of people.
C. a measure of the probability and severity of adverse effects.
D. any workplace condition that can result in injury, death, or property damage.

11. Which is a financial method for reducing the cost of losses in an organization?

A. Risk transfer
B. Risk projection
C. Financial risk management
D. Hierarchy of loss controls

12. Failure Modes and Effects Analysis (FMEA) is a:

A. top down system safety technique.
B. bottom up system safety technique.
C. fault tree system safety technique.
D. response management safety technique.

13. When presenting justifications for capital budget expenditures to decision-makers, safety professionals frequently use cost–benefit analysis. A cost–benefit analysis requires that:

A. project costs and benefits can be reasonably estimated in advance.
B. business units bearing the costs must be the same as those earning the benefits.
C. projects must be based on a minimal 10-year useful life.
D. financial professionals must approve and validate every assumption.

14. In behavior-based safety programs, Antecedent-Behavior-Consequence Analysis is often used to evaluate safety performance. In terms of consequences, the *most powerful* influencers are:

A. soon, uncertain, and negative.
B. latent, uncertain, and positive.
C. soon, certain, and positive.
D. latent, certain, and negative.

15. A company operates a fleet of remote estimators working alone traveling between several job sites. Can a behavior-based safety (BBS) system be implemented for individual drivers?

A. Yes, by using a self-observation protocol.
B. Yes, by following each driver and recording their behaviors.
C. No, BBS is designed for peer-to-peer observation.
D. No, BBS only works for fixed locations with large groups of employees.

Domain 3 Quiz 3 Answers

1. Answer: **B**. According to international standards on Machine tool safety such as ANSI B11 series and EN1050 (now ISO 14121), "zero risk" does not practically exist. The goal is to reduce risk to a tolerable level, then **fully communicating any residual risk to** the user. Hazards and their effects can best be identified by analyzing tasks and can be classified by the worst credible injury that may occur from a hazardous event.

   The risk is determined by estimating the severity of the hazard—and the probability of occurrence of a hazardous event:

   - Hazards and their effects can best be identified by analyzing tasks.
   - Hazards can be classified by the worst credible injury that may occur from a hazardous event.
   - Risk is determined by estimating the severity of the hazard—and the probability of occurrence of a hazardous event.

2. Answer: **D**. In ANSI Z10, risk is defined as an estimate of the combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or illness that may be caused by the event or exposures. According to ANSI/ASSE/ISO Guide 73 (Z690.1-2011) Vocabulary for Risk Management, risk is simply the effect of uncertainty on objectives. Risk tolerance is an organization's readiness to bear the risk after risk treatment in order to achieve its objectives. Risk acceptance is an informed decision to take a particular risk. Acceptable risk is a residual risk level achieved after risk reduction measures have been applied. It is a risk level that is accepted for a given task (hazardous situation) or hazard. The terms "acceptable risk," "retained risk," and "tolerable risk" are considered synonymous. Residual risk is defined as the risk remaining after preventive measures have been taken. No matter how effective the preventive actions, residual risk will always be present if a facility or operation continues to exist.

3. Answer: **C**. This is the description of a hazard and operability study, commonly called a HAZOP study. When conducting a HAZOP, subject matter experts familiar with the process being studied are essential. A process hazard analysis leader familiar with the analytical method is important, but it is not essential for the study leader to be familiar with the process being studied.

4. Answer: **B**. According to "The Behavior Based Safety Process," a change in behavior does lead to a change in attitude.

5. Answer: **B**. Incident costs include both those that are insured and those that are not insured. The insured include medical and compensation costs paid to the claimant by the insurance company. The noninsured include time lost by others who observed or rendered assistance at the time of the incident, time lost to investigate the incident, time required to train a replacement, cost for damaged materials, etc.

6. Answer: **D**. According to Petersen (2003), only answers A, B, and C are representative of basic principles of loss control.

7. Answer: **C**. Most experts agree that the two things needed for reinforcement of desired behaviors are to provide positive reinforcement and to keep reinforcement close in time to a specified behavior for a stronger effect. Some experts say to effect long-term changes for minor infractions, a negative reinforcement may be used without overreacting.

   When discussing the "carrot and stick" management philosophy, some experts believe that the stick is no longer available, and the carrot is becoming less of an incentive.

8. Answer: **B**. According to E. Scott Geller, *The Psychology of Safety*, all four answers have an impact on behavior, but consequences, in general, have the most impact. Discipline and feedback can be considered types of consequences, but there are others to be considered including positive reinforcement and reward. Activators are signals preceding behavior.

9. Answer: **B**.

   As Low As Reasonably Practicable (ALARP) and promotes a management review, the intent of which is to achieve acceptable risk levels.

   As Low As Reasonably Achievable (ALARA). According to NRC, ALARA means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical.

   Best Available Control Technology (BACT). This level of control is required for new criteria pollutant sources in attainment areas. BACT is typically defined in the permitting process and can vary from state to state. Its use is determined through consideration of several factors including energy and environmental impacts as well as economics.

   Maximum Achievable Control Technology (MACT). The EPA 1990 CAAA changed the regulation of air toxins from substance-specific, health-based standards to industry-specific, technology-based requirements. Major hazardous air pollutants (HAP) sources must use MACT to reduce their emissions.

10. Answer: **C**. A hazard is defined as a condition, set of circumstances, or inherent property that can cause injury, illness, or death. Risk is an estimation of the combination of the likelihood of an occurrence of a hazardous event or exposure(s), and the severity of injury or illness that may be caused by the event or exposures. Risk assessment is a process(s) used to evaluate the level of risk associated with hazards and system issues. A risk assessment matrix provides a qualitative method to categorize combinations of indicators for occurrence probability and severity outcome, thus establishing risk levels (**Table 5**). A matrix provides an effective visual tool and helps in communication with decision-makers when deciding on the actions to be taken to reduce the risk. Risk assessment matrices can also be used to compare and prioritize risks and to effectively allocate mitigation resources (ANSI/ASSE Z10 2012).

Table 5 Risk Assessment Matrix

Likelihood of Occurrence or Exposure	Severity and Consequences			
	NEGLIGIBLE: First aid or minor medical treatment	**MARGINAL:** Minor injury, lost workday	**CRITICAL:** Disability in excess of 3 months	**CATASTROPHIC:** Death or permanent total disability
FREQUENT: Likely to occur repeatedly	MEDIUM	SERIOUS	HIGH	HIGH
PROBABLE: Likely to occur several times	MEDIUM	SERIOUS	HIGH	HIGH
OCCASIONAL: Likely to occur sometime	LOW	MEDIUM	SERIOUS	HIGH
REMOTE: Not likely to occur	LOW	MEDIUM	MEDIUM	SERIOUS
IMPROBABLE: Very unlikely to occur	LOW	LOW	LOW	MEDIUM

Risk Level:

LOW: Risk acceptable or tolerable, remedial action discretionary

MEDIUM: Take remedial action at appropriate time

SERIOUS: High priority remedial action

HIGH: Operation not permissible

These definitions are provided for illustration purposes and each organization must define these terms as applicable to their process.

11. Answer: **A**. Several control techniques available are for treating loss exposures. The two categories for reducing the costs of accidents in an organization: prevention (loss control) and financial (cost reduction). Loss control techniques include engineering, administrative controls, and personal protective equipment to deal with losses. Engineering controls include building a ventilation system to reduce explosive vapor levels, whereas administrative controls might limit exposures to toxic materials. Issuing personal protective equipment (PPE) such as respirators is the last line of defense against hazards in the workplace. A company might try to avoid the loss altogether. Organizations can reduce exposure by substitution. Instead of mixing methylene chloride as a solvent ingredient in a commercial aerosol product, a company could substitute a "safer" solvent to reduce the likelihood of a worker being exposed. ***Risk transfer*** assigns the liability to another party rather than running the risk of loss itself. If methylene chloride mixing could not be accomplished safely in the plant, the company may choose to have the product shipped to a contractor who would mix the ingredient. If the contractor's workers are overcome by vapors from the solvent mixing, then the contractor would typically hold the liability. *Another form of risk transfer is insurance. Insurance* is designed to permit the company to shift the financial consequences of the risk to an insurance company. By paying the insurance company's *premiums*, the organization can expect specified *benefits* in the event of loss. With large numbers of insureds, insurance companies can more accurately estimate its own losses. Organizations may retain their loss exposures without dealing with them. This may be a result of ignorance or choice. Organizations that retain their own exposures may ignore them, or attempt to reduce them or they may, in fact, self-insure. Ignoring the risks may make the owners more confident, but dealing with the risks will make them more prepared for loss. Self-insurance is simply no insurance; the company retains the loss exposure. It should only be undertaken by companies with the financial resources necessary to absorb potential losses.

Reproduced from Friend, M. A., & J. P. Kohn. *Fundamentals of Occupational Safety and Health*. Lanham, MD: Rowman & Littlefield, 2018.

12. Answer: **B**. Failure mode and effects analysis (FMEA)—also "failure modes," plural, in many publications—was one of the first highly structured, systematic techniques for failure analysis. A FMEA is often the first step of a system reliability study. It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA worksheet. There are numerous variations of such worksheets. A FMEA can be a qualitative analysis but may be put on a quantitative basis when mathematical failure rate models are combined with a statistical failure mode ratio database. Sometimes FMEA is extended to FMECA (failure mode, effects, and criticality analysis) to indicate that criticality analysis is performed too. FMEA is an inductive reasoning (forward logic) single point of failure analysis and is a core task in reliability engineering, safety engineering, and quality engineering. Quality engineering is especially concerned with the "Process" (Manufacturing and Assembly) type of FMEA.

    A successful FMEA activity helps to identify potential failure modes based on experience with similar products and processes—or based on common physics of failure logic. It is widely used in development and manufacturing industries in various phases of the product life cycle. Effects analysis refers to studying the consequences of those failures on different system levels. Functional analyses are needed as an input to determine correct failure modes, at all system levels, both for functional FMEA or Piece-Part (hardware) FMEA. An FMEA is used to structure Mitigation for Risk reduction based on either failure (mode) effect severity reduction or based on lowering the probability of failure or both. The FMEA is in principle a full inductive (forward logic) analysis; however, the failure probability can only be estimated or reduced by understanding the failure mechanism. Ideally this probability shall be lowered to "impossible to occur" by eliminating the (root) causes. It is therefore important to include in the FMEA an appropriate depth of information on the causes of failure (deductive analysis).

13. Answer: **A**. Costs need to be expressed in terms that are useful. Expressing costs in the right terms can help people understand the importance of safety and its contribution to company profit. Although each level may have a preferred way of expressing cost data, it can help first-line supervisors and workers understand the importance of safety, and if expressions of cost are understood by workers, they are certainly understandable by managers. A popular way to justify business expenditures is by comparing the cost of some expenditure with the benefit achieved in financial terms. In cost–benefit analysis, the dollar values of all benefits and costs connected with program alternatives are estimated and then compared. Not all cost and benefits can be converted to quantitative terms; some may be expressed only qualitatively. A final decision applies both to quantitative and qualitative factors.

    Reproduced from Brauer, R. *Safety and Health for Engineers*, 2nd ed. Hoboken, New Jersey: Wiley & Sons Inc, 2006.

14. Answer: **C**. This is an essential tool of safety management for discovering and addressing the root causes of accidents. Applied behavior analysis helps the organization to assess the factors that are really driving its safety efforts.

    ABC analysis involves the following principles:

    - Both antecedents and consequences influence behavior.
    - Consequences influence behavior powerfully and directly.
    - Antecedents (activators, triggers) influence behavior indirectly, primarily serving to predict consequences.
        - The highest level of performance you can expect from the people you supervise is determined by the minimum standards you have established and maintained.
        - Actions influence performance: Remember that silence (failure to act) is consent.

This nonpunitive approach characterizes the discussions and interviews with workers, developing a list of triggers or antecedents of the at-risk behavior. ABC Analysis has three fundamental steps:

1. Analyze the At-risk Behavior.
2. Analyze the Safe Behavior.
3. Draft the Action Plan.

When a facility's safety effort is not working, it is the consequences in favor of safe behavior that are weaker than the consequences in favor of at-risk behavior.

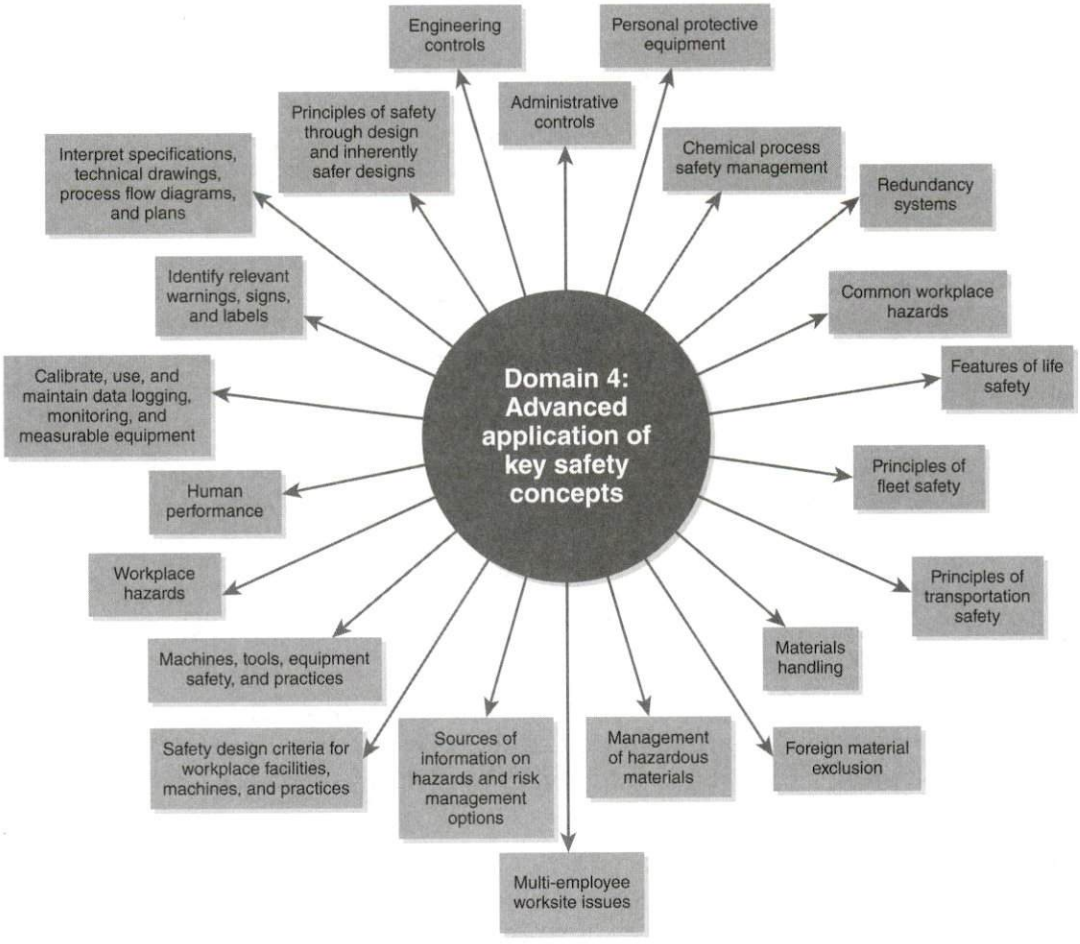
There are three features that determine which consequences are stronger than others. The strongest behavioral consequences are "soon, certain, and positive."

- **Timing.** A consequence that follows soon after a behavior influences behavior more effectively than consequences that occurs later. Again, silence is consent, thus failing to correct the unsafe act or at-risk behavior gives employees the indication that their behavior is acceptable, and the behavior goes uncorrected. This may set precedence for continued at risk behaviors. In an effective safety program, the at-risk behavior is identified and corrected immediately and effectively through immediate resolution of the antecedents.
- **Consistency.** A consequence that is certain to follow a behavior influences behavior more powerfully than an unpredictable or uncertain consequence. Failure to respond to each at-risk behavior or failure to consistently reinforce the standard of performance will send mixed signals to employees. Prompt, consistent, and persistent corrective action is required. In any safety cultural change implementation, it is essential that all members of the team be informed of the consequence for at-risk behavior and that supervision enforces the rules. This lays the groundwork for predictable consequence.
- **Significance.** A positive consequence influences behavior more powerfully than a negative consequence. Punitive verses resolution: Resolution comes in the form of discussion, investigation of the behavior, in search of the underlying causes or antecedents that may have given the employee the misguided perception that has created the at-risk behavior. By talking with the employee and altering the perception, we have educated the employee without punitive action and have gained buy-in for safe behavior.

Many safety programs are oriented toward penalties and punishments rather like the traffic citation for speeding. The usual effect is not to change behavior but rather to teach people not to get caught. Negative consequences are less powerful in their impact on worker behavior than positive consequences (Krause 2005).

15. Answer: **A**. Behavior-based safety systems (BBS) typically use peer-to-peer observation methods to assess and measure conformance with behavior expectations. However, a self-observation protocol can be developed and implemented. It is important that the self-observed are involved in program design and development for successful implementation and buy-in to how the data will be used. The primary goal for any safety program is to cultivate safer workers. Safer workers are a result of behavior change, in that workers recognize unsafe or at-risk behaviors for what they are and then perform or do things to reduce or eliminate the at-risk behavior.

Domain 4: Advanced Application of Key Safety Concepts



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.

Key CSP Blueprint Themes

Blueprint reference

Domain 4: Advanced Safety Concepts

- Evidence-based practice
- Situational analysis, hazard/risk recognition, evaluation, control
- Loss control, Loss prevention, Loss reduction
- Applied hierarchy of controls
- Risk transfer
- Safety through design
- Elements of chemical process safety management
- Subject matter expertise and where to find it

Key CSP Blueprint Themes: Domain 4

Domain 4 Quiz 1 Questions

1. **The *major* benefit of a data logger with industrial hygiene monitoring devices is to:**

   A. manually records data.
   B. code the data so it can't be read without the code.
   C. digitize data for future use and analysis.
   D. This does not need to be monitored.

2. **Hazardous waste profiles from several chemical processes to include nonpotable water, lithium metal, acetone, and halogenated hydrocarbons. What is the *greatest* concern for a waste site worker segregating waste streams into 55-gal drums?**

   A. Mixing lithium metal and nonpotable water
   B. Mixing lithium metal and acetone
   C. Mixing spent acetone and nonpotable water
   D. Mixing halogenated hydrocarbons and acetone

3. **Stack sampling for particulate aerosols is done in an isokinetic manner to:**

   A. avoid size discrimination of collected particles.
   B. minimize particle deposition in sampling tube.
   C. collect respirable size particles only.
   D. collect samples suitable for direct analysis.

4. **The principle of wet collectors' type ventilation system air filters is to get the dust into direct contact with a liquid. Which *wet collector* systems uses high velocity air and water fed through to the throat, resulting in a pressure drop-off from 10 to 15 in. wg?**

   A. Spray chamber
   B. Packed tower
   C. Wet centrifugal
   D. Venturi type

5. **Multiplexing is an information technology *best* described as:**

   A. the mixture of signals for amplified bandwidth.
   B. the broadcast of small, condensed packets of information.
   C. a method of decreasing bandwidth and signal-to-sound ratio.
   D. the transmission of multiple signals on a single path.

6. **In product development, manufacture, and use, which phase is *most important* to ensure a safe product is provided to the consumer?**

   A. Design
   B. Testing
   C. Production
   D. Maintenance

7. **When conducting a preliminary hazard evaluation for a new process, which question is *least appropriate* during this phase of analysis?**

   A. What are the raw materials?
   B. What intermediate products are formed in the process?
   C. What by-products may be released?
   D. When should you provide PPE?

8. The *most important* factor of wrench design is:

A. the purpose of the tool and how it will be used.
B. the type of metals used and grip strength.
C. the type of worker and work environment.
D. the use of self-opening springs and grip size.

9. What does a CE marking on an electrical product for sale indicate?



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A. The product is a certified electrical device.
B. The product is a listed on the European Union certified equipment list.
C. The product can be exported from the European Union to the United States or Canada.
D. The product conforms to European Union health, safety, and environmental protection standards.

10. A piece of office equipment is labeled with the mark shown in the exhibit. This mark indicates:



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A. a specific piece of equipment and model number has been tested and certified that it meets underwriters laboratories published standards for product safety.
B. the product manufacturer has determined that this line of products is safe for intended use.
C. the product is listed in the universal library for patents.
D. a statement that the product is certified to operate for a minimum number of hours before failure.

11. UN 1A1/ is the code for a steel, closed-head drum, meaning the:



From UN packing symbol of United Nations General Assembly, United Nations. Reprinted with the permission of the United Nations.

A. drum contents are hazardous and must be listed on shipping paper.
B. drums can be shipped internationally.
C. packaging conforms to performance requirements for shipment.
D. packaging was produced by the United Nations.

12. Safety Data Sheets (SDS) for chemicals in the work area shall be readily accessible to workers in a reasonable amount of time. The *most effective* way to maintain updated SDSs for the entire facility is to:

A. distribute all facility SDSs to each worker by email and place printed copies in each work area.
B. maintain a master printed copy of all SDSs in the safety office and make available on request.
C. provide an external hard drive in each work area with copies of all the facility SDSs.
D. integrate an automated electronic SDS updates from suppliers with cloud-based searchable databases synced with worker smartphones.

13. A facility is installing a new machine as part of their operations. The new equipment consists of two rollers rotating inward, creating a pinch point. The *best* option for protecting operators from this hazard is:

A. installation of a fixed guard with interlocks.
B. proper training to safely bypass a removable guard.
C. use of distance to prevent worker exposure.
D. install pull-back hand restraints.

14. Insulated enclosures are often used in noise control and designed *primarily* to:

A. eliminate the source from generating sound pressure levels.
B. reduce noise level at the point of sound wave generation.
C. reduce noise exposure with sound pressure level absorbing materials.
D. amplify sound pressure levels between source and the barrier.

15. A _____consists of all equipment used to keep an employee from reaching a fall point, such as the edge of an elevated working surface.

A. fall restraint system
B. fall protection system
C. fall arrest system
D. safety net system

16. Which of the following are the GHS signal words that indicate the relative degree of a hazard's severity?

A. Danger, Warning
B. Caution, Danger
C. Hazardous, Dangerous
D. Warning, Caution

17. The *primary* hazards associated with pyrophoric liquids and solids are classified as:

A. physical hazards.
B. health hazards.
C. hazards not otherwise classified (HNOC).
D. mechanical asphyxiants.

18. All Safety Data Sheets are comprised of:

A. 10 sections.
B. 12 sections.
C. 14 sections.
D. 16 sections.

19. The pictogram represents which hazard?



OSHA, Hazard Communication Standard Pictogram, U.S. Department of Labor.

A. Pyrophorics and explosives
B. Narcotic effects
C. Reproductive toxicity
D. Acute toxicity and narcotic effects

20. The *first* action to be considered in the hierarchy of control is:

A. training of workers based on job hazard analysis.
B. prevention by risk avoidance through hazard elimination.
C. issue personal protective equipment for risk reduction.
D. hazardous substitution through risk transfer.

Domain 4 Quiz 1 Answers

1. Answer: **C**. A data logger is an electronic instrument used to take measurements from sensors and store those measurements for future use. Some common measurements include temperature, pressure, current, velocity, strain, displacement, and other physical phenomena.

   A data logger works with sensors to convert physical phenomena and stimuli into electronic signals such as voltage or current. These electronic signals are then converted, or digitized into binary data. The binary data is then easily analyzed by software and stored on a PC hard drive or on other storage media such as memory cards.

   The ability to take sensor measurements and store the data for future use is, by definition, a characteristic of a data logger. However, a data-logging application rarely requires only data acquisition and storage. Inevitably, you need the ability to analyze and present the data to determine results and make decisions based on the logged data.

2. Answer: **A**. The consequences of mixing incompatible chemicals together are potentially severe from a health and safety perspective. From a disposal perspective, mixing of wastes can be costly. Mixed wastes can result in the need for sequential treatment using different technologies at different facilities. It is unlikely that random mixing of different waste materials together will reduce the toxicity of the mixture. Lithium metal is water reactive and should not be mixed.

3. Answer: **A**. Isokinetic or "equal velocity" sampling occurs when the velocity at the sampling probe tip is equal to the gas stream velocity. If the velocities are substantially different (nonisokinetic), it can cause size-selective segregation of particulate matter entering the probe. When the stack/stream velocity is lower than the probe velocity, larger particles are not able to turn with the gas flow into the probe nozzle, leading to underestimation of the mass concentration. Likewise, when the stream velocity is greater than the probe velocity, exaggerated readings of concentration are produced.

4. Answer: **D**. As the name implies the *Venturi-type* is the correct answer. The questions on the CSP examinations about the various wet collector systems are usually not this friendly and require you to understand the difference between at least seven types of wet collectors' systems commonly employed in industry today. We suggest a good review of this subject in the National Safety Council's *Fundamentals of Industrial Hygiene* (Plog 2012). One of the oldest methods of spray cleaning is *spray chambers,* which result in a pressure drop of about 2.5 to 6 in. wg. *Packed towers* are used by the chemical industry for gas absorption and sometimes for toxic dusts. They have a pressure drop of only 1.5 to 3.5 in. wg. *Wet centrifugals* use a combination of centrifugal force and water contact to capture dust particles. Pressure drop is in the area of 2.5 to 6 in. wg. Another type of wet collector is the Orifice type that has a pressure drop from 1 to 20 in. wg.

5. Answer: **D**. **Multiplexing** is defined as the transmission of multiple signals over a single transmission path (e.g., data and voice at the same time). There are two primary types of multiplexing: frequency division and time division.

   Frequency division multiplexing is achieved by dividing the channel bandwidth into bands and allocating a band to each system, requiring the use of the channel for the transmission of its signals. This allows multiple signals at the same time.

   In a time division multiplex system, the information is discrete in time; therefore, transmission scheme can provide rest periods between transmissions. This form of multiplexing provides a simpler and cheaper form of multiplexing than frequency division multiplexing; however, it only accesses one device at a time.

6. Answer: **A**. According to Willie Hammer in "*Product Safety Management and Engineering*," management responsibilities throughout the process is the most important; however, during the design phase, the designers are the most important in producing a safe product.

7. Answer: **D**. According to Plog (2012), the initial hazard recognition process, includes the following questions: What are the raw materials? What is produced? What intermediate products are formed in the process? What by-products may be released? What are the usual cleaning or maintenance procedures at the end of the day, end of a run, or changeover to another product? What hazardous waste is produced, and how is it disposed of?

8. Answer: **A**. According to NIOSH, the best nonpowered hand tool is one that fits the job you are doing, fits the workspace available, reduces the force you need to apply, fits your hand, and can be used in a comfortable work position.

9. Answer: **D**. This is a European marking that states the electrical equipment shall be safely constructed in accordance with principles generally accepted within the member states as constituting good engineering practice in relation to safety matters. It shall be designed and constructed to ensure that it is safe when connected to the electrical supply system by providing a level of protection against electric shock. This relies on a combination of insulation and the protective earthing conductor contained within the electrical supply system or which achieves that level of protection by other means. In conformity with the principal elements of the safety objectives for electrical equipment. Like the UL and FM listing in the United States, the CE marking is used on many types or products offered for sale in the European Union and indicates that the product conforms to established safety and health standards in the European Union. The implication is that these standards are government-adopted.

10. Answer: **A**. The Underwriters Laboratory (UL) Mark on a product means that UL has tested and evaluated representative samples of that product and determined that they meet UL requirements. There are many types of UL Marks, each with its own specific meaning. The only way to determine if a product has been certified by UL is to look for the UL Mark on the product itself. In a few instances, the UL Mark may be present only on the packaging of a product. The UL Listing Mark is one of the most common UL Marks. If a product carries this mark, it means UL found that representative product samples met UL's safety requirements. These requirements are primarily based on UL's own published standards for safety. This type of mark is seen commonly on appliances and computer equipment, furnaces and heaters, fuses, electrical panel boards, smoke and carbon monoxide alarms, fire extinguishers and sprinkler systems, personal flotation devices, bullet-resistant glass, and thousands of other products.
11. Answer: **C**. The Research and Special Program Administration (RSPA) published final rule HM-181. In this rule, RSPA adopted a performance-oriented approach to construction of nonbulk and intermediate-bulk hazardous materials packaging. These changes were based on the United Nations (UN) Recommendations on Transport of Dangerous Goods and harmonized US and International standards for the transportation of hazardous materials. Each manufacturer must mark every packaging that meets UN standards with markings specified in §49 CFR 178.503. The identification codes must be durable and legible. Identification marks will be placed in a location on the packaging to be readily visible.

    All certified hazardous materials packaging's must bear the United Nations symbol.

    The letters UN may be applied in place of the symbol. Identification codes must be printed or embossed on packaging in association with the UN Symbol. The packaging identification code designates:

    - type of packaging;
    - material of construction; and, when appropriate
    - category of packaging.



From UN packing symbol of United Nations General Assembly, United Nations. Reprinted with the permission of the United Nations.

12. Answer: **D**. The most effective means described is to integrate an automated electronic SDS update service from suppliers with cloud-based searchable databases synced with worker smartphones. All updates are available to all work areas as soon as they are posted.
13. Answer: **A**. If the pinch point in question does not require frequent access for maintenance or cleaning, the best answer is a permanent fixed guard designed with interlocks to deenergize equipment that makes removal difficult if the guard is opened.
14. Answer: **C**. According to Plog (2012), generally, an enclosure is placed around a noise source to prevent noise from getting outside. Enclosures are normally lined with sound-absorption material to decrease internal sound pressure buildup. Another option is to enclose the worker, such as sound-proof booths that prevent noise from getting inside.
15. Answer: **A**. The best selection is A because the definition of a fall restraint system consists of the equipment used to keep an employee from *reaching a fall point*, such as the edge of a roof or the edge of an elevated working surface. The most commonly utilized fall restraint system is a standard guardrail. A tie-off system that "restrains" the employee from falling off an elevated working surface is another type of fall restraint. Fall protection systems consist of:

    - Guardrail Systems
    - Safety Net Systems
    - Personal Fall Arrest Systems
    - Positioning Device Systems
    - Warning Line Systems
    - Controlled Access Zones
    - Safety Monitoring Systems
    - Covers
    - Protection from Falling Objects
    - Fall Protection Plan (limited)

Personal Fall Arrest Systems must include four elements, referred to as ABCDs of Fall Arrest:

- A—Anchorage: a fixed structure or structural adaptation, often including an anchorage connector, to which other components of PFAS are rigged
- B—Body Wear: a full body harness worn by worker
- C—Connector: a subsystem component connecting harness to anchorage—such as a lanyard
- D—Deceleration Device: a subsystem component designed to dissipate forces associated with a fall arrest event

16. Answer: **A**. The signal word indicates the relative degree of severity of a hazard. The only two signal words used in GHS are:

- "Danger" for more severe hazards
- "Warning" for less severe hazards

Signal words are standardized and assigned to hazard categories within endpoints. Some lower level hazard categories do not use signal words. Only one signal word corresponding to the class of the most severe hazard should be used on a label. The GHS hazard pictograms, signal word, and hazard statements should be located together on the label (**Figure 17**). The actual label format or layout is not specified in GHS. National authorities may choose to specify where information should appear on the label or allow supplier discretion.

There will only be one signal word on the label no matter how many hazards a chemical may have. If one of the hazards warrants a "Danger" signal word and another warrants the signal word "Warning," then only "Danger" should appear on the label.

Labels for a hazardous chemical must contain:

- Name, Address, and Telephone Number
- Product Identifier
- Signal Word
- Hazard Statement(s)
- Precautionary Statement(s)
- Pictogram(s)

Figure 17 Labels for Hazardous Chemicals

17. Answer: **A**. According to the Hazard Communication Standard, OSHA 1910.1200 (2012) *Appendix B, Physical Criteria (Mandatory)*, *pyrophoric liquid* means a liquid that, even in small quantities, is liable to ignite within 5 minutes after contact with air.

A pyrophoric liquid shall be classified in a single category for this class using test N.3 in Part III, subsection 33.3.1.5 of the UN ST/SG/AC.10 (incorporated by reference; See §1910.6), in accordance with Table B.9.1.

Table B.9.1 Criteria for Pyrophoric Liquids

Category	Criteria
1	The liquid ignites within 5 min when added to an inert carrier and exposed to air, or it ignites or chars a filter paper on contact with air within 5 min.

The classification procedure for pyrophoric liquids need not be applied when experience in production or handling shows that the chemical does not ignite spontaneously on coming into contact with air at normal temperatures (i.e., the substance is known to be stable at room temperature for prolonged periods of time (days)).

Pyrophoric solid means a solid that, even in small quantities, is liable to ignite within 5 minutes after coming into contact with air.

A pyrophoric solid shall be classified in a single category for this class using test N.2 in Part III, subsection 33.3.1.4 of the UN ST/SG/AC.10 (incorporated by reference; see §1910.6), in accordance with Table B.10.1.

Table B.10.1 Criteria for Pyrophoric Solids

Category	Criteria
1	The solid ignites within 5 min of coming into contact with air.

18. Answer: **D**. The SDS will include at least the following section numbers and headings and associated information within each heading, in the order listed (OSHA, *Hazard Communication Standard: Safety Data Sheets*):

- **Section 1 Identification**—includes product identifier, manufacturer or distributor name, address, phone number, emergency phone number, recommended use, and restrictions on use
- **Section 2 Hazard(s) identification**—includes all hazards regarding the chemical and required label elements
- **Section 3 Composition/Information on ingredients**—includes information on chemical ingredients and trade secret claims
- **Section 4 First-aid measures**—includes important acute or delayed symptoms or effects and required treatment
- **Section 5 Fire-fighting measures**—lists suitable extinguishing techniques, equipment, and chemical hazards from fire
- **Section 6 Accidental release measures**—lists emergency procedures, protective equipment, and proper methods of containment and cleanup
- **Section 7 Handling and storage**—lists precautions for safe handling and storage, including incompatibilities
- **Section 8 Exposure controls/Personal protection**—lists OSHA's permissible exposure limits, threshold limit values (TLVs), appropriate engineering controls, and personal protective equipment (PPE)
- **Section 9 Physical and chemical properties**—lists the chemical's characteristics
- **Section 10 Stability and reactivity**—lists chemical stability and possibility of hazardous reactions
- **Section 11 Toxicological information**—includes routes of exposure, related symptoms, acute and chronic effects, and numerical measures of toxicity
- **Section 12 Ecological information***
- **Section 13 Disposal considerations***
- **Section 14 Transportation information***
- **Section 15 Regulatory information***
- **Section 16 Other information**—includes date of preparation or last revision

*Notation concerning Sections 12 to 15: OSHA will not enforce information requirements in Sections 12 to 15; however, the SDS must include at least the heading names for those sections.

19. Answer: **D**. It is used on a chemical label for substances that represent the following hazards **(Table 6)**:

- Irritant—irritates the skin or eyes
- Skin sensitizer—an allergic response following skin contact
- Acute toxicity—a single short-term exposure may be fatal or cause organ damage
- Narcotic effects, such as drowsiness, lack of coordination, and dizziness
- Respiratory tract irritation

Table 6 GHS Pictograms and Hazard Classes

		
• Oxidizers	• Flammables • Self-Reactives • Pyrophorics • Self-Heating • Emits Flammable Gas • Organic Peroxides	• Explosives • Self-Reactives • Organic Peroxides

(continued)

		
• Acute toxicity (severe)	• Corrosives	• Gases Under Pressure
		
• Carcinogen • Respiratory Sensitizer • Reproductive Toxicity • Target Organ Toxicity • Mutagenicity • Aspiration Toxicity	• Environmental Toxicity	• Irritant • Dermal Sensitizer • Acute toxicity (harmful) • Narcotic Effects • Respiratory Tract • Irritation

OSHA, Hazard Communication Standard Pictogram, U.S. Department of Labor.

20. Answer: **B**. Risks are reduced to an acceptable level through the application of the hierarchy of controls. A hierarchy of controls provides a systematic way of thinking, considering steps in a ranked and sequential order, to choose the most effective means of eliminating or reducing hazards and their associated risks. Acknowledging that premise that risk reduction measures should be considered and taken in a prescribed order represents an important step in the evolution of the practice of safety. These methods are to be applied when new facilities, equipment, and processes are acquired; when existing facilities, equipment, and processes are altered; and when incidents are investigated.

    In applying a hierarchy of controls, the desired outcome of actions taken is to achieve an acceptable risk level. Acceptable risk is that risk for which the probability of a hazards-related incident or exposure occurring and the severity of harm or damage that could result are as low as reasonably practicable and tolerable in the situation being considered. That definition requires several factors be taken into consideration:

    - avoiding, eliminating, or reducing the probability of a hazards-related incident or exposure occurring;
    - reducing the severity of harm or damage that may result if an incident or exposure occurs; and
    - the feasibility and effectiveness of risk-reduction measures to be taken, and their costs, in relation to the amount of risk reduction to be achieved.

    Six Levels of Action

    Decision-makers should understand that with respect to the six levels of action shown in the following hierarchy of controls, the methods described in the first, second, and third action levels are more effective because they:

    - are preventive actions that eliminate/reduce risk by design, substitution, and engineering measures;
    - rely the least on the performance of personnel; and
    - are less likely defeated or bypassed by supervisors or workers.

    Actions described in the fourth, fifth, and sixth levels are contingent actions and rely greatly on the performance of personnel for their effectiveness. The following hierarchy of controls (**Table 7**) is considered state-of-the-art, and it is compatible with the hierarchy in ANSI/ASSE Z10 (2012):

    1. Eliminate or reduce risks in the design and redesign processes.
    2. Reduce risks by substituting less hazardous methods or materials.
    3. Incorporate safety devices.
    4. Provide warning systems.
    5. Apply administrative controls (e.g., work methods, training, work scheduling).
    6. Provide PPE.

Table 7 Hierarchy of Controls Prioritized from Most Effective to Least Effective

Controls	Examples
1. Elimination	Design to eliminate hazards: falls, HAZMAT, confined spaces, materials handling, tools and machinery, etc.
2. Substitution	Substitute for less hazardous materials and equipment, reduce energy, etc.
3. Engineering Controls	Incorporate safety through design such as: ventilation systems, enclosures, guarding, interlocks, lift tables, conveyors, etc.
4. Warnings	Strategically place signs, alarms, enunciators, labels, etc.
5. Administrative Controls	Standard Operating Procedures (SOPs) such as: conduct JSAs, job rotation, inspections, training, mentoring, etc.
6. Personal Protective Equipment	PPE assessments may result in the use of safety glasses, goggles, face shields, fall protection, protective footwear, gloves, respirators, chemical suits, etc.

ANSI/ASSE Z10. *American National Standard for Occupational Health & Safety Management Systems*. Des Plaines, IL: American Society of Safety Engineers, 2012.

Domain 4 Quiz 2 Questions

1. **Large metal facility measures 900 feet by 300 feet with warehousing operations and general offices occupying 90 workers. A risk assessment indicates that the building contents are highly *unlikely* to explode, not hazardous materials, and will readily burn when exposed to fire, emitting volumes of smoke. What is the *likely* hazard classification for this facility?**

   A. Low hazard
   B. Ordinary hazard
   C. High hazard
   D. Extra high hazard

2. **The incorporation of hazard analysis and risk assessment methods early in design and redesign processes and taking appropriate actions so risks of injury or damage are at an acceptable level is termed:**

   A. severity.
   B. deterrence through design.
   C. safety through design.
   D. hierarchy of controls.

3. **A confined space is large enough and so configured that an employee can bodily enter and perform assigned work, is not designed for continuous employee occupancy, and:**

   A. has a hazardous atmosphere that impairs self-rescue.
   B. has only one way in and one way out.
   C. has limited or restricted means for entry or exit.
   D. has an internal configuration that creates a trap.

4. **In a confined space operation, it is required to control hazardous chemicals in a section of piping system. What is the *best* way to control this hazard?**

   A. Blanking and blinding
   B. Inerting the space
   C. Confined space permit
   D. Double block and bleed

5. The proper order of atmospheric testing in a confined space is:

A. flammability, oxygen, toxic.
B. toxic, oxygen, flammability.
C. oxygen, flammability, toxicity.
D. oxygen, toxics, flammability.

6. IR-B includes light wavelengths from 1.4 to 100 μm. Infrared radiation can cause eye injury and *most likely* associated with which work environment?

A. Dark room for photography
B. Microscope used in a laboratory
C. Foundry operations
D. X-ray technician

7. The signal word "DANGER," on product warning labels is used where there is an immediate hazard and exposure that, if encountered, may result in:

A. death or severe personal injury.
B. death, severe personal injury, or extensive property damage.
C. death, extensive property damage, extensive product damage, and severe personal injury.
D. death, loss of livelihood, and property damage.

8. The *primary* function of a warning sign is:

A. to provide information for supervisors.
B. to provide information for employees.
C. for employees to recognize and understand hazards.
D. to protect a company from regulatory citations and lawsuits.

9. Proof testing is defined as:

A. a test that stretches the sling to its maximum tensile strength.
B. a logic tree designed to help in selection of a proper sling.
C. a chemical test to make certain the correct material was used to construct a sling.
D. a nondestructive tension test performed by the sling manufacture or an equivalent entity to verify construction and workmanship of a sling.

10. New construction work is being conducted on an interior room on a high floor of a building. The ceiling, floor, and east and west walls are constructed. The north and south walls are tarped, and a kerosene heating unit is in the space. What is the *best* action?

A. Rotate work crew in and out.
B. Monitor the atmosphere.
C. Remove the heating fuel.
D. Supply fresh airflow.

11. A company is setting up a laboratory to do experimental work for their electroplating division. One workstation involves use of perchloric acid. Management plans on purchasing a local exhaust hood for this station and to ask a CSP for recommendations on hood specifications. Which recommendation should *not* be included?

A. Hood and duct material must be nonreactive, acid resistant, and relatively impervious.
B. Hood and duct should be designed for easy cleaning and built-in wash-down facilities.
C. Construction should allow for easy visual inspection.
D. Utility controls should be inside the hood.

12. Which statement *best* characterizes the implication of substituting the phrase "design to achieve minimum risk" with the phrase "design to achieve acceptable risk"?

A. The two phrases are synonymous.
B. Designing to achieve acceptable risk is appropriate only when designing to achieve minimum risk is shown to be unachievable.
C. Designing to achieve minimum risk may require spending much more money to reduce the risk of a certain event far below what would be an acceptable risk level.
D. Designing to achieve minimum risk is what safety and health professionals should solely advocate since they must have no opinion on what constitutes acceptable risk.

13. LASER is an acronym for:

A. Luminance Absorption of Stimulated Emitted Radioactivity.
B. Light Amplification by Stimulated Emission of Radiation.
C. Light Adsorption by Special Electromagnetic Radiation.
D. Lumens of Amplified Stimulated Electronic Radioactivity.

14. A _____ is an object that connects a piece of electrical equipment to earth or some conducting body that serves in place of earth. A _____ serves to complete the electrical circuit and prevent the hazard to electrical shock caused by defective equipment and that may cause death or serious injury.

A. bond
B. ground
C. metal frame
D. double-insulation

15. Damaged electrical equipment:

A. should be removed from service.
B. indicates a lack of supervisory accountability.
C. indicates unsafe employee behavior.
D. indicates a lack of safety resources.

16. Vehicle airbags:

A. are the most important safety device in the vehicle.
B. remain inflated for safety until emergency personnel can disable them.
C. require children under the age of 12 to remain in the back seat.
D. are most effective when the driver is within 5 inches of the steering wheel.

17. Only a small percentage of car accidents are the result of mechanical failure. How can a company *best* control the major cause of driver error?

A. Conducting monthly safety meetings
B. Requiring substance abuse testing of all drivers
C. Hiring only drivers under 40 years of age
D. Implementing a program of driver selection, training, and supervision

18. A canopy hood would *not* be considered an acceptable ventilation system for a large solvent dip tank if:

A. the hood would be unacceptably large.
B. larger fans are needed.
C. contaminant is drawn through the breathing zone.
D. a hood would get in the way of the lifting device.

19. The final step in a machine lockout procedure is to:

A. verbally announce that the machine is now locked-out.
B. release all stored or residual energy sources.
C. verify the isolation of the equipment by operating the machine controls.
D. make sure all emergency-stop buttons have been depressed.

20. Tag attachments must warn employees about machine hazards if energized and be standardized, self-locking, nonreleasable, and with a minimum unlocking strength of:

A. 50 lbs.
B. 25 lbs.
C. 10 lbs.
D. 75 lbs.

Domain 4 Quiz 2 Answers

1. Answer: **B**. The NFPA 101®, *Life Safety Code®*, classifies the hazard of contents of any building or structure as low, ordinary, or high based on the characteristics of the contents. *These are not the same classifications used to categorize sprinkler systems.*

   - Low hazard contents are seldom encountered and consist of materials of such low combustibility that no self-propagating fire can occur.
   - Ordinary hazard contents are those that are likely to burn with moderate rapidity or to give off a considerable volume of smoke.
   - High hazard contents are classified as those that are likely to burn with extreme rapidity and from which explosions are likely.

   Reproduced from NFPA 101®, Life Safety Code®, NFPA 13

   NFPA codes are revised every three years.

2. Answer: **C**. **Safety through design is defined as** the integration of hazard analysis and risk assessment methods early in the design and redesign processes and taking the actions necessary so that the risks of injury or damage are at an acceptable level. This concept encompasses facilities, hardware, equipment, tools, materials, layout and configuration, energy controls, environmental concerns, and products.

   - **Severity is** the extent of harm or damage that could result from an incident.
   - **Prevention through design is** addressing occupational safety and health needs in design and redesign processes to prevent or minimize work-related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, equipment, and processes.
   - **Hierarchy of controls is** a systematic way of thinking and acting, considering steps in a ranked and sequential order, to choose the most effective means of eliminating or reducing hazards and the risks that derive from them.

   An example is the requirement of suppliers of services to attest that processes have been applied to identify and analyze hazards and to reduce the risks deriving from those hazards to an acceptable level. There is precedent for having suppliers attest that risk analyses have been completed. Manufacturers of equipment to be used in the European Union are required by International Organization for Standardization (ISO) standards to certify that they have met applicable standards, including ISO 12100-1 and ISO 14121.

3. Answer: **C**. As per the OSHA 1910.146 Standard, **"confined space"** means a space that:

   - is large enough and so configured that an employee can bodily enter and perform assigned work;
   - (2) has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
   - (3) is not designed for continuous employee occupancy. "Nonpermit confined space" means a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

"Permit-required confined space (permit space)" means a confined space that has one or more of the following characteristics:

- Contains or has a potential to contain a hazardous atmosphere;
- Contains a material that has the potential for engulfing an entrant;
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
- Contains any other recognized serious safety or health hazard. "Permit-required confined space program (permit space program)" means the employer's overall program for controlling, and, where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces. "Entry permit (permit)" means the written or printed document that is provided by the employer to allow and control entry into a permit space. "Permit system" means the employer's written procedure for preparing and issuing permits for entry and for returning the permit space to service following termination of entry.

4. Answer: **D**.

"Isolation" means the process by which a permit space is removed from service and completely protected against the release of energy and material into the space by such means as: blanking or blinding; misaligning or removing sections of lines, pipes, or ducts; a double block and bleed system; lockout or tagout of all sources of energy; or blocking or disconnecting all mechanical linkages.

"Double block and bleed" means the closure of a line, duct, or pipe by closing and locking or tagging two inline valves and by opening and locking or tagging a drain or vent valve in the line between the two closed valves.

"Blanking or blinding" means the absolute closure of a pipe, line, or duct by the fastening of a solid plate (such as a spectacle blind or a skillet blind) that completely covers the bore and that can withstand the maximum pressure of the pipe, line, or duct with no leakage beyond the plate.

"Line breaking" means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

"Inerting" means the displacement of the atmosphere in a permit space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible. *NOTE:* This procedure produces an IDLH oxygen-deficient atmosphere (OSHA 1910.146 Standard).

5. Answer: **C**. Atmospheric testing is required for two distinct purposes: evaluation of the hazards of the permit space and verification that acceptable conditions exist for entry into that space. Verification testing is done to make sure that the chemical hazards that may be present are below the levels necessary for safe entry, and that they meet the conditions identified on the permit. Test the atmosphere in the following order: (1) for oxygen, (2) for combustible gases, and then (3) for toxic gases and vapors. The testing results, the actual test concentrations, must be recorded on the permit near the levels identified for safe entry. The testing results and the decisions about what steps must be followed before entry must be evaluated by, or reviewed by, a technically qualified professional like an, a certified industrial hygienist, a registered safety engineer, or a certified safety professional. The technically qualified professional must consider all the serious hazards in his/her evaluation or review (OSHA 1910.146, Appendix B).

"Hazardous atmosphere" means an atmosphere that may expose employees to the risk of death, incapacitation, and impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

1. Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);
2. Airborne combustible dust at a concentration that meets or exceeds its LFL; *NOTE:* This concentration may be approximated as a condition in which the **dust obscures vision at a distance of 5 feet** (1.52 m) or less.
3. Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;

4. Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of this Part and which could result in employee exposure in excess of its dose or permissible exposure limit; *NOTE:* An atmospheric concentration of any substance that is not capable of causing death, incapacitation, and impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision. (5) Any other atmospheric condition that is immediately dangerous to life or health (OSHA 1910.146 Standard).

6. Answer: **C**. Infrared radiation has wavelengths from 700 nm to 1 mm and is characterized by smaller bands. IR-A (near infrared) is the spectral region from 701 to 1400 nm. IR-B includes wavelengths from 1.4 to 100 mm. The IR-C spectrum is 0.1 to 1 mm. Most radiative heat transfer involves the infrared region. Sources of infrared typically are sources of radiative heat, including fires and open flames, stoves, electrical heating elements, certain lasers, and many other sources. Near infrared radiation (700–1400 nm) passes through the lens of the eye to the retina or is refracted from other tissues. High energy levels can cause a variety of eye disorders, among which is scotoma. Scotoma is loss of vision in a portion of the visual field resulting from damage to the retina where radiation is absorbed. Other disorders range from simple reddening from low-level exposures to swelling of the eye, hemorrhaging, and lesions. Extended exposures to infrared radiation can cause cataracts. Common examples are glassblower's and bottle maker's cataracts that result from looking into fire and heat sources. Iron workers who peer into furnaces extensively have a high incidence of cataracts. To limit the danger from infrared radiation, limit the duration of exposure and the intensity of exposure. Because the danger is mainly to the retina of the eye, considering infrared sources should be avoided. The intensity of exposure is most easily reduced by shielding. Eyewear that absorbs and reduces the amount of infrared reaching the eye should be worn. Lenses in glasses, goggles, or face shields must have the correct shade to reduce harmful levels.

   Reproduced from Brauer, R. *Safety and Health for Engineers*, 2nd ed. Hoboken, NJ: Wiley & Sons Inc., 2006.

7. Answer: **A**. There are three traditional levels of warnings:

   - Danger is used where there is an immediate hazard, which, if encountered, will result in severe personal injury or death.
   - Warning is the signal word for hazards or unsafe practices which could result in severe personal injury or death.
   - Caution is used for hazards or unsafe practices which could usually result in minor personal injury, product damage, or property damage.

   Evaluation of the warning adequacy at minimum requires consideration of the dangerousness of the product, the intensity of and form of the warning given, and the likelihood that a warning will be adequately communicated. The burden is upon the manufacturer to provide such warnings.

8. Answer: **C**. The word "sign" refers to a surface prepared for the warning of, or safety instructions of, industrial workers or members of the public who may be exposed to hazards. Excluded from this definition, however, are news releases, displays commonly known as safety posters, and bulletins used for employee education.

   The wording of any sign should be easily read and concise. The sign should contain sufficient information to be easily understood. The wording should make a positive rather than negative suggestion and should be accurate in fact. "Major message" means that portion of a tag's inscription that is more specific than the signal word and that indicates the specific hazardous condition or an instruction to be communicated to the employee. Examples include: "High Voltage," "Close Clearance," "Do Not Start," "Do Not Use," or a corresponding pictograph used with a written text or alone. "Signal word" means that portion of a tag's inscription that contains the word or words that are intended to capture the employee's immediate attention.

9. Answer: **D**. This is the definition listed in the definitions of 29 CFR 1910.184.

10. Answer: **D**. When working with a combustion heater in an enclosed workspace, carbon monoxide is a concern. A continuous supply fresh air flow is needed for proper air changes to reduce the buildup of carbon monoxide (CO).

11. Answer: **D**. Perchloric acid ($HClO_4$) is a common acid used primarily by the chemical, electroplating, and incendiary (fireworks) industries. It is a strong oxidizing acid that reacts with organic compounds, including cellulosic materials such as sawdust and cork. A mixture of perchloric acid and these materials may ignite spontaneously. Therefore, hoods and ducts must be nonreactive, easily cleaned and inspected for acid buildup, and should include water wash-down capability. The ACGIH Industrial Ventilation Manual contains a list of design and work practices for perchloric acid hoods. They recommend stainless steel with rounded corners and all-welded construction. **Never use perchloric acid in a hood designed for other purposes.**

12. Answer: **C**. Those who oppose the use of the term "acceptable risk" often offer substitute terms. One frequent suggestion is to say that designers and operators should achieve *minimum* risk levels or *minimize* the risks. Requiring that systems be designed and operated to minimum risk levels, that risks be minimized, is impractical because the investments necessary to do so may be so high that the cost of the product required to recoup the investment and make a reasonable profit would not be competitive in the marketplace.

13. Answer: **B**. LASER is an acronym which stands for Light Amplification by Stimulated Emission of Radiation. The laser produces an intense, highly directional beam of light. The most common cause of laser-induced tissue damage is thermal in nature, where the tissue proteins are denatured due to the temperature rise following absorption of laser energy. Laser work and similar operations create intense concentrations of heat, ultraviolet, infrared, and reflected light radiation. A laser beam of sufficient power can produce intensities greater than those experienced when looking directly at the sun. Unprotected laser exposure may result in eye injuries including retinal burns, cataracts, and permanent blindness. ANSI Z136.1 (Safe Use of Lasers) Laser eyewear must be selected with the specific laser wavelength in mind. The International Electro-Technical Commission (IEC) publishes standards on laser safety. The IEC also sets out five classes of laser: 1, 2, 3A, 3B, and 4. This classification gives the user an indication of the degree of laser hazard.

    - **Class 1** lasers have an output power that is below the level at which eye injury can occur.
    - **Class 2** lasers emit visible light and are limited to a maximum output power of 1-milliwatt (mW). A person receiving an eye exposure from a Class 2 laser will be protected from injury by their natural blink reflex, an involuntary response that causes the person to blink and turn their head, thereby avoiding eye exposure.
    - **Class 3A** lasers may have a maximum output power of 5 mW. This limit restricts the power entering a fully dilated human eye (taken as a 7 mm aperture) to 1 mW. Thus, accidental exposure to a Class 3A laser should be no more hazardous than exposure to a Class 2 laser. However, Class 3A laser pointers are hazardous when viewed with an optical aid such as binoculars and are therefore unsuitable for the general consumer.
    - **Class 3B** lasers have an **output power up to 500 mW, sufficient to cause eye injury.** The extent and severity of any eye injury will depend upon several factors including the laser power entering the eye and the exposure duration.
        - Class 1, Class 2, Class 3A, and Class 3B lasers do not have sufficient power to cause a skin injury.
    - **Class 4** lasers have an output power greater than 500 mW and can cause injury to both the eye and skin and will be a fire hazard if sufficiently high output powers are available.

14. Answer: **B**.

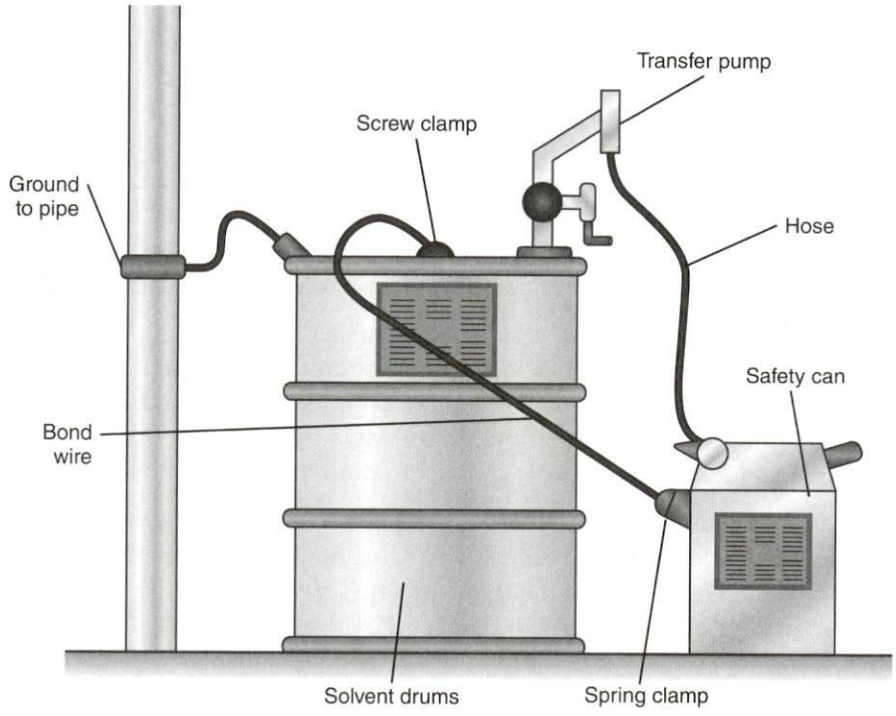


Figure 18 Bonding and Grounding Diagram

This is the definition of a ground and a bond according to the NSC. The continuity test ensures that the equipment grounding conductor is electrically continuous (**Figure 18**).

15. Answer: **A**. Defective electrical equipment that might expose an employee to injury should be removed from service (Haight 2012a).

16. Answer: **C**. Frontal air bags have saved thousands of lives; however, they are supplemental safety devices with the seat belt as the primary device. Children 12 and younger should be placed in the back seat. The rear seat is the safest for children. If the vehicle is equipped with an airbag ON-OFF switch, the operator should check its position in the vehicle and the airbag should be turned off for front seat passengers under the age of 13.

17. Answer: **D**. According to the NSC, "Companies can control driver error by introducing a program of driver selection, training and supervision, while vehicle failure can be reduced by implementing a preventive maintenance program."

18. Answer: **C**. Since canopies are above the worker, the contaminant must travel very close to, and most of the time through, the worker's breathing zone.

19. Answer: **C**. "Lockout/tagout" refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities. This requires, in part, that a designated individual turns off and disconnects the machinery or equipment from its energy source(s) before performing service or maintenance and that the authorized employee(s) either lock or tag the energy-isolating device(s) to prevent the release of hazardous energy and take steps to verify that the energy has been isolated effectively. If the potential exists for the release of hazardous stored energy or for the reenergization of stored energy to a hazardous level, the employer must ensure that the employee(s) take steps to prevent injury that may result from the release of the stored energy.

Lockout devices hold energy-isolation devices in a safe or "off" position. They provide protection by preventing machines or equipment from becoming energized because they are positive restraints that no one can remove without a key or other unlocking mechanism or through extraordinary means, such as bolt

cutters. Tagout devices, by contrast, are prominent warning devices that an authorized employee fastens to energy-isolating devices to warn employees not to reenergize the machine while he or she services or maintains it. Tagout devices are easier to remove and, by themselves, provide employees with less protection than do lockout devices.

As part of an energy-control program, employers must:

- Establish energy-control procedures for removing the energy supply from machines and for putting appropriate lockout or tagout devices on the energy-isolating devices to prevent unexpected reenergization. When appropriate, the procedure also must address stored or potentially reaccumulated energy;
- Train employees on the energy-control program, including the safe application, use, and removal of energy controls; and
- Inspect these procedures periodically (at least annually) to ensure that they are being followed and that they remain effective in preventing employee exposure to hazardous energy.

In Appendix A to 1910.147, OSHA provides a *Typical Minimal Lockout Procedure*. Before beginning service or maintenance, the following steps must be accomplished in sequence and according to the specific provisions of the employer's energy-control procedure:

1. Prepare for shutdown;
2. Shut down the machine;
3. Disconnect or isolate the machine from the energy source(s);
4. Apply the lockout or tagout device(s) to the energy-isolating device(s);
5. Release, restrain, or otherwise render safe all potential hazardous stored or residual energy. If a possibility exists for reenergization of hazardous energy, regularly verify during the service and maintenance that such energy has not reaccumulated to hazardous levels; and
6. Verify the isolation and deenergization of the machine (OSHA 3120 Standard, *Control of Hazardous Energy Lockout/Tagout*).

20. Answer: **A**. A tagout device is a prominent warning that clearly states that the machinery being controlled must not be operated until the tag is removed in accordance with an established procedure. Tags are essentially warning devices and do not provide the physical restraint of a lock. Tags may evoke a false sense of security. For these reasons, OSHA considers lockout devices to be more secure and more effective than tagout devices in protecting employees from hazardous energy. Whether lockout or tagout devices are used, they must be the only devices the employer uses in conjunction with energy-isolating devices to control hazardous energy. The employer must provide these devices and they must be singularly identified and not used for other purposes. In addition, they must have the following characteristics:

- Durable enough to withstand workplace conditions. Tagout devices must not deteriorate or become illegible even when used with corrosive components such as acid or alkali chemicals or in wet environments.
- Standardized according to color, shape, or size. Tagout devices also must be standardized according to print and format. Tags must be legible and understandable by all employees. They must warn employees about the hazards if the machine is energized, and offer employees clear instruction such as: "Do Not Start."
- Substantial enough to minimize the likelihood of premature or accidental removal. Employees should be able to remove locks only by using excessive force with special tools such as bolt cutters or other metal-cutting tools. Tag attachments must be nonreusable, self-locking, and nonreleasable, with a **minimum unlocking strength of 50 pounds**. Tags must be attachable by hand, and the device for attaching the tag should be a one-piece nylon cable tie or its equivalent so it can withstand all environments and conditions.
- Labeled to identify the specific employees authorized to apply and remove them.

Training must ensure that employees understand the purpose, function, and restrictions of the energy-control program. Employers must provide training specific to the needs of "authorized," "affected," and "other" employees.

"Authorized" employees are those responsible for implementing the energy-control procedures or performing the service or maintenance activities. They need the knowledge and skills necessary for the safe application, use, and removal of energy-isolating devices. They also need training in the following:

- Hazardous energy source recognition;
- The type and magnitude of the hazardous energy sources in the workplace; and
- Energy-control procedures, including the methods and means to isolate and control those energy sources.

"Affected" employees (usually machine operators or users) are employees who operate the relevant machinery or whose jobs require them to be in the area where service or maintenance is performed. These employees do not service or maintain machinery or perform lockout/tagout activities. Affected employees must receive training in the purpose and use of energy-control procedures. They also need to be able to do the following:

- Recognize when the energy-control procedure is being used;
- Understand the purpose of the procedure; and
- Understand the importance of not tampering with lockout or tagout devices and not starting or using equipment that has been locked or tagged out.

The employer must provide initial training before starting service and maintenance activities and must provide retraining as necessary. In addition, the employer must certify that the training has been provided (OSHA 3120 Standard, *Control of Hazardous Energy Lockout/Tagout*).

Domain 4 Quiz 3 Questions

1. During an inspection of an industrial area, you observe the following conditions: A large dip tank of heated trichlorethylene located next to a large sealed tank containing 50% sodium hydroxide solution. What hazards would be encountered if these materials are allowed to contact each other?

A. Produce chlorine gas
B. Could cause fire and explosion
C. NaOH gives off cyanide gas
D. No hazards, inert materials

2. Metal carbonates react with acids to produce:

A. carbon dioxide and water.
B. salt, water, and carbon dioxide gas.
C. hydrogen gas and salt.
D. salt and water.

3. Chemical hazards are generally divided into the following categories:

A. toxic, reactive, corrosive, and flammable.
B. toxic, reactive, acids, and combustibles.
C. inert, organic, hydrocarbons, and cryogens.
D. acids, bases, explosives, and hydrocarbons.

4. The movement of liquids or vapors through a garment material that occurs on a molecular level is called:

A. penetration.
B. osmosis.
C. convection.
D. permeation.

5. There is a process in an industrial operation that utilizes vinyl chloride. The concentration in the operational area is 400 ppm. The *best* respiratory protection at this exposure level is:

A. APR with HEPA filter.
B. half-face SAR.
C. full-face SAR in negative mode with escape bottle.
D. positive pressure SCBA.

6. Verification that the procedures and practices developed under the Process Safety Management standard are adequate requires certification of compliance every:

A. 5 years.
B. 3 years.
C. year.
D. Based on company compliance

7. Spoiling evidence would include:

A. loss of evidence.
B. destruction of evidence.
C. tampering with evidence.
D. chain of custody.

8. What percentage of new construction workers are likely to be injured in the first 30 days of the job?

A. 5%
B. 50%
C. 25%
D. 90%

9. The analysis of cut sets is a technique that identifies single-point and multiple-case failures in a software system and is called:

A. software logic.
B. fault tree.
C. soft tree.
D. fault logic.

10. Which of the following is the common language of client/server database management?

A. SQL
B. URL
C. HTML
D. VPN

11. The primary benefit of an extranet is:

A. enhancing a company's intranet.
B. allowing information to be downloaded through the Internet.
C. providing accessibility to the Internet by employees when offsite.
D. allowing secure admission into a section of business information or operations with suppliers, vendors, partners, customers, or other businesses.

12. If the operation is grinding and workers are using full-face respirators with a combination cartridge of acid gas/organic vapor, are they protected?

A. No, a particulate respirator is needed.
B. No, respirators are not required for grinding operations.
C. Yes, combinations cartridges are acceptable.
D. Yes, organic vapor cartridges will filter particulates.

13. Padding the budget is considered a project budgeting method of:

A. marginalizing.
B. lowballing.
C. highballing.
D. estimating.

14. A company uses several temp agencies and contract workers. Data indicates an increase in incidents among this group of workers at the facility. The *best* course of action is to:

A. do a new more comprehensive contractor new hire orientation.
B. implement and enforce a zero-tolerance disciplinary policy.
C. do nothing as these workers are not employees of the company.
D. develop a contractor safety committee to discuss issues and solutions.

15. The conditions *most common* to crane side loading are:

A. high wind, "off rubber," boom extended.
B. load is dragged, not level, high wind.
C. hook on center of load, shock loading, outriggers set.
D. not level, high wind, "on rubber."

16. When a pitot tube is connected to a manometer for ventilation measurements, the inputs to the manometer are _____ and _____ and the output is_____?

A. VP, SP, TP
B. VP, TP, SP
C. TP, SP, VP
D. TP, SP, NP

17. Which of the following operations requires the greatest capture velocity?

A. Evaporation from tanks; degreasing; water baths
B. Spray booths; intermittent container filling; welding
C. Spray painting in shallow booths; barrel filling; crushers
D. Grinding; abrasive blasting; tumbling

18. Name the instrument used for measuring air velocity in the opening of a spray booth.

A. Spirometer
B. Velometer
C. Smoke tube
D. Pitot tube

19. The design of an exhaust hood requires sufficient knowledge of the process or operation so that the most effective hood or enclosure (one requiring minimum exhaust volumes with desired collection efficiency) can be installed. The *most important* factor to successful design of an exhaust hood depends on the:

A. rate of airflow through the hood.
B. location of the hood.
C. shape of the hood.
D. duct diameter.

Domain 4 Quiz 3 Answers

1. Answer: **B**. The most common of all the corrosives bases is sodium hydroxide, NaOH (LYE or CAUSTIC SODA). Sodium hydroxide and its concentrated solutions can cause considerable heat and when mixed with water or solvents can cause sufficient heat to produce fire and explosions.

2. Answer: **B**. Metal carbonates react with acids to produce salt, water, and carbon dioxide gas. The chemical formula of the **carbonate** group is CO_3.

3. Answer: **A**. Chemical hazards are generally divided into toxic, reactive, corrosive, and flammable subcategories.

4. Answer: **D**.

   Permeation involves sorption of the chemical into the surface of the material, diffusion through the material, and desorption on the opposite side.

   Osmosis is a process by which molecules of a solvent tend to pass through a semipermeable membrane from a less concentrated solution into a more concentrated one, thus equalizing the concentrations on each side of the membrane.

   Convection is the movement caused within a fluid (gas or liquid) by the tendency of hotter and therefore less dense material to rise and colder, denser material to sink under the influence of gravity, which consequently results in transfer of heat.

   Penetration is the passage of vapors or liquids through zippers, seams, holes, etc.

   Degradation is the physical changes to the material caused by the chemical, which can include swelling, stiffening, wrinkling, changes in color, and other physical deterioration.

5. Answer: **D**. Vinyl chloride is a suspected carcinogen with an OSHA TWA of 1 ppm (ACGIH TLV 5 ppm) for 8 hours and a 15-minute ceiling limit of 5 ppm. NIOSH recommends respiratory protection to consist of self-contained breathing apparatus with full-face piece and operated in a positive-pressure mode. A full-face respirator with airline can be used if operated in positive-pressure mode and used in combination with an auxiliary self-contained breathing apparatus operated in a positive-pressure mode. A full-face respirator operated in a positive-pressure mode provides a protection factor of "1000," **while an SCBA provides a protection factor of approximately "10,000"** (**Table 8**).

   The maximum use concentration (MUC) for respirators is calculated by multiplying the APF for the respirator by the PEL. The MUC is the upper limit at which the class of respirator is expected to provide protection.

$$MUC = TLV \times APF$$

   End-of-service-life indicator (ESLI) means a system that warns the respirator user of the approach of the end of adequate respiratory protection, for example, that the sorbent is approaching saturation or is no longer effective.

Table 8 Assigned Protection Factors

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-fitting Facepiece
1. Air-Purifying Respirator	5	10	50	—	—
2. Powered Air-Purifying Respirator (PAPR)	—	50	1000	25/1000	25
Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	—	10	50	—	—
• Continuous flow mode	—	50	1000	25/1000	25
• Pressure-demand or other positive-pressure mode	—	50	1000	—	—
Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	—	10	50	50	—
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	—	—	10,000	10,000	—

Occupational Safety and Health Administration. *3352-02 2009 Assigned Protection Factors for the Revised Respiratory Protection Standard*. https://www.osha.gov/Publications/3352-APF-respirators.pdf

6. Answer: **B**. According to OSHA Publication 3132 Process Safety Management:
   - Employers shall certify that they have evaluated compliance with the provisions of the PSM standard at least every three years to verify that the procedures and practices developed under the standard are adequate and being followed. The compliance audit must be conducted by at least one person knowledgeable in the process and a report of the findings of the audit must be developed and documented noting deficiencies that have been corrected. The two most recent compliance audit reports must be kept on file.
   - All process hazard analyses must be updated and revalidated, based on their completion date, at least every five (5) years. The process hazard analysis shall be performed by a team with expertise in engineering and process operations, and the team shall include at least one employee who has experience and knowledge specific to the process being evaluated. Also, one member of the team must be knowledgeable in the specific process hazard analysis methodology being used.
   - Incident investigation reports must be retained for five (5) years and must be initiated as promptly as possible, but not later than 48 hours following the incident.
   - Inspection and testing must be performed on process equipment, using procedures that follow recognized and generally accepted good engineering practices. The frequency of inspections and tests of process equipment must conform with manufacturers' recommendations and good engineering practices or more frequently if determined to be necessary by prior operating experience. Each inspection and test on process equipment must be documented, identifying the date of the inspection or test, the name of the person who performed the inspection or test, the serial number or other identifier of the equipment on which the inspection or test was performed, a description of the inspection or test performed, and the results of the inspection or test.
   - Training must include emphasis on the specific safety and health hazards of the process and emergency operations, including shutdown and other safe work practices that apply to the employee's job tasks. Refresher training must be provided at least every three (3) years. The employer must determine whether each employee operating a process has received and understood the training required by PSM. A record must be kept containing the identity of the employee, the date of training, and how the employer verified that the employee understood the training.
7. Answer: **C**. The **spoliation of evidence** is the **intentional**, reckless, or negligent withholding, hiding, altering, fabricating, or destroying of evidence relevant to a legal proceeding.
8. Answer: **A**. According to the Bureau of Labor Statistic, 60% of construction workplace injuries occur within the employee's first year of employment.

   According to OSHA sources, research has identified the following variables as being related to a disproportionate share of injuries and illnesses at the work site on the part of employees and should be considered when identifying employee groups for training in occupational safety and health.

   1. The age of the employee (younger employees have higher incidence rates)
   2. The length of time on the job (new employees have higher incident rates)
   3. The size of the firm (in general terms, medium-sized firms have higher incidence rates than smaller or larger firms)
   4. The type of work performed (incidence and severity rates vary significantly by SIC Code)
   5. The use of hazardous substances (by SIC Code)
9. Answer: **C**. According to the *System Safety Engineering and Risk Assessment: A Practical Approach*, 2nd edition, there now is sufficient software to check logic, interfaces, and constraints to the software modules. Revisit the hazard descriptions, causes, effects, and controls noted in the previous analysis level and update as needed. At this level, coding approaches to control hazards are recommended. Two of the more common detailed design analysis techniques are:
   - Software fault tree analysis (also called soft tree analysis)
   - Petri-Net

Soft tree analysis is just like its cousin—fault tree analysis. It is particularly useful in software safety because programmers tend to use forward inference in their design logic. Software development is predicated on assumptions that the system is at a certain state before transitioning to another state. The soft tree analysis does just opposite; as you know from fault tree logic, it starts with a top-level fault and works down, identifying the events that make that top event occur. This is especially useful in finding software faults because it is so vastly different from the way programmers perform their work. This is particularly important for safety-critical systems.

As discussed in *Assurance Technologies Principles and Practices: A Product, Process, and System Safety Perspective*, 2nd edition, soft tree analysis is a tool that engineers, and software programmers can both understand. If the engineer is comfortable with fault trees, then it will not take long to feel comfortable with soft tree analysis. The logic gate symbols are the same. It can be used with any software language. NASA uses this method extensively on spacecraft control systems. The US Airforce Software System Safety Handbook suggest the following safety analysis tools:

- Software Fault Tree (Soft Tree) Analysis: In this technique, the hardware and software trees are constructed with standard symbols. The two trees are then linked at their interfaces so that the entire system can be analyzed. A slightly different way of accomplishing this is to construct a hardware failure tree in which the software interfaces are identified. A software fault tree is then added to the interfacing points.
- Use of Cut Sets: This technique identifies single-point and multiple-case failures. In the case of the software system, the technique is applied to soft trees. Computer programs for cut set analysis are commercially available.

10. Answer: **A**.

SQL is the abbreviation for Structured Query Language. It is a standardized application language for relational databases that is used to enter data into a database, modify data, delete data, and retrieve data.

URL is the abbreviation of Uniform Resource Locator, the global address of documents and other resources on the World Wide Web.

HTML stands for Hyper Text Markup Language and is used for web publishing.

HTTP stands for Hyper Text Transfer Protocol and is a file transfer protocol.

TCP/IP stands for Transmission Control Protocol/Internet Protocol, which is a set of protocols that make Telnet, FTP, e-mail, and other services possible among computers that don't belong to the same network.

IP stands for Internet Protocol, which is the set of technology standards and technical specifications that enable information to be routed from one network to another over the Internet.

VPN is a **virtual private network** that extends across a public network or Internet. It enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network. VPNs can provide functionality, security, and/or network management benefits to the user.

A **search engine** is software that searches the Internet for specific words or word strings. A remotely accessible program that lets you do keyword searches for information on the *Internet*. There are several types of search engine; the search may cover titles of documents, *URLs*, headers, or the *full text*. A **web browser** (commonly referred to as a **browser**) is a software application for retrieving, presenting, and traversing information resources on the World Wide Web. An *information resource* is identified by a **Uniform Resource Identifier** (URI/URL) and may be a web page, image, video, or other piece of content. Hyperlinks present in resources enable users easily to navigate their browsers to related resources.

11. Answer: **D**. An **extranet** is a private network that uses Internet protocols, network connectivity, and possibly the public telecommunication system to **securely share part of a business's information or operations with suppliers, vendors, partners, customers, or other businesses**. An extranet can be viewed as part of a company's intranet that is extended to users outside the company (e.g., normally over the Internet).

It has also been described as a "state of mind" in which the Internet is perceived as a way to do business with other companies as well as to sell products to customers. An extranet requires security and privacy. These can include firewalls, server management, the issuance and use of digital certificates or similar means of user authentication, encryption of messages, and the use of virtual private networks (VPNs) that tunnel through the public network.

The most common computer networks are peer-to-peer and client/server. Peer-to-peer networks are generally described as having three to five users (more than that can be confusing), they can share printers, scanners, and fax machines and generally the workstations have the same capabilities. Internets, intranets, and extranets were created to permit communications among a variety of users and all systems are built using TCP/IP protocols, the domain name system and Internet Protocol addresses are the same on all systems and web browsers and e-mail can be used on all of these systems.

Local Area Networks (LANs) are a common means of making information available to multiple users. They consist of a network operating system that is specifically designed for transmitting data; communication links are both software and hardware designed to facilitate data transfer, and Ethernet is a LAN technology.

12. Answer: **A**. Grinding operations can produce dust particles and would require a particulate respirator.

Particulate Respirators
- Capture particles in the air, such as dusts, mists, and fumes.
- Do not protect against gases or vapors.
- Generally, become more effective as particles accumulate on the filter and plug spaces between the fibers.
- Filters should be replaced when user finds it difficult to breathe through them.

Combination Respirators
- Are normally used in atmospheres that contain hazards of both particulates and gases.
- Have both particulate filters and gas/vapor filters.
- May be heavier.

Gas & Vapor Respirators
- Are normally used when there are only hazardous gases and vapors in the air.
- Use chemical filters (called cartridges or canisters) to remove dangerous gases or vapors.
- Do not protect against airborne particles.
- Are made to protect against specific gases or vapors.
- Provide protection only as long as the filter's absorbing capacity is not depleted.
- The service life of the filter depends upon many factors and can be estimated in various ways.

13. Answer: **C**. According to *The Safety Professionals Handbook* (Haight 2012b), once the decision has been made to pursue a project, the budgeting process should occur. A budget is a financial plan that establishes specific amounts of cash (and sometimes employee hours) that are expected to be spent on specific activities. Budgeting accomplishes a number of related purposes discussed very briefly below. Budgeting is a form of prioritization. By establishing a budget for a safety-related expenditure, one is securing management approval for this expenditure and is decreasing the chance that unexpected cash flow problems, or a manager's bad day, will prevent a planned safety expenditure from taking place. Budgeting is an important part of cost control. Expenditures should be tracked and compared against expected expenditures for each point in time. Significant differences between actual and expected expenditures indicate either poor tracking (in that actual expenditures are not being assigned to the correct budget item), unexpected circumstances, or poor initial estimation and budgeting. This indicates that budgeting is part of the Plan-Do-Check-Act (PDCA) cycle of process improvement. Budgets are part of the short-term operational plan. This "plan" is then executed as the "do" step. During operational execution, management should "check" by comparing actual expenditures to planned expenditures. If a significant difference exists between the two, managers "act," resolving any unforeseen problems and, if necessary, adjusting future budgets to prevent future deviations from plans. Budgeting is an important part of decision-making. A manager must estimate the costs to include in an economic analysis. This estimate usually forms the basis for one's budget. But decision-making does not end once the budget is established. If actual expenditures significantly exceed planned expenditures at any

time, it may be appropriate to reevaluate the entire project. How future cash flows almost always hold some degree of uncertainty means there is always a risk that the best estimates of future costs may be low. Most managers understandably want to reduce that risk by proposing a budget that includes a contingency amount, or padding, but two problems arise when including such buffers in budgets. One problem is that allocating contingency resources to a budget prevents those resources from being used for other good projects. A second and even worse problem is that many managers will attempt to hide their over budgeting, or "highballing," by inefficiently spending any remaining funds as the end of the fiscal year approaches. Decisions about budget allocation should be based on which projects will provide the greatest return on investment to the company as a whole. Another dark side of budgeting is that some managers propose excessively large budgets, because the larger the budgets they manage, the more status, power, security, and salary they personally can enjoy. Because managers enjoying power and status typically are loathe to brook any reduction, it is not uncommon for managers to submit budgets for the next year that are based mostly on similar budgets in years past. In recent decades, a process called zero-based budgeting has emerged to combat such budget inertia. Instead of assuming that each project or manager will receive approximately the budget they had previously, managers and projects are assumed to have no budget until they justify in detail why they should receive any funds at all.

14. Answer: **D**. The best course of action is to involve the contractor agencies and workers in a safety committee to determine the cause and solutions for the injuries. The need for employee participation is highlighted by several safety management systems, including ANSI ZlO (ANSI/ASSE 2012), OHSAS 18000, ISO 450001, and OSHA. Worker participation can take several forms:

    - participating on joint labor-management committees and other advisory or specific-purpose committees
    - conducting site inspections
    - analyzing routine hazards in each step of a job or process, and preparing safe work practices or controls to eliminate or reduce exposure
    - developing and revising the site safety and health rules
    - training both current and newly hired employees
    - providing programs and presentations at safety and health meetings
    - conducting accident/incident investigations
    - reporting hazards to upper management and/or responsible parties
    - fixing hazards within your control
    - supporting your fellow workers by providing feedback on risks and assisting them in eliminating hazards
    - participating in accident/incident investigations
    - performing a preuse or change analysis for new equipment or processes in order to identify hazards up front before use

    ANSI Z10, *Health and Safety Management Systems* (2012) also specifically itemizes effective employee participation, including a role in activities such as incident investigations, procedure development, health- and safety-related audits, training development, job safety analysis, and all aspects of the planning process. In organizations where social responsibility is already a goal of the organization, the SH&E professional should already be able to identify several activities within the organization that address employee involvement. Areas where employee involvement is lacking or hampered can be more easily implemented by demonstrating that they add value to the organization's social responsibility goals. Examples of obstacles or barriers to employee involvement include lack of response to employee input or suggestions, reprisals (supervisory and/or peer), or any other forms of discrimination (ANSI/ASSE 2012). Social responsibility is part of sustainability, involves employees in an organization, and gives them a voice on safety issues. Safety committee development is another way to demonstrate direct employee involvement in the safety program while also satisfying another component of good social responsibility. Safety committees are voluntary in many organizations but may be required by company policy or local regulations.

    According to Petersen (2001), the least authentic is usually the traditional safety committee because typically only a few can serve on the committee. The safety committee structure can create a three-class workplace: management, involved employees, and noninvolved employees. This may create additional problems because

the noninvolved employees must do the work, while the involved sit in meetings. Although safety committees are traditional and they may be required by law in the future, they are perhaps the least effective route to employee involvement. Petersen advocates the use of improvement teams. Improvement teams are, in effect, ad-hoc committees—people working together for a short period, solving a specific problem, and presenting their findings and solutions to management. Improvement teams can be ad-hoc committees formed within a department because the boss has asked for help or task forces formed by upper management to solve a specific systemic problem. A team might consist of workers targeting areas like the following:

- Ergonomic fixes
- Identifying hazards
- Identifying traps
- Identifying systemic problems
- Assessing culture

15. Answer: **B**. The load chart ratings apply only to freely suspended loads and when the load is picked up directly under the boom tip. If the load is to either side of the boom tip, side loading occurs, which affects the crane's capacity. Side loading is one of the most common causes of boom failure and usually occurs without warning. Side loading can occur when a load is dragged or pulled sideways, when the load starts swinging rapidly, when the crane is not level, and when exposed to high wind speeds. Tilt-up construction methods can also cause side loading of the boom. Shock loading can be caused by rapid acceleration, sudden stopping, sudden load release, and sudden load snatching.

    The key to lifting a maximum capacity load with a mobile crane is the outriggers. They provide a solid platform for the crane's safe operation and efficient use. Operators and workers within a crane's radius must always be aware of how critical the placement and use of outriggers are to the crane's performance. Statistics show that at least 50% of crane incidents occur because the mobile crane or outriggers are not set up properly. Specific hazards that can cause or contribute to failure or collapse include:

    - Failure to extend the outriggers fully
    - Not extending all outriggers
    - Failure to get completely "off-rubber"
    - Not accounting for poor ground conditions
    - Failure to level the crane

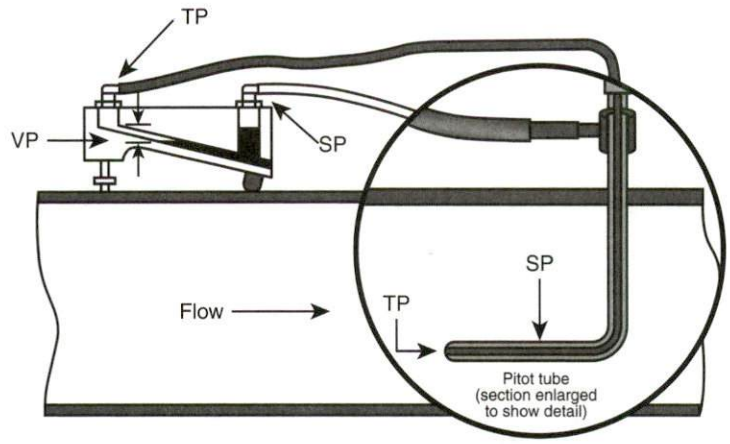
    Use the Correct Load Chart: The purpose of outriggers is to improve the stability of the crane. Accurate use of the *"on-outriggers fully extended"* load chart requires that outriggers be fully extended, and they must bring the rig completely off-rubber. If the tires are touching the ground, then the *"on-rubber"* load chart is the only one that can be used. Manufacturers do not recommend extending only one or two of the outriggers. If outriggers are to be used, fully extend all of them and get the tires off the ground. Accidents commonly occur because the operator is lifting from only one side of the rig, with only two outriggers extended. Then, later in the day, this same operator is asked to swing the boom to the other side of the rig for a pick. He does this without thinking and topples the crane.

    Outrigger Pads and Floats: The pads found on all crane outriggers are designed for good ground conditions. Poor conditions reduce the amount of load a crane can safely place on the outrigger pad. Because of this, many crane operations require additional support or "floats." Supplemental floats are made of substantial material and must *always* be larger than the outrigger pad. These floats disperse the weight of the crane and its load over more ground area than does the pad. Any float or cribbing, which is smaller than the pad, actually *increases* the pressure placed on the ground. This increase in pressure, particularly in poor ground conditions, can cause an outrigger to "punch through," and bring about an accident.

    Leveling: Also, be aware that all floats and cribbing must be level. If the outrigger pad is set down on an unleveled float, the outrigger pad may slide off when under load, causing the crane to tip. Many manufacturers stipulate that the crane must be within 1% of level before their load chart applies.

16. Answer: **C**.

Refer **Figure 19**.



TP = VP + SP or VP = TP – SP

Figure 19 Pitot Tube Connected to a Manometer for Ventilation Measurements

17. Answer: **D**.

Refer to **Table 9**.

Table 9 Capture Velocities

Condition of Dispersion	Examples	Capture Velocity (FPM)
Released with practically no velocity into quiet air	Evaporation from tanks; degreasing; etc.	50–100
Released at low velocity into moderately still air	Spray booths; intermittent container filling; low speed conveyor transfers; welding; plating; pickling	100–200
Active generation into zone of rapid moving air	Spray painting in shallow booths; barrel filling; conveyor loading; crushers	200–500
Released at high initial velocity into zone of very rapid moving air	Grinding; abrasive blasting; tumbling	500–2000

18. Answer: **B**. The Swinging Vane Anemometer or *Velometer* would be the instrument of choice where the exhaust opening is large, and the air velocities are low as in spray booths or chemical hoods. The *rotating vane anemometer* is useful for measuring the airflow through large supply and exhaust openings where the air velocities are relatively high. In the calibration of airflow instruments, a spirometer is considered a primary standard.

19. Answer: **A**.

The design of an exhaust hood requires sufficient knowledge of the process or operation so that the most effective hood or enclosure (one requiring minimum exhaust volumes with desired collection efficiency) can be installed. The successful design of an exhaust hood depends on all three:

- Rate of airflow through the hood
- Location of the hood
- Shape of the hood

According to OSHA, the rate of airflow through the exhaust hood (that is, the exhaust volume rate) is the most important factor for all types of hoods. For local, side, downdraft, and canopy hoods, the location is equally important because the rate of airflow is based on the relative distance between the hood and the source. The shape of the exhaust hood is another design consideration. If the hood shape is not selected properly, considerable static pressure losses may result.

Domain 5: Emergency Preparedness, Fire Prevention, and Security



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Themes

Blueprint reference

Domain 5: Emergency Preparedness, Fire Prevention, and Security

- Emergency Management Institute (FEMA 908 course)
  - Memorandum of Understanding (MOU), Mutual Aid Agreements (MAA)
  - Table top exercises, contingency planning, pre-emergency planning, mitigation
  - Hazard Vulnerability Analysis
  - Chemical Facility Anti Terrorism Standards (CFATS)
- Emergency Response
  - Disaster response and recovery operations
  - Incident Command System (ICS), National Incident Management System (NIMS) National Response Framework (NRF), (FEMA ICS 100,200, 400, 700, 800, 930 online courses)
  - HAZWOPER (OSHA 1910.120, NFPA 473)
- Physical and Information Security
  - Authorized access to information, loss prevention and control, surveillance (FEMA 914, 915, 916, 921 course)
  - Layers of Protection Analysis (LOPA)
  - Workplace violence (NIOSH, FEMA 906, 907 courses)
- Fire Prevention
  - Fire science, extinguishing agents, fire tetrahedron
  - Hot work permit, combustible dust, flammable material storage, segregation
  - NFPA 10, 13, 30, 70E

Key CSP Blueprint Themes: Domain 5

Domain 5 Quiz 1 Questions

1. Determine the required pressure for a fire protection sprinkler with a "K" factor of 5.6, protecting 120 ft² with a density of 0.22 gpm per ft².

A. At least 7 psi
B. 22.2 psi
C. 33.3 psi
D. 11.1 psi

$$P = \left(\frac{Q}{K}\right)^2$$

2. A sprinkler system is designed with the pipes 9 ft apart and the sprinkler heads every 9 ft along each pipe. All sprinkler heads are the same. If the k factor is 5.2 and each head requires 12.6 psi to operate, what is the density requirement for the last sprinkler head?

A. 0.057 gpm/ft²
B. 0.228 gpm/ft²
C. 0.810 gpm/ft²
D. 0.202 gpm/ft²

$$P = \left(\frac{Q}{K}\right)^2$$

3. Find the velocity pressure in a two inch (actual diameter) open ended pipe with 325 gallons per minute of water flowing.

A. 14.7 psi
B. 7.4 psi
C. 32 psi
D. 162.5 psi

$$P_v = \frac{Q^2}{891\ d^4}$$

4. The approximate value for determining the pressure exerted by a column of water is:

A. multiply each foot of rise by 8.34.
B. multiply each inch of rise by 0.433.
C. multiply each foot of rise by 0.433.
D. divide each foot of rise by 8.66.

5. Which of the following groups of hydrocarbons would have the greatest chance of *not* being flammable?

A. Aliphatic hydrocarbons
B. Aromatic hydrocarbons
C. Halogenated hydrocarbons
D. Ethers

6. Which of the following is the greatest flammability range?

A. Acetone
B. Benzene
C. Hexane
D. Acetylene

7. Which of the following is *not* an oxidizer?

A. Fluorine
B. Hydrazine
C. Potassium permanganate
D. Hydrogen peroxide

8. Which of the following describes materials that ignite spontaneously when in contact with air?

A. Pyrophoric
B. Hypergolic
C. Pyrolysis
D. Deflagration

9. What type of extinguisher is used for an incipient stage aluminum powder fire?

A. Class C
B. Class D
C. Class K
D. Class B

10. The particle size of combustible dust determines the maximum pressure potential in a confined space and:

A. has no impact on the explosion hazard.
B. has an impact on the explosion only if settled in the space.
C. has a lesser impact for a weaker explosion.
D. has a greater impact for more a powerful explosion.

11. The *best* fire protection policy for building construction, alteration, or demolition is/are provided by:

A. sprinklers that are operational in as many building areas as possible.
B. fire bottles available on all floors.
C. the fire marshal making monthly visits to all construction or demolition areas.
D. a fire watch hired as soon as debris starts to accumulate.

12. In the theory of fire, understanding the fire tetrahedron is important for understanding how to extinguish a fire. The four elements that must be present for a fire to occur are a fuel, heat, an oxidizing agent (usually oxygen), and a chemical chain reaction. One method used to reduce the possibility of a fire hazard is use of an inerting gas to reduce the oxidizing agent concentration. The *most important* property of this gas is:

A. heat capacity.
B. molecular weight.
C. vapor pressure.
D. content of hydrogen.

13. A flammable liquid with a flash point of 70°F and a boiling point of 120°F is classified by the NFPA as a:

A. Class I liquid.
B. Class IA liquid.
C. Class IB liquid.
D. Class II liquid.

14. A local fire department has responded to a blaze on the surface of a combustible liquid in a laboratory setting. If firefighters apply AFFF, what hazard is associated with this approach option?

A. The foam will not work at 100°C or higher.
B. The high temperature will increase foam solubility and slow down its ability to smother the fire.
C. Foam is not a recommended extinguisher for a combustible liquid fire.
D. Foam will form an emulsion of steam, air, and fuel that may cause frothing of the burning liquid.

15. The characterization of a Class II, Division 2 location, according to the National Electrical Code is:

A. a site where flammable or combustible vapors may be present in sufficient quantities to be hazardous.
B. a place where combustible dust is normally present in adequate quantities to be hazardous.
C. a scene where flammable or combustible vapors are not normally present, but could be, due to atypical or intermittent operations.
D. a location where combustible dust is not normally present but with the potential due to abnormal or periodic operations.

16. The fire tetrahedron states that combustion requires an oxidizer, fuel, heat, and which of the following?

A. Confinement
B. Surface area
C. Chain reaction
D. Deflagration

17. If a storage facility is used to store flammable products, where the possibility of explosion is high if involved in a fire, what would be the maximum travel distances allowable to exits, with and without a fire sprinkler system installed? (NFPA 101®, *Life Safety Code*®)

A. 75 feet without and 150 feet with an approved fire sprinkler system
B. 100 feet without and 150 feet with an approved fire sprinkler system
C. 200 feet without and 200 feet with an approved fire sprinkler system
D. 75 feet without and 100 feet with an approved fire sprinkler system

18. Fire detection and alarm systems protect property and processes and are widely used in the United States. These fire protection systems use three distinct types of fire alarm signals: supervisory, alarm, and _____?

A. trouble.
B. activation.
C. warning.
D. sabotage.

19. A rate-of-rise detector responds to which condition?

A. Smoke particulate in the air
B. Water pressure in fire suppression piping
C. Indoor humidity
D. Heat

20. Four components must be present for a chemical explosion to occur. These are an oxidizer, fuel, ignition source, and:

A. overpressure.
B. confinement.
C. reduction.
D. detonation.

Domain 5 Quiz 1 Answers

1. Answer: **B**.

Step 1: Determine quantity of water required for this application.

$$Q = \frac{0.22 \text{ gpm}}{\text{ft}^2} \times \frac{120 \text{ ft}^2}{1} = 26.4 \text{ gpm}$$

Step 2: Determine the required pressure in psi.

$$P = \left(\frac{Q}{K}\right)^2$$

$$P = \left(\frac{26.4}{5.6}\right)^2 = 4.714^2$$

$$P = 22.2 \text{ psi}$$

Note: While selection "B" is the best answer, selection "A" may well be true considering that, in general, NFPA requires all sprinkler heads to have at least 7 psi.

Reference NFPA 13, 5-3.6 **Exposure Protection.**

"5-3.6.1 Piping shall be hydraulically calculated in accordance with Section 6-4 to furnish a minimum of 7 psi (48 kPa) at any sprinkler with all sprinklers facing the exposure operating."

2. Answer: **B**.

Step 1: Determine required flow.

$$P = \left(\frac{Q}{K}\right)^2$$

$$Q = K\sqrt{P} = 5.2\sqrt{12.6}$$

$$Q = 18.46 \text{ gpm}$$

Step 2: Calculate protection area of each sprinkler.

$$\text{Area} = 9 \text{ ft} \times 9 \text{ ft} = 81 \text{ ft}^2$$

Step 3: Calculate the density.

$$Q = \text{Density} \times \text{Area}$$

$$\text{Density} = \frac{Q}{\text{Area}}$$

$$\text{Density} = \frac{18.46 \text{ gpm}}{81 \text{ ft}^2}$$

$$\text{Density} = 0.228 \text{ gpm per ft}^2$$

3. Answer: **B**.

$$P_v = \frac{Q^2}{891\ d^4}$$

$$P_v = \frac{325^2}{891 \times 2^4}$$

$$P_v = \frac{105{,}625}{891 \times 16}$$

$$P_v = \frac{105{,}625}{14{,}256} = 7.4 \text{ psi}$$

4. Answer: **C**.

The weight density of water is 62.4 lbs/ft^3. To convert to inch per foot of rise, divide by 144 (square inches in a foot). This equals about 0.433 psi per foot of water. For example:

The water level in a large freshwater storage tank is 40 feet from the outlet piping. What is the pressure in psi?

$$40 \text{ ft} \times 0.433 = 17.32 \text{ psi}$$

5. Answer: **C**. ***Hydrocarbons*** are compounds that contain atoms of carbon and hydrogen only. They are broadly classified into two types, that is; aliphatic and aromatic. *Aliphatic hydrocarbons* are subdivided into saturated and unsaturated compounds and include the alkanes: methane, ethane, propane, and butane. ***Aromatic hydrocarbons*** are derivative of the parent compound benzene. ***Ethers*** are members of a class of organic compound in which an oxygen atom has bridged between two hydrocarbon groups. Aliphatic ethers are highly volatile and extremely flammable. Hydrocarbons that have been partially halogenated burn but generally with much less ease than their nonhalogenated analogs. The fully ***halogenated*** derivatives such as carbon tetrachloride are noncombustible.

6. Answer: **D**. Acetylene has the greatest flammability range (**Table 10**).

Table 10 Comparisons of Common Flammable Compounds

Compound	Lower Explosive Limit (%)	Upper Explosive Limit (%)	Flashpoint (°F)	Vapor Density
Acetone	2.15	13	–4	2.0
Acetylene	2.50	100	Gas	0.9
Ammonia (anhydrous)	16	25	Gas	0.6
Benzene	1.30	7.1	12	7.8
Carbon monoxide	12.4	74	Gas	1.0
Gasoline	1.4	7.6	–45	3.4
Hexane	1.1	7.5	–7	3.0
Toluene	1.2	7.1	40	3.1
Vinyl chloride	3.6	33	Gas	2.2
p-xylene	1.0	6.0	90	3.7

7. Answer: **B**. Oxidizing agents generally are recognizable by their structures or names. They tend to have a high oxygen ratio in their structures and sometimes release oxygen as a result of thermal decomposition. Oxidizing agents often have *per* prefixes (perchlorate, peroxides, and permanganate) and end in *-ate* (chromate, nitrate, chlorate). Strong oxidizers have more potential incompatibilities than perhaps any other chemical group (with the possible exception of water-reactive substances). Oxidizers should not be stored or mixed with any other material except under carefully controlled conditions. Storing oxidizing and reducing agents where they could mix can be a recipe for disaster. Common oxidizing agents listed in decreasing order of oxidizing strength include:

- Fluorine
- Chlorine
- Ozone
- Sulfuric acid (concentrated)
- Hydrogen peroxide
- Oxygen
- Perchloric acid (concentrated)
- Hypochlorous acid
- Metallic iodates
- Metal chlorates
- Bromine
- Lead dioxide
- Ferric (iron +3) salts
- Metallic permanganates
- Iodine
- Metallic dichromates
- Sulfur
- Nitric acid (concentrated)
- Stannic (tin +4) salts

8. Answer: **A**. *Pyrophoric* materials ignite spontaneously when in contact with air. *Hypergolic* describes a violent reaction, which occurs when two materials encounter each other. *Pyrolysis* is the process of decomposition in the presence of heat. *Deflagration* is a rapid burning fire that produces flame speed that travels slower than the speed of sound.

9. Answer: **B**. Aluminum powders have the highest K_{ST} rate (a measurement of inherent explosive power) of all the combustible metal dusts. The designation "dry powder" has been especially chosen to indicate an agent's suitability for use on Class D (combustible metal) fires. The term "dry chemical" is reserved for agents effective on A:B:C or B:C fires (**Figure 20**).

Fire type	Extinguishing	
	Agent	Method
Ordinary solid materials 	Water foam	Removes heat removes air and heat
	Dry chemical	Breaks chain reaction
Flammable liquids 	Foam CO_2	Removes air
	Dry chemical halon	Breaks chain reaction
Electrical equipment 	CO_2	Removes air
	Dry chemical halon	Breaks chain reaction
Combustible metals 	Special agents	Usually remove air

Figure 20 Types of Portable Fire Extinguishers

10. Answer: **D**. Combustible dust is defined as a solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition, which presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations. Combustible dusts are often either organic or metal dusts that are finely ground into very small particles, fibers, fines, chips, chunks, flakes, or a small mixture of these. As discussed in OSHA's Safety and Health Information Bulletin (SHIB): *Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions*, dust particles with an effective diameter of less than 420 microns (those passing through a U.S. No. 40 standard sieve) should be deemed to meet the criterion of the definition. However, larger particles can still pose a deflagration hazard (for instance, as larger particles are moved, they can abrade each other, creating smaller particles). In addition, particles can stick together (agglomerate) due to electrostatic charges accumulated through handling, causing them to become explosible when dispersed. Types of dusts include, but are not limited to: metal dust, such as aluminum and magnesium; wood dust; plastic or rubber dust; biosolids; coal dust; organic dust, such as flour, sugar, paper, soap, and dried blood; and dusts from certain textiles. Five elements are necessary to initiate a dust explosion, often referred to as the "Dust Explosion Pentagon" (**Figure 21**).

The first three elements are those needed for a fire:

1. combustible dust (fuel);
2. ignition source (heat); and
3. oxygen in air (oxidizer).

An additional two elements must be present for a combustible dust explosion:

1. dispersion of dust particles in sufficient quantity and concentration; and
2. confinement of the dust cloud.

If one of the above five elements is missing, an explosion cannot occur.

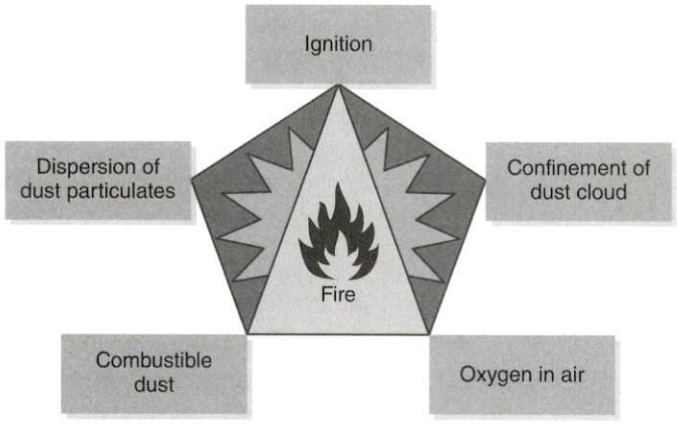


Figure 21 Dust Explosion Pentagon

The ease of ignition and the severity of a combustible dust explosion are typically influenced by particle size. Other factors that influence the explosiveness of dusts include moisture content, ambient humidity, oxygen available for combustion, the shape of dust particles, and the concentration of dust in the air. Physical properties used to measure combustible dusts include:

- MIE, the minimum ignition energy, which predicts the ease and likelihood of ignition of a dispersed dust cloud.
- MEC, the minimum explosible concentration, which measures the minimum amount of dust dispersed in air required to spread an explosion. (The MEC is analogous to the Lower Flammable Limit (LFL) or Lower Explosive Limit (LEL) for gases and vapors in air.)
- K_{st}, the dust deflagration index, measures the relative explosion severity compared to other dusts. The larger the value for K_{st}, the more severe the explosion (see **Table 11**). K_{st} provides the best "single number" estimate of the anticipated behavior of a dust deflagration.

Table 11 Examples of K_{st} Values for Different Types of Dusts

Dust Explosion Class*	K_{st} (bar.m/s)*	Characteristic*	Typical Material**
St 0	0	No explosion	Silica
St 1	>0 and = 200	Weak explosion	Powdered milk, charcoal, sulfur, sugar, and zinc
St 2	>200 and = 300	Strong explosion	Cellulose, wood flour, and poly methyl acrylate
St 3	>300	Very strong explosion	Anthraquinone, aluminum, and magnesium

The actual class is sample specific and will depend on varying characteristics of the material such as particle size or moisture.

* OSHA's Safety and Health Information Bulletin (SHIB): Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions.

** Reproduced from NFPA 68, Standard on Explosion Prevention by Deflagration Venting.

Decreasing particle size increases K_{st}, and to a lesser degree, increases the explosion pressure Pmax.

Specific guidance measures to prevent explosions can be found in OSHA's SHIB *Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions*, which lists measures to control dusts, eliminate ignition sources, and limit the effects of explosions to minimize injuries. Initial preventative steps are to contain combustible dust to areas that are properly designed and located, with ignition sources either eliminated or controlled. Equipment or spaces such as ducts, dust collectors, vessels, and processing equipment that contain combustible dust should be designed in a manner to prevent leaks to minimize the escape of dust into work areas. Any dust that settles on workplace surfaces should be removed through a routinely implemented housekeeping program. Areas or equipment potentially subject to explosions, including the dust collection system, should also be designed to relieve pressure in a safe manner, or be provided with proper suppression, explosion prevention systems, or an oxygen-deficient atmosphere. The current definition in NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* is "a combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations, regardless of particle size or shape." The same definition is used for combustible metal dust in NFPA 484,

Standard for Combustible Metals, Metal Powders, and Metal Dusts contains comprehensive guidance on the control of dusts to prevent explosions. The following are some of its recommendations:

- Minimize the escape of dust from process equipment or ventilation systems;
- Use dust collection systems and filters;
- Use surfaces that minimize dust accumulation and facilitate cleaning;
- Provide access to all hidden areas to permit inspection;
- Inspect for dust residues in open and hidden areas, at regular intervals;
- Clean dust residues at regular intervals;
- Use cleaning methods that do not generate dust clouds, if ignition sources are present;
- Only use vacuum cleaners approved for dust collection;
- Locate relief valves away from dust hazard areas; and
- Develop and implement a hazardous dust inspection, testing, housekeeping, and control program (preferably in writing with established frequency and methods).

Facilities should carefully identify the following in order to assess their potential for dust explosions:

- Materials that can be combustible when finely divided;
- Processes which use, consume, or produce combustible dusts;
- Open areas where combustible dusts may build up;
- Hidden areas where combustible dusts may accumulate;
- Means by which dust may be dispersed in the air; and
- Potential ignition sources.

11. Answer: **A**. The threat of fire during construction, alteration, or demolition projects is extremely high due to the presence of large quantities of combustible materials and debris and the many ignition sources available from construction or destruction operations. Additionally, the arson threat is greater during construction than at any other time. The maintenance of an operational fire sprinkler system with adequate water supply is the single most important fire prevention action one can take during these operations. Fire sprinklers should be the first system enabled and the last system disabled during construction or demolition.

12. Answer: **A**. According to *The Fire Protection Handbook*, the most important property is the heat capacity of a gas.

13. Answer: **C**. Flammable and combustible liquids are subdivided into classes, as shown in **Table 12.**

Table 12 Basic Classification of Flammable and Combustible Liquids

Class	Boiling Point	Flash Point
I		below 100°F
IA	below 100°F	below 73°F
IB	at or above 100°F	below 73°F
IC		at or above 73°F and below 100°F
II		at or above 100°F and below 140°F
III		at or above 140°F
IIIA		at or above 140°F and below 200°F
IIIB		at or above 200°F

Reproduced from NFPA 30 and 321, *Basic Classification of Flammable and Combustible Liquids.*

14. Answer: **D**. According to the *Fire Protection Handbook*, if the temperature of the liquid itself is above the boiling point of water used to create the foam, a frothy and voluminous emulsion of steam, air, and burning fuel may occur upon application of the foam to the surface of the fire.

15. Answer: **D**. Class II, Division 2 locations are those in which combustible dust is not normally present but might be due to abnormal or periodic operations. During those times, sufficient dust may be present in the air to produce explosive or ignitable mixtures. A Class II, Division 2 location is an area normally free of dust, but due to some incident, dust may be introduced. Mechanical breakdown of a valve or a break in a pipe are examples of conditions that would require an area to be classified as Division 2.

16. Answer: **C**. According to *The NFPA Fire Protection Handbook*, for combustion to occur, four components are necessary: (1) oxygen (oxidizing agent); (2) fuel (substrate); (3) heat (ignition); and (4) a self-sustained chemical reaction (also referred to as the chain reaction). These components can be graphically described as the "fire tetrahedron." Each component of the tetrahedron must be in place for combustion to occur. Remove any one of the four components and combustion will not occur. If ignition has already occurred, the fire is extinguished when one of the components is removed from the reaction.

17. Answer: **D**. Section 29 of the NFPA 101®, *Life Safety Code®*, provides guidance on maximum travel distance to exits. In the preceding question, the content's hazard was classified as ordinary hazard, and the distance to an exit could not exceed 200 feet or 400 feet if equipped with an approved automatic fire sprinkler system. However, any area used for storage of high hazard materials shall have an exit within 75 feet of the point where persons might be present. This distance can be extended to 100 feet when fire sprinkler protection is provided. Travel distances vary with different occupancies. Again, a review of the *Life Safety Code®* is certainly in order prior to the examination.

18. Answer: **A**. Protective signaling systems provide three categories of signals:

    - Alarm signals—used to indicate water flow, manual station actuation, fire detector activation, discharge of a system, or other indication of a fire.
    - Supervisory signals—used to indicate time critical input, such as guard check-in, or loss of water or agent pressure, valves in wrong position, exit light not functioning, etc.
    - Trouble signals—used to indicate a fault in the system, shorted wiring, loss of signal, ground fault, etc.

    Note: The preferred reference for additional study is NFPA 72, *Protective Signaling Systems*.

19. Answer: **D**. There are three types of heat detectors that candidates should be familiar with for the examination. They are listed below with their general characteristics:

    Fixed-Temperature Designed to alarm when the temperature of the operating element reaches a specified point. These units are susceptible to "thermal lag."

    Rate Compensation Designed to alarm when the temperature of surrounding air reaches a predetermined level, regardless of rate of temperature rise. Element configuration compensates for thermal lag.

    Rate-of-Rise Designed to alarm when the rate of temperature increase exceeds a predetermined value (usually 12 to 15°F per minute). An example of use would be on a petroleum-based hydraulic pump to prevent explosions.

20. Answer: **B**. As described in Burke's *Counter Terrorism for Emergency Responders*, 2nd edition, a chemical explosion, like fire, requires oxidizer, fuel, ignition, and chemical reaction, but more importantly, it requires confinement of the oxidizer and fuel. Without confinement, the materials will not explode; they will merely burn with great intensity.

Domain 5 Quiz 2 Questions

1. What is the purpose of a jockey pump?

A. To pump water through a sprinkler system to extinguish a fire
B. To maintain system pressure when the sprinkler system is not in use
C. To open the sprinkler heads the proper size based on the rate of rise
D. To deliver water through the pipes so that the system can continue to put out the fire

2. A flood destroys a company's operations ability. After emergency management issues are addressed, the business implements several plans for recovery of critical files and information that had been stored offsite, establishes a temporary facility from which operations can be conducted, informs customers of circumstances and how customers will be served. These plans are examples of a comprehensive loss control activity called:

A. Emergency Management/Emergency Response.
B. Situational Awareness.
C. Disaster Recovery/Business Continuity Planning.
D. Business Impact Analysis.

3. Advanced emergency management planning is the best way to minimize potential loss from natural or technological disasters and accidents. The primary responsibilities of emergency planning must exclude:

A. establishing continuity of operations for the customers' sake.
B. providing for the safety of employees and public.
C. protecting property and environment.
D. establishing methods to restore operations to a new normal as soon as possible.

4. Many different agencies might be responsible for controlling and cleaning up more complex hazardous materials incidents. Which of the following is the critical first step in responding to chemical release when multiagencies are involved?

A. Approve the Incident Action Plan.
B. Establish the Incident Command System.
C. Approve resource requests.
D. Order demobilization.

5. The National Incident Management System (NIMS) is the responsibility of the:

A. Department of State (DOS).
B. Department of Health and Human Services (DHHS).
C. Department of Defense (DOD).
D. Department of Homeland Security (DHS).

6. Under ICS, the Command Staff positions include:

A. Safety Officer, Public Information Officer, and Liaison Officer.
B. Liaison Officer, Operations Section Chief, and Finance and Administration Section Chief.
C. Public Information Officer, Chief Executive Officer, and Safety Officer.
D. Logistics Section Chief, Safety Officer, and the Contracting Officer.

7. Which training level applies to employees who are only likely to witness or discover a hazardous substance release and who need to be trained to initiate an emergency response sequence by notifying the proper authorities of the release?

A. Awareness level
B. Operations level
C. Hazardous materials technicians
D. Specialist employees

8. The Clean Air Act (CAA) places the responsibility for the prevention of accidental chemical releases on both OSHA and EPA. OSHA has implemented the Process Safety Management (PSM) Rule. Which of the following represents the EPA's related program for threshold quantities of extremely hazardous substances?

A. Risk Mitigation Process (RMP) Rule
B. Response Management Protocols (RMP) Rule
C. Response Mitigation Program (RMP) Rule
D. Risk Management Program (RMP) Rule

9. The public resists change for all the following reasons *except:*

A. fear of the unknown.
B. false confidence.
C. loss of face.
D. lack of purpose.

10. The *most important* spokesperson characteristics for effective risk communication to the public are:

A. expertise and authoritative presence.
B. appearance and empathy.
C. authoritative presence and credibility.
D. credibility and technical competency.

Domain 5 Quiz 2 Answers

1. Answer: **B**. A jockey pump, or a pressure-maintenance pump, is a small apparatus that works together with a fire pump as part of a fire-protection sprinkler system. It is designed to keep the pressure in the system elevated to a specific level when the system is not in use so that the fire pump doesn't have to run all the time and the system doesn't go off randomly. It can also help prevent the system from damage when a fire happens and water rushes into the pipes. These devices consist of a three-part assembly. In many places, there are governmental guidelines and recommendations for installing these devices to make sure they work properly. To understand how a jockey pump works, it's important to understand how a fire sprinkler system works. Sprinkler systems consist of pipes with pressurized water in them and heads that are designed to open when they reach a certain temperature. When the heads open, the water pressure in the pipes drops, since water is flowing out of them. When this happens, a large device called a fire pump starts to send more water through the pipes so that the system can continue to put out the fire. The purpose of the jockey pump is to keep the water pressure in the pipes within a specific range when there's not a fire so that the sprinklers won't go off randomly. Since pipes leak, over time, the water pressure inside them automatically goes down. The jockey pump senses this, and then fills them back up to normal pressure. If a fire happens and the pressure drops dramatically, the jockey pump won't be able to keep up, and the pressure drop will trigger the large fire pump to start sending water. Secondarily, this pump prevents sprinkler systems from being damaged when the fire pump begins sending water. If a system does not have a jockey pump keeping it pressurized, it may have a relatively low pressure. When the fire pump starts sending highly pressurized water through the pipes, the sudden change in pressure can damage or destroy the system.

2. Answer: **C**. According to *Risk Analysis and the Security Survey*, 3rd edition, business continuity planning is a key part of a loss control program. Such plans should include recovering corporate information, setting up operations, and financing temporary operations until a new facility can be commissioned. Depending upon the risk of a natural disaster, some companies purchase business interruption insurance to help finance operations.

3. Answer: **A**. According to the National Safety Council, advanced emergency management planning should include the following and they should be ranked as they are sequenced.

   1. Provide for the safety of employees and public
   2. Protect property and the environment
   3. Establish methods to restore operations to normal as soon as possible

   When developing emergency management plans, sometimes the fundamental purpose is lost, which is to protect life, property, and the environment. Though command and communication responsibilities are important and must be part of the planning process, fundamental strategies must be developed to protect people, property, and the environment and then tactics can be applied.

   When developing a risk management plan, one must anticipate what will go wrong and make timely attempts to overcome identified loss scenarios. The risk management process consists of the following steps:

   - Identify loss scenarios
   - Develop alternatives to control them

- Implement best solution(s)
- Manage and control risk(s)

4. Answer: **B**. According the *NFPA Hazardous Materials/WMD Response Handbook* (2008), all the answers are tasks for the Incident Commander. A vital step during pre-incident planning is to identify these agencies. The first thing to establish is the Incident Command System and designate who is in charge. The *National Incident Management System* (FEMA, 2017) establishes the following functions as the Incident Commander (IC) primary responsibilities include:
   - having clear authority and knowing agency policy.
   - ensuring incident safety.
   - establishing the incident command post (ICP).
   - setting priorities, determining incident objectives and strategies.
   - establishing incident command system (ICS).
   - approving incident response plan (IAP).
   - coordinating command and general staff activities.
   - approving resource requests and use of volunteers and auxiliary personnel.
   - ordering demobilization as needed.
   - ensuring after action review.
5. Answer: **D**. The *National Incident Management System (NIMS)*, is the responsibility of the Department of Homeland Security (DHS). It provides a consistent template for managing incidents is a companion document to the National Response Framework and provides standard command and management structures that apply to response activities. This system provides a consistent, nationwide template to enable federal, state, tribal, and local governments, the private sector, and nongovernmental organizations (NGOs) to work together to prepare for, prevent, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity. This consistency provides the foundation for utilization of the NIMS for all incidents, ranging from daily occurrences to incidents requiring a coordinated federal response.
6. Answer: **A**. ICS is organized into three components—Incident Command, Command Staff, and General Staff positions. Incident Command can be comprised either of a single Incident Commander or a Unified Command. An example ICS organizational chart is shown in **Figure 22**.

   The Command Staff (CS) members perform incident-wide tasks and report directly to the IC. The three most common CS positions include:
   - **Safety Officer**—responsible for the safe operations of all tasks performed on-site. The Safety Office has the essential authority to terminate any operations deemed to be unsafe and even to override the authority of the IC to do so.
   - **Public Information Officer**—the PIO is responsible for passing information regarding the incident to the public and to the media. Traditionally the PIO was responsible for press releases and public warning statements issued through the media. In recent years with the huge explosion of social media, the PIO position has expanded greatly.
   - **Liaison Officer**—this position is responsible for interacting and coordinating with other response entities not represented.
7. Answer: **A**. The OSHA 1910.120 Hazardous Waste Operations and Emergency Response standard defines several levels of training for hazardous materials emergency responders. These include:
   - **Awareness Level**—First responders at the awareness level are individuals who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. They would take no further action beyond notifying the authorities of the release.
   - **Operations Level**—First responders at the operations level are individuals who respond to releases or potential releases of hazardous substances as part of the initial response to the site for protecting nearby persons, property, or the environment from the effects of the release. They are trained to respond in a defensive fashion without trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures.

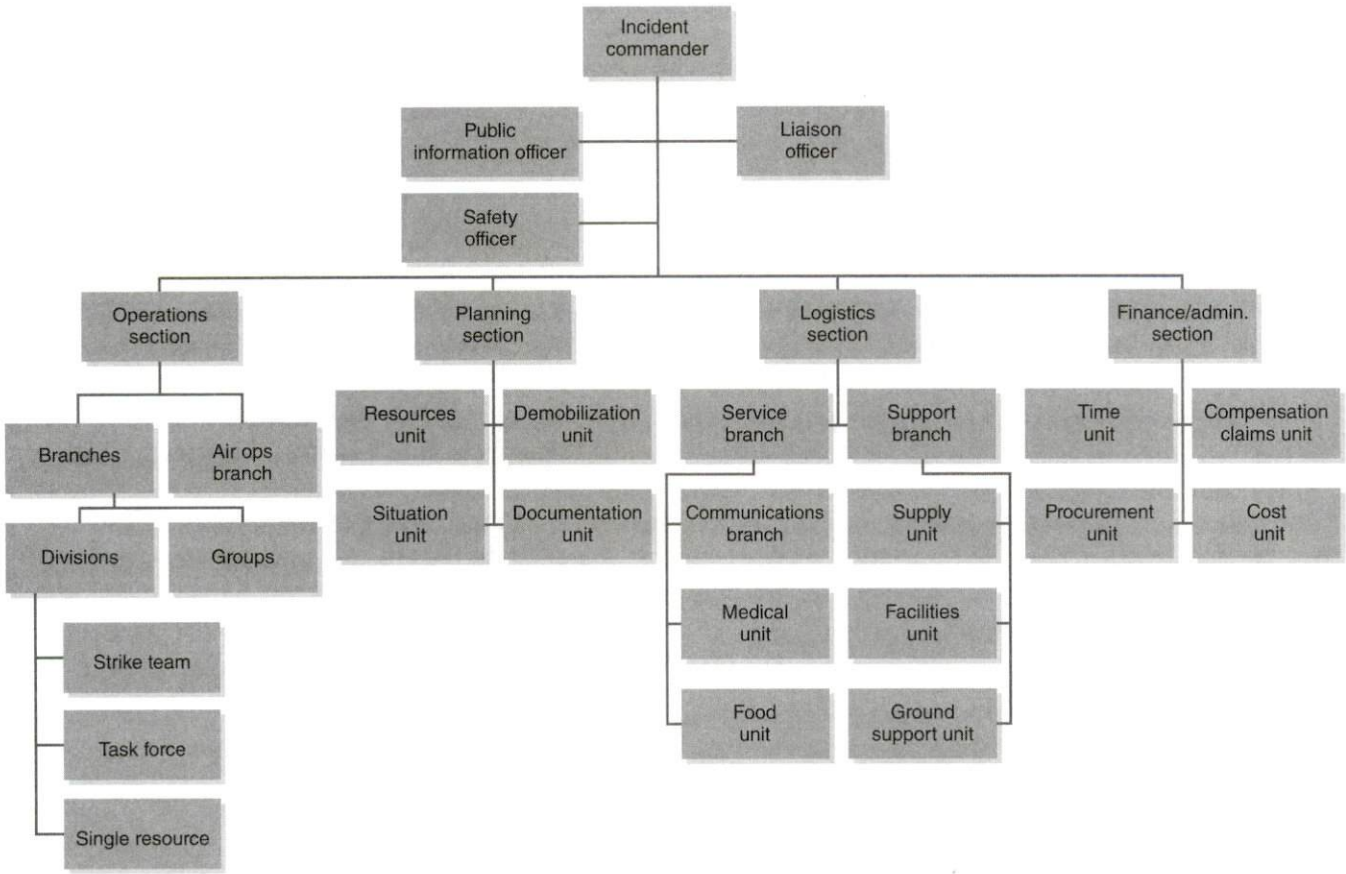


Figure 22 ICS Organizational Chart Example

ICS Organizational Structure and Elements

EXTRACTED FROM - E/L/G 0300 Intermediate Incident Command System for Expanding Incidents, ICS 300. United States Department of Homeland Security.

- **Hazardous Materials Technician**—Hazardous materials technicians are individuals who respond to releases or potential releases for stopping the release. They assume a more aggressive role than a first responder at the operations level in that they will approach the point of release to plug, patch, or otherwise stop the release of a hazardous substance.
- **Hazardous Materials Specialist**—Hazardous materials specialists are individuals who respond with and provide support to hazardous materials technicians. Their duties parallel those of the hazardous materials technician; however, those duties require a more directed or specific knowledge of the various substances they may be called upon to contain. The hazardous materials specialist would also act as the site liaison with federal, state, local, and other government authorities regarding site activities.
- **On-scene Incident Commander**—Incident commanders assume control of the incident scene beyond the first responder awareness level.
- **Skilled Support Personnel**—Personnel, not necessarily an employer's own employees, who are skilled in the operation of certain equipment, such as mechanized earth moving or digging equipment or crane and hoisting equipment, and who are needed temporarily to perform immediate emergency support work that cannot reasonably be performed in a timely fashion by an employer's own employees, and who will be or may be exposed to the hazards at an emergency response scene.
- **Specialist Employees**—Employees who, in the course of their regular job duties, work with and are trained in the hazards of specific hazardous substances and who will be called upon to provide technical advice or assistance at a hazardous substance release incident to the individual in charge.

Each of these classes of employees must receive the appropriate level of training for the tasks they are to perform. The standard prescribes minimum duration of training, and many organizations require longer

training courses. Similar standards and guidance are provided from other sources, such as National Fire Protection Association (NFPA) 472.

8. Answer: **D**. OSHA has the responsibility for the protection of workers, the public, and the environment from accidental chemical releases under the Process Safety Management (PSM) standard. The EPA has the responsibility for protection of the public and the environment from accidental chemical releases and promulgated the Risk Management Program (RMP). The RMP ensures that the public will be properly informed about chemical risks in their communities and that the federal, state, and local regulators will have more effective tools to assist with lowering chemical accident risk. The PSM and RMP programs regulate toxic, reactive, and flammable substances with many substances listed in both rules. As a result, if an employer were required to implement the PSM Rule for a covered process, that same process may also be subject to the RMP Rule. Both the PSM and RMP Rules are important elements of an integrated approach to chemical safety. There are a lot of similarities between the two chemical safety regulations, but the two are very much different—OSHA requires no reporting of a facility's PSM program, but EPA does require a facility to submit their RMP (online using "e-Submit" software). The other major difference is the EPA's "off-site consequence analysis" (OCA) required for each "covered process" in order to determine the facility's "Worst Case Release Scenario" and their "Alternative Release Scenario." But the obvious differences stop there, and unfortunately there are several other significant requirements that can cause some serious compliance issues for facilities that must comply with the RMP rule. To determine if your process is covered by either standard is to determine the quantity in the process and compare that to the ***threshold quantities*** prescribed by the standard to determine if the process is covered by one or both standards. In some cases, the process may be covered by RMP and not OSHA and vice versa. For instance, a facility that uses one-ton chlorine cylinders would be covered by OSHA's PSM but would NOT be covered by EPA's RMP rule. This is because OSHA's threshold for chlorine is 1500 pounds and EPA's threshold are 2500 pounds. The other difference in the "threshold determination" is that OSHA lumped ALL FLAMMABLE LIQUIDS (FP<100°F) together and set their threshold at 10,000 pounds. EPA treats flammable liquids differently in that the SPECIFIC FLAMMABLE LIQUID MUST be listed by CAS number to be considered to be an "Extremely Hazardous Substance" (EHS).

9. Answer: **B**. Some of the common reasons that people resist change are:

   - fear of the unknown.
   - disrupted habits.
   - loss of confidence.
   - loss of control.
   - poor timing.
   - work overload.
   - loss of face.
   - lack of purpose.

10. Answer: **A**. Spokespersons allow the public to put a face to the act of responding to, investigating, and resolving a crisis. How a spokesperson handles public and media inquiries, in addition to what he or she says, helps establish credibility for an organization. It also contributes to the public's transition from the crisis stage to resolution and recovery stages. An organization should carefully choose the personnel who will represent it.

    The selection should be based on two factors:

    - The individual's familiarity with the subject matter
    - His or her ability to talk about it clearly and with confidence

    Risk communication (RC) is a complex, multidisciplinary, multidimensional, and evolving process of increasing importance in protecting the public's health. Public health officials use RC to give citizens necessary and appropriate information and to involve them in making decisions that affect them—such as where to build waste disposal facilities. The National Research Council (NRC) defines risk communication as "an interactive process of exchange of information and opinion among individuals, groups, and institutions." The definition includes "discussion about risk types and levels and about methods for managing risks." Specifically, this process is defined by levels of involvement in decisions, actions, or policies aimed at

managing or controlling health or environmental risks. There are seven cardinal rules for the practice of risk communication, as first expressed by the US Environmental Protection Agency:

- Accept and involve the public as a legitimate partner.
- Plan carefully and evaluate your efforts.
- Listen to the public's specific concerns.
- Be honest, frank, and open.
- Coordinate and collaborate with other credible sources.
- Meet the needs of the media.
- Speak clearly and with compassion.

Communicating with the Public: 10 Questions to Ask

- Why are we communicating?
- Who is our audience?
- What do our audiences want to know?
- What do we want to get across?
- How will we communicate?
- How will we listen?
- How will we respond?
- Who will carry out the plans? When?
- What problems or barriers have we planned for?
- Have we succeeded?

Table 13 Factors Influencing Risk Perception

Risk Perceptions More Likely to be Accepted	Risk Perceptions Less Likely to be Accepted
Voluntary	Imposed
Under an individual's control	Controlled by others
Have clear benefits	Have little or no benefit
Fairly distributed	Unfairly distributed
Natural	Manmade
Statistical	Catastrophic
Generated by a trusted source	Generated by an untrusted source
Familiar	Exotic
Affect adults	Affect children

Snyder, D. J. *Philosophia Soteria: How occupational safety and health professionals influence decision makers. Theses and dissertations*, 2018. https://scholarworks.uark.edu/etd/3140

According to FEMA, the person who delivers the messages plays a critical role in both risk and crisis communications. Communications experts have identified six traits of successful risk communicators:

- Communicator's speaking ability
- Reputation among audience members (trustworthiness and credibility)
- Subject matter knowledge
- Image of authority
- Obvious lack of vested interest
- Ability to connect, sympathize, or empathize with the audience

During a crisis or emergency, the messenger(s) puts a human face on disaster response, and this person(s) is critical to building confidence in the public that people will be helped and their community will recover. Public Information Officers (PIOs) regularly deliver information and messages to the media and the public. However, the primary face of the disaster response should be an elected or appointed official (i.e., mayor, governor, county administrator, city manager) or the director of the emergency management agency or both.

These individuals bring a measure of authority to their role as messenger, and in the case of the emergency management director, someone who oversees response and recovery operations. The public wants to hear from an authority figure, and the media wants to know that the person they are talking to is the one making the decisions. Emergency management agencies should also designate appropriate senior managers who will be made available to both the traditional and new media to provide specific information on their activities and perspective. This is helpful in even the smallest disaster when persons with expertise in specific facets of the response can be very helpful in delivering disaster response information and messages. Any official who serves as a communicator during and after a crisis should receive media training before the crisis. Ultimately, communicators will seek to create actual messages that transmit certain knowledge, whether factual (awareness) or action-based (operational).

Six principles of effective crisis and risk communication:

1. Be First: Crises are time sensitive. Communicating information quickly is almost always important. For members of the public, the first source of information often becomes the preferred source.
2. Be Right: Accuracy establishes credibility. Information can include what is known, what is not known, and what is being done to fill in the gaps.
3. Be Credible: Honesty and truthfulness should not be compromised during crises.
4. Express Empathy: Crises create harm, and the suffering should be acknowledged in words. Addressing what people are feeling, and the challenges they face, builds trust and rapport.
5. Promote Action: Giving people meaningful things to do calms anxiety, helps restore order, and promotes a restored sense of control.
6. Show Respect: Respectful communication is particularly important when people feel vulnerable. Respectful communication promotes cooperation and rapport.

Domain 6: Occupational Health and Ergonomics



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Key Themes

Blueprint reference

Domain 6: Occupational Health and Ergonomics

- Basic toxicology principles
  - symptoms of an exposure, LD50, mutagens, teratogens
- Ergonomics and human factors principles
  - visual acuity, body mechanics, patient lifting, vibration, anthropometrics
- How to recognize occupational exposures
  - hazardous chemicals, radiation, noise, biological agents, heat/cold, infectious diseases, nanoparticles, indoor air quality
- How to evaluate occupational exposures
  - hazardous chemicals, radiation, noise, biological agents, heat/cold, infectious diseases, ventilation, nanoparticles, indoor air quality, including techniques for measurement, sampling, and analysis
- How to control occupational exposures
  - hazardous chemicals, radiation, noise, biological agents, heat/cold, ventilation, nanoparticles, infectious diseases, indoor air quality)
- Occupational exposure limits
  - hazardous chemicals, radiation, noise, biological agents, heat

Key CSP Blueprint Themes: Domain 6

Domain 6 Quiz 1 Questions

1. A leaking pressurized piping system ejects 5 gallons of ethyl alcohol in a laboratory that is 15 feet by 15 feet by 8 feet. The molecular weight of ethyl alcohol is 46, and the SG is 0.79. LEL is 3.3%. With no air change and complete evaporation, does the ethyl alcohol concentration created exceed the LEL?

A. Yes, more than 4 times the LEL.
B. No, 10% of the LEL.
C. No, 25% of the LEL.
D. Yes, more than 9 times the LEL.

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

2. Vapor from a process tank is generated at 1.2 cfm. The process location room measures 100 feet by 110 feet by 10 feet. Due to a fan malfunction, the dilution ventilation has been reduced to 2000 cfm. Calculate the vapor concentration generated in the room, after the process tank has operated for 5 minutes, 15 minutes, and 25 minutes.

A. 28.4 ppm, 78 ppm, 120 ppm
B. 809 ppm, 2223 ppm, 3430 ppm
C. 76 ppm, 208 ppm, 319 ppm
D. 52 ppm, 143 ppm, 220 ppm

$$C = \frac{G}{Q} \times \left(1 - e^{-Nt/60}\right)$$

3. A worker was exposed to the following chemicals in air: hexane at 30 ppm, toluene at 16 ppm, and xylene at 40 ppm. Does the exposure exceed the 8-hour time-weighted average? The TLVs for each are hexane 50 ppm, toluene 20 ppm, and xylene 100 ppm.

A. No, the TLV is less than 1.0.
B. Yes, the TLV is greater than 1.0.
C. Yes, the TLV is greater than 2.0.
D. No, the TLV is less than 0.5.

$$TLV_m = \frac{C_1}{TLV_1} + \frac{C_2}{TLV_2} + \ldots + \frac{C_n}{TLV_n}$$

4. A safety professional received a report on the given percentage of the workforce affected by a chemical's toxicity. The toxic effects criteria are defined as a function of concentration (C) and time (T), which yields dose (d) or d = C x T. Toxic doses are as indicated below. If the workforce is exposed to a release of gas Z for 30 minutes, what is the predicted minimum concentration that will cause fatalities in 50% of the personnel?

LTL_{50} 50% population mortality

LTL_{05} 5% population mortality

TL_{50} 50% population irreversible effects

Gas	Exponent	LTL_{50}	LTL_{05}	TL_{50}	TLV	STEL
X	$(C)^{2.75}(T)$	1.52×10^{11}	4.05×10^{10}	1.32×10^{9}	100	150
Y	$(C)^{2.65}(T)$	3.77×10^{4}	1.66×10^{5}	5.31×10^{3}	150	225
Z	$(C)^{2.50}(T)$	3.4×10^{8}	1.7×10^{8}	1.6×10^{8}	10	15

A. 63 ppm
B. 3171 ppm
C. 733 ppm
D. 663 ppm

5. Determine the TWA concentration from the following measurement data: 7:00 a.m. to 10:00 a.m. @ 210 ppm; 10:00 a.m. to 12:00 p.m. @ 195 ppm; 12:00 p.m. to 1:00 p.m. @ 60 ppm; 1:00 p.m. to 2:00 p.m. @ 0 ppm; 3:00 p.m. to 4:00 p.m. @ 300 ppm.

A. 155.0 ppm
B. 167.8 ppm
C. 172.5 ppm
D. 222.6 ppm

$$TWA = \frac{(C_1 \times T_1) + (C_2 \times T_2) + \ldots + (C_n \times T_n)}{T_1 + T_2 + \ldots + T_n}$$

6. For an 8-hour workday, what is the allowable time limit for a 101.8 dBA noise?

A. 1.5 hours
B. 95 minutes
C. 1 hour
D. 156 minutes

$$T = \frac{8}{2^{[(L-90)/5]}}$$

7. Based on the allowable limits in the table, if the noise in a work area was 95 dBA for 3 hours, 90 dBA for 4 hours, and 85 dBA for 1 hour, is the allowable limit exceeded?

A. No, is under the limit by > 25%.
B. Yes, exceeds by < 50%.
C. Yes, exceeds by > 50%.
D. No, it is under the limit < 25%.

Permissible Noise Exposures

Hrs	dBA	Hrs	dBA	Hrs	dBA
8	90	3	97	1	105
6	92	2	100	0.5	110
4	95	1.5	102	0.25	115

8. An industrial hygienist uses a sound level meter to determine the noise level in the center of 4 identical machines. The reading is 79.55 dB. Based upon this reading, determine the sound level reading of each machine.

A. 70.3 dB
B. 72.6 dB
C. 73.5 dB
D. 78.0 dB

$$L_{pt} = L_{pi} + 10 \log_N$$

9. A significant shift in hearing loss that may cause health concerns is an average shift of _____ or greater at 2000, 3000, and 4000 Hz in either ear.

A. 1 dB
B. 5 dB
C. 8 dB
D. 10 dB

10. NIOSH recommends a de-rated Noise Reduction Rating (NRR) of:

A. 30% for all protectors.
B. 25% for earplugs and earmuffs.
C. 70% for earmuffs.
D. 50% for formable earplugs.

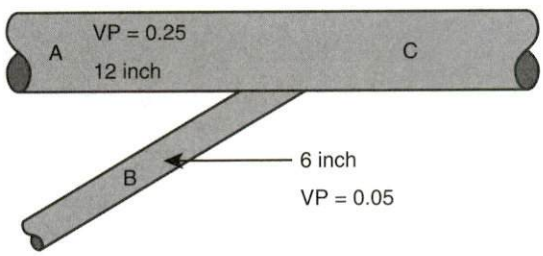
11. Using the following formula, evaluate the effectiveness of hearing protection provided to an employee who is using an ear plug assigned an NRR of 37 combined with muffs (NRR = 21) when exposed to an 8-hour TWA of 115 dBA.

A. Protected TWA = 98
B. Protected TWA = 95
C. Protected TWA = 85
D. Protected TWA = 82

$$A_f = \frac{NRR - 7}{2} + 5$$

12. Using the information provided in the illustration below, calculate the duct flow at point "C."

A. 1750 cfm
B. 1550 cfm
C. 2145 cfm
D. 2245 cfm



$$Q = AV$$

$$V = 4005\sqrt{VP}$$

13. What is the Recommended Weight Limit (RWL) for the following conditions: Weight to be lifted = 20 lbs.; Distance between body and hand grip on the object to be lifted = 24 inches; Vertical position at the beginning of the lift = 36 inches; Vertical position at end of lift = 46 inches; Frequency of lift = once every 5 minutes for 8 hours. Note: Hand coupling is poor, and this job requires a twist from the "eyes front" position of 15°.

A. 14.8 lbs.
B. 16.8 lbs.
C. 20 lbs.
D. 26.8 lbs.

$$RWL\,(lbs) = 51\left(\frac{10}{H}\right)(1 - .0075\,|\,V - 30\,|)\left(.82 + \frac{1.8}{D}\right)\left(1 - (0.0032 \times A)\right)(FM)\,(CM)$$

Coupling Multiplier (CM)		
	Coupling Multiplier	
Coupling Type	V< 30 inches (75 cm)	V ≥30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

Frequency Multiplier Table (FM)						
	Work Duration					
	≤ 1 hour		> 1 but ≤ 2 hours		>2 but ≤ 8 hours	
Frequency Lifts/min. (F)**	V < 30*	V ≥30	V < 30	V ≥30	V <30	V ≥30
≤ 0.2	1.00	1.00	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.80	0.80	0.60	0.60	0.35	0.35
6	0.75	0.75	0.50	0.50	0.27	0.27
7	0.60	0.70	0.42	0.42	0.22	0.22
8	0.52	0.60	0.35	0.35	0.18	0.18
9	0.45	0.52	0.30	0.30	0.00	0.15
10	0.41	0.45	0.26	0.26	0.00	0.13
11	0.37	0.41	0.00	0.23	0.00	0.00
12	0.00	0.37	0.00	0.21	0.00	0.00
13	0.00	0.34	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	0.00	0.00	0.00
15	0.00	0.28	0.00	0.00	0.00	0.00
> 15	0.00	0.00	0.00	0.00	0.00	0.00

14. Determine the Lifting Index for a 20-pound load with a calculated recommended weight limit of 14.8 lbs.

A. 0.55
B. 1.35
C. 0.82
D. 0.90

Domain 6 Quiz 1 Answers

1. Answer: **A**.

Step 1: Determine volume in m^3.

$$\frac{15 \text{ ft}}{1} \times \frac{0.305 \text{ m}}{1 \text{ ft}} = 4.6 \text{ m}$$

$$\frac{8 \text{ ft}}{1} \times \frac{0.305 \text{ m}}{1 \text{ ft}} = 2.44 \text{ m}$$

$$4.6 \times 4.6 \times 2.44 = 51.6 \text{ m}^3$$

Step 2: Determine weight.

$$\frac{5 \text{ gal}}{1} \times \frac{8.34 \text{ lbs}}{\text{gal}} \times 0.79 = 32.9 \text{ lbs}$$

Step 3: Convert—lbs to mg.

$$\frac{32.9 \text{ lb}}{1} \times \frac{0.454 \text{ kg}}{1 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1000 \text{ mg}}{1 \text{ g}}$$

$$= 14{,}936{,}600$$

$$= 1.49 \times 10^7 \text{mg}$$

Step 4: Compute—ppm.

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MV}}$$

$$\text{ppm} = \frac{\left(1.49 \times 10^7 / 51.6\right) \times 24.45}{46}$$

$$\text{ppm} = 153{,}859$$

Step 5: Convert to %.

$$\left(\frac{153{,}859}{1{,}000{,}000}\right) \times 100 = 15.39\%$$

Alternate Solution

Step 1: Determine—volume.

$$15 \times 15 \times 8 = 1800 \text{ ft}^3$$

Step 2: Determine—weight.

$$\frac{5 \text{ gal}}{1} \times \frac{8.345 \text{ lbs}}{\text{gal}} \times 0.79 = 32.9 \text{ lbs}$$

Step 3: Determine the volume occupied by the ethyl alcohol.

$$\frac{46 \text{ lbs}}{392 \text{ ft}^3} = \frac{32.9 \text{ lbs}}{\text{X}}$$

$$\text{X} = \frac{32.9 \times 392}{46}$$

$$\text{X} = 280 \text{ ft}^3$$

Step 4: Determine concentration of ethyl alcohol in the 1800 ft^3 room.

$$\frac{280\ ft^3}{1800\ ft^3} \times 100 = 15.58\%$$

2. Answer: **D**.

Step 1: Compute volume of room and determine the number of air changes per hour.

$$V = L \times W \times H$$
$$V = 100 \times 110 \times 10$$
$$V = 110{,}000\ ft^3$$
$$N = \frac{Q \times 60}{V}$$
$$N = \frac{2{,}000 \times 60}{110{,}000}$$
$$N = 1.09$$

Step 2: Apply formula and solve for 5 minutes of exposure.

$$C = \frac{G}{Q} \times \left(1 - e^{-Nt/60}\right)$$
$$C = \frac{1.2}{2000} \times \left(1 - e^{-(1.09 \times 5)/60}\right)$$
$$C = 0.0006 \times \left(1 - e^{-0.09}\right)$$
$$C = 0.0006 \times 0.0861$$
$$C = 0.0000517$$

Step 3: Convert to ppm.

$$ppm = C \times 1{,}000{,}000$$
$$ppm = 0.0000517 \times 1{,}000{,}000$$
$$ppm = 51.7$$

Step 4: Apply formula and solve for 15 minutes of exposure.

$$C = \frac{G}{Q} \times \left(1 - e^{-Nt/60}\right)$$
$$C = \frac{1.2}{2000} \times \left(1 - e^{-(1.09 \times 15/60)}\right)$$
$$C = 0.0006 \times \left(1 - e^{-0.2725}\right)$$
$$C = 0.0006 \times 0.239$$
$$C = 0.000143$$

Step 5: Convert to ppm.

$$ppm = C \times 1{,}000{,}000$$
$$ppm = 0.000143 \times 1{,}000{,}000$$
$$ppm = 143$$

Step 6: Apply formula and solve for 25 minutes of exposure.

$$C = \frac{G}{Q} \times \left(1 - e^{-Nt/60}\right)$$

$$C = \frac{1.2}{2000} \times \left(1 - e^{-(1.09 \times 25/60)}\right)$$

$$C = 0.0006 \times \left(1 - e^{-0.454}\right)$$

$$C = 0.0006 \times 0.365$$

$$C = 0.000219$$

Step 7: Convert to ppm.

$$ppm = C \times 1{,}000{,}000$$

$$ppm = 0.000219 \times 1{,}000{,}000$$

$$ppm = 219$$

3. Answer: **B**. When two or more hazardous chemicals with similar toxic effects are present in the environment, the combined effect should be evaluated rather than the individual effect. NOTE: The units can be either mg/m^3 or PPM but must be consistent in the equation. For calculating the TLV for a mixture of in air with additive health effects, use the formula:

$$TLV_m = \frac{C_1}{TLV_1} + \frac{C_2}{TLV_2} + \cdots + \frac{C_n}{TLV_n} \qquad TLV_{mix} = \frac{30}{50} + \frac{16}{20} + \frac{40}{100}$$

$$TLV_{mix} = 0.6 + 0.8 + 0.4 = 1.8$$

TLV_{mix} is the Threshold Limit Value for a mixture of airborne chemicals with additive effects. If the sum is greater than one (1), then an overexposure exists.

4. Answer: **D**.

Find the concentration of gas Z using $C \times T = dose$

$$C^{2.5} \times 30 = 3.4 \times 10^8$$

$$C^{2.5} = \frac{3.4 \times 10^8}{30} = 11{,}333{,}333$$

$$\sqrt[2.5]{C^{2.5}} = \sqrt[2.5]{11{,}333{,}333}$$

$$C = 663$$

5. Answer: **C**.

$$TWA = \frac{\left(C_1 \times T_1\right) + \left(C_2 \times T_2\right) + \cdots + \left(C_n \times T_n\right)}{\left(T_1 + T_2 + \cdots + T_n\right)}$$

$$ppm = \frac{(C_1 \times T_1) + (C_2 \times T_2) + (C_3 \times T_3) + (C_4 \times T_4)}{T_1 + T_2 + T_3 + T_4}$$

$$\frac{(210 \times 3) + (195 \times 2) + (0 \times 1) + (60 \times 1) + (300 \times 1)}{3 + 2 + 1 + 1 + 1} = \frac{1380}{8} = 172.5$$

OR

6. Answer: **A**.

$$T = \frac{8}{2^{\left(\frac{L-90}{5}\right)}} = \frac{8}{2^{\left(\frac{101.8-90}{5}\right)}} = \frac{8}{2^{\left(\frac{11.8}{5}\right)}} = \frac{8}{2^{2.36}} = \frac{8}{5.13}$$

$$T = 1.56 \text{ hours}$$

Under OSHA standards, workers are not permitted to be exposed to an 8-hour TWA equal to or greater than 90 dBA. OSHA uses a 5-dBA exchange rate, meaning the noise level doubles with each additional 5 dBA. **Table 14** shows how long workers are permitted to be exposed to specific noise levels:

Table 14 Permissible Duration for Exposure to Specific Noise Levels

Permissible Duration (Hours per Day)	Sound Level (dBA, Slow Response)
16	85
8	90
4	95
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

7. Answer: **B**.

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} = \text{exposure}$$

$$\frac{3}{4} + \frac{4}{8} = 1.25$$

1.25 is >1 exposure not allowed

8. Answer: **C**. Decibels are measured using a logarithmic scale, which means decibels cannot be added arithmetically. For example, if two noise sources are each producing 90 dB right next to each other, the combined noise sound level will be 93 dB, as opposed to 180 dB. The following equation should be used to calculate the sum of sound pressure levels, sound intensity levels, or sound power levels:

$$L_{pt} = L_{pi} + 10 \log N$$

L_{Pt} = total sound pressure level generated by N sources (dB)

L_{Pi} = individual sound level of of each source (dB)

N = number of sound pressure levels

$$L_{pt} = L_{pi} + 10 \log N$$

$$L_{pi} = L_{pt} - 10 \times \log 4$$

$$L_{pi} = L_{pt} - 6.02$$

$$L_{pi} = 79.55 - 6.02$$

$$L_{pi} = 73.53 \text{ dB}$$

Table 15 can be used to estimate a sum of various sound levels.

Table 15 Accumulative Sound Levels from Multiple Noise Sources

Difference Between Two Levels to be Added	Amount to Add to Higher Level to Find the Sum
0–1 dB	3 dB
2–4 dB	2 dB
5–9 dB	1 dB
10 dB	0 dB

9. Answer: **D**. Noise exposure can result in threshold shifts at one frequency when moderate at two or more adjacent frequencies, or when even small successive shifts occur consistently over a period of years. OSHA's current definition of a significant or "standard" threshold shift is an average shift of 10 dB or greater at 2000, 3000, and 4000 Hz in either ear.

10. Answer: **D**. According to *Fundamentals of Industrial Hygiene* (Plog 2012), the most convenient method by which to gauge the adequacy of a hearing protector's attenuation capacity is to check its **Noise Reduction Rating (NRR)**, a rating that was developed by the EPA. According to the EPA regulation, the NRR must be printed on the hearing protector's package. The NRR can be correlated with an individual worker's noise environment to assess the adequacy of the attenuation characteristics of the particular hearing-protective device. Appendix B of 29 CFR 1910.95 describes methods of using the NRR to determine whether a particular hearing-protective device (HPD) provides adequate protection within a given exposure environment. It must be noted, however, that NRRs are based on data obtained under laboratory conditions using trained listeners who are fitted by professionals. Their ratings differ significantly from what is achieved in the real world. In 1998, the National Institute of Safety and Health (NIOSH) published *Occupational Noise Exposure*, Revised Criteria. Based on studies conducted by numerous researchers of real world NRRs achieved by 84% of wearers in 20 independent studies, they recommend lowering the manufacturer's NRRs significantly. NIOSH recommended using subject fit data based on ANSI 512.6-1997 to estimate HPD attenuation. If this is not available, they recommend that the labeled NRRs be derated as follows:

- **Earmuffs—subtract 25 percent from the manufacturer's labeled NRR**
- **Formable earplugs—subtract 50 percent from the manufacturer's NRR**
- **All other plugs—subtract 70 percent from the manufacturer's NRR (NIOSH 1998)**

Noise Reduction Rating (NRR) is a unit of measurement used to determine the effectiveness of hearing protection devices to decrease sound exposure within a given working environment. The purpose is to calculate the noise attenuation for protecting workers by preventing sensorineural (occupational induced) hearing loss.

Also, the NIOSH derating scheme does not affect the 7-decibel dBC to dBA correction as it is applied to the NRR only, de-rated or not. This compendium uses the NIOSH derating of the NRR when searching for hearing protectors based on the compendium user's input of noise exposure levels in dBA or octave band levels.

The OSHA Hearing Conservation Amendment to the Occupational Noise Standard describes six methods for using the NRR to determine a worker's protected A-weighted noise exposure. These methods vary according to the instrumentation and parameters used to determine the unprotected noise levels. However, they can be summarized into two basic formulas, depending on whether unprotected exposure levels were measured on a C-weighted or an A-weighted scale.

For C-weighted measurements: protected dBA = unprotected dBC – NRR, where the protected dBA and the unprotected dBC are 8-hour time-weighted averages determined according to the Occupational Noise Standard. This method is how the NRR was designed to be used. For example, if a protector has an NRR of 17 dB and it is used in an environmental noise level of 95 dBC, the noise level entering the ear could be expected to be 78 dBA [95 – 17 = 78] or lower in 98% of the cases if the protector is worn according to manufacturer's specification.

For A-weighted measurements: protected dBA = unprotected dBA – [NRR – 7] where, again, the protected and unprotected dBA are 8-hour time-weighted averages determined according to the Occupational Noise Standard. This method is an adaptation for those whose instrumentation does not have C-weighting capabilities. The 7 dB correction factor is used to account for the deemphasis of low-frequency energy inherent to the A-weighting scale. So, for example, if a protector has an NRR of 17 dB, and it is used in an environmental noise level of 95 dBA, the noise level entering the ear could be expected to be 85 dBA [95 – (17 – 7) = 85] or less in 98% of the cases. **A-weighting is applied to instrument-measured sound levels in an effort to account for the relative loudness perceived by the human ear, as the ear is less sensitive to low audio frequencies.**

11. Answer: **B**. When trying to evaluate the impact of high noise levels on the human ear, it is very difficult to determine the effectiveness of hearing protectors. Hearing protectors are evaluated under laboratory conditions specified by ANSI Z24.22 and ANSI S3.19

    However, in field conditions the ***Noise Reduction Rating (NRR)*** given hearing protectors often is provided a safety factor of 2 or reduced by 50%. This is necessary because field conditions never equal laboratory conditions. Additionally, when two noise reduction devices are properly worn, an additional 5 dB (doubling) of protection is provided. After field attenuation is calculated, it is subtracted from the 8-hour TWA value to obtain the protected TWA (sound level reaching the cochlea).

    Remember, the exam baseline is federal OSHA standard of 90 dBA and 85 dBA if the individual has had a threshold shift.

$$A_f = \frac{NRR - 7}{2} + 5$$

$$A_f = \frac{37 - 7}{2} + 5$$

$$A_f = 15 + 5$$

$$A_f = 20$$

$$\text{ProtectedTWA} = TWA_8 - A_f$$

$$\text{ProtectedTWA} = 115 - 20$$

$$\text{ProtectedTWA} = 95 \text{ dBA}$$

12. Answer: **A**.

$$Q_A + Q_B = Q_C$$

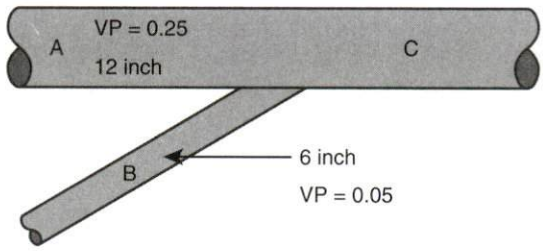


Figure 23 Ventilation Duct Schematic, Question 12

The flows in each branch of the duct are additive (**Figure 23**).

Step 1: Determine the Velocity of air flowing in branch "A."

$$V = 4005\sqrt{VP}$$

$$V = 4005\sqrt{0.25}$$

$$V = 4005 \times 0.5$$

$$V = 2003 \text{ fpm}$$

Step 2: Determine the area of the duct in branch "A."

$$A = \pi r^2$$

$$A = 3.14 \times \left(\frac{6}{12}\right)^2$$

$$A = 3.14 \times 0.25$$

$$A = 0.7854 \text{ square feet}$$

Step 3: Determine quantity of air flowing in duct "A."

$$Q = V A$$
$$Q = 2003 \times 0.7854$$
$$Q = 1573 \text{ cfm}$$

Step 4: Determine the velocity of air flowing in branch "B."

$$V = 4005 \sqrt{VP}$$
$$V = 4005 \sqrt{0.05}$$
$$V = 4005 \times 0.224 = 896 \text{ fpm}$$

Step 5: Determine area of duct in branch "B."

$$A = \pi r^2$$
$$A = 3.14 \times \left(\frac{3}{12}\right)^2$$
$$A = 3.14 \times 0.0625$$
$$A = 0.1963 \text{ square feet}$$

Step 6: Determine quantity of air flowing in duct "B."

$$Q = VA$$
$$Q = 896 \times 0.1963 = 176 \text{ cfm}$$

Step 7: Determine sum of two branch flows.

$$Q_C = Q_A + Q_B$$
$$Q_C = 1573 + 176$$
$$Q_C = 1749 \text{ cfm}$$

13. Answer: **A**. The 1991 NIOSH lifting equation is a specialized risk assessment tool. It has been designed to meet selected lifting related criteria and encompasses biomechanical, work physiology, and psychophysical elements in a practical application framework that, if followed, will result in a reduced number of workplace mishaps.

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$
$$RWL = 51\left(\tfrac{10}{H}\right)(1 - .0075 \mid V - 30 \mid)\left(.82 + \tfrac{1.8}{D}\right)\left(1 - (0.0032 \times A)\right)(FM)(CM)$$
$$RWL = 51\left(\tfrac{10}{24}\right)(1 - .0075 \times 6)\left(.82 + \tfrac{1.8}{10}\right)\left(1 - (0.0032 \times 15)\right)(0.85)(0.9)$$
$$RWL = 51 \times 0.417 \times .955 \times 1 \times 0.952 \times 0.85 \times 0.9$$
$$RWL = 14.8 \text{ lbs}$$

14. Answer: **B**.

$$LI = \frac{L}{RWL}$$
$$LI = \frac{20}{14.8} = 1.35$$

The Lifting Index provides a numerical indicator of the need for redesign. A LI of greater than one (1) means the job needs to be redesigned. As one can readily see from the previous question, this job could benefit from locating the work closer to the employee. Additionally, some value might be gained by shortening workday length devoted to lifting.

Domain 6 Quiz 2 Questions

1. **When testing for chromium (VI) using the Biological Exposure Indices (BEIs), what determinate is tested for?**

   A. Chromium in the urine
   B. Chromium in the blood
   C. Mandelic acid in the urine
   D. Mandelic acid in the blood

2. **Compression of nerves and blood vessels between clavicle and first and second ribs is a disease known as:**

   A. polymorphous light eruption.
   B. pneumothorax.
   C. atelectasis.
   D. thoracic outlet syndrome.

3. **A CIH has found that part of the workforce is being exposed to chromium (VI). Assessment of exposed employees is conducted on Fridays at the shift end. The company CSP places all test results:**

   A. on a computer.
   B. in a file cabinet.
   C. in employee's personnel file.
   D. in employee's medical record.

4. **A metal fume hazard potentially present when welding stainless steel is:**

   A. hexavalent chromium.
   B. lead chromate.
   C. zinc oxide.
   D. magnesium oxide.

5. **A CIH is involved in a monitoring operation using a carbon monoxide direct reading instrument. The instrument has recorded readings of 20 ppm for 4 hours. Abruptly, without any change in plant conditions, the indicator increases rapidly to 75 ppm and has remained constant for 5 minutes. This should initiate what action?**

   A. Shut down all production operations immediately.
   B. Stop all operating PITs until readings drop.
   C. Continue monitoring.
   D. Stop and recalibrate instrument.

6. **Which device is *best* for measuring an employee's accumulated radiation dose?**

   A. Portacount®
   B. Currie counter
   C. Pocket dosimeter
   D. Geiger counter

7. **Amount of absorbed energy deposited in tissue/matter is called a:**

   A. RAD.
   B. REM.
   C. ALARA.
   D. Roentgen.

8. Which of the following procedures would be used to determine the effectiveness of recently implemented controls for exposure reduction to benzene?

A. Urine analysis preceding work shift, as well as after
B. Blood draws bimonthly
C. Saliva test before work each shift
D. Urine test after the work shift

9. Sick building syndrome is defined as:

A. a lack of sufficient makeup air.
B. a high level of carbon monoxide.
C. formaldehyde that is being released from new carpet at an undesirable rate.
D. a building in which a significant number (more than 20%) of occupants report illnesses perceived as building related.

10. The National Institutes of Health (NIH) publishes biosafety guidelines commonly used for containment of biohazardous agents in workplaces (Biosafety in Microbiological and Biomedical Laboratories). How many Biosafety levels (BSL) are there?

A. 2
B. 3
C. 4
D. 5

11. Which is the *best* method to prevent infection from a surface in a lab?

A. Use of disposable PPE
B. Decontamination procedures for PPE
C. Industrial hygiene programs
D. Containment

12. The *least common* form of cold stress is:

A. chilblains.
B. hypothermia.
C. frostbite.
D. trenchfoot.

13. If a person is suffering from heatstroke, which symptom would they *unlikely* experience?

A. Severe headache
B. Profuse sweating and cool, moist skin
C. Loss of consciousness
D. Rapid temperature-rise and hot, dry skin

14. The science of measuring the human body for differences in various physical characteristics is:

A. kinesiology.
B. anthropometry.
C. physiology.
D. ergonomics.

15. Liver damaging substances such as carbon tetrachloride, chloroform, tannic acid, and trichloroethylene are called?

A. Nephrotoxins
B. Hematoxins
C. Hepatotoxins
D. Lacrimators

16. Disorders that affect the muscles, nerves, blood vessels, ligaments, and tendons are called:

A. chronic wasting disease (CWD).
B. musculoskeletal disorders (MSDs).
C. cumulative trauma disorders (CTDs).
D. soft tissue diseases (STDs).

Domain 6 Quiz 2 Answers

1. Answer: **A**. The test for chromium (VI) is for the "total chromium in the urine to be conducted at the end of shift at end of workweek."

2. Answer: **D**. Thoracic outlet syndrome is defined as a disorder resulting from a compression of nerves and blood vessels between clavicle and first and second ribs at the brachial plexus. It can be caused by typing, keying, carrying heavy loads or keeping the head, arms, and/or shoulders in an unnatural position.

3. Answer: **D**. According to OSHA 1910, employee exposure records are part of medical records. 1910.1020(c)(5): "Employee exposure record" means a record containing any of the following kinds of information:

   1910.1020(c)(5)(i): Environmental (workplace) monitoring or measuring of a toxic substance or harmful physical agent, including personal, area, grab, wipe, or other form of sampling, as well as related collection and analytical methodologies, calculations, and other background data relevant to interpretation of the results obtained;

   1910.1020(c)(5)(ii): Biological monitoring results which directly assess the absorption of a toxic substance or harmful physical agent by body systems (e.g., the level of a chemical in the blood, urine, breath, hair, fingernails, etc.) but not including results which assess the biological effect of a substance or agent or which assess an employee's use of alcohol or drugs.

4. Answer: **A**. According to the NSC *Accident Prevention Manual for* Business *and Industry:* Since chromium is used in all stainless steel alloys, welding stainless steel can cause fumes of *trivalent or hexavalent form of* chromium to be released into the welder's breathing zone.

5. Answer: **D**. Based on the statement in the question that there were no changes in plant operations, we feel the best course of action would be to stop monitoring and recalibrate the instrumentation. The reading of 65 ppm is not life threatening (the IDLH is 1200 ppm), and recalibration should be able to be accomplished in fresh air in a very short time. If hydrogen sulfide was present, since it is an interference agent with carbon monoxide sensors, it could cause the CO readings to be incorrect.

6. Answer: **C**. A pocket dosimeter measures a person's accumulated radiation dose. A pocket dosimeter is frequently used in conjunction with a film badge (Themoluminescent Dosimetry Badge).

7. Answer: **A**.

   Radiation is energy that comes from a source and travels through space at the speed of light. This energy has an electric field and a magnetic field associated with it and has wave-like properties. You could also call radiation "electromagnetic waves." Three common measurements of radiation are the amount of radioactivity, ambient radiation levels, and radiation dose. The guiding principle of radiation safety is ALARA or "as low as reasonably achievable" (**Table 16**).

Table 16 Radiation Exposure Measurements

Roentgen (R)	A measure of energy deposited in tissue/matter Amount of charge from ion particles produced in air Coulombs/Kg air A unit of exposure to ionizing radiation
Radiation Absorbed Dose (RAD)	Amount of absorbed energy deposited in tissue/matter 1 rad = 100 ergs of deposited energy in a gram of tissue/matter 1 gray (Metric) = 100 rads (10,000 ergs) Applicable to all types of radiation
Roentgen Equivalent Man (REM)	Rem is a biologically weighted absorbed dose. It is a dose equivalent that takes into account the energy absorbed and the biological effect upon tissue. This is especially important in cases of internal exposure. It's often expressed in terms of thousandths of a rem (or mrem). Alpha, beta, and gamma radiation do not all cause the same damage—they have different biological effects.
As Low as Reasonably Achievable (ALARA)	A principle of safety Limits exposure to radiation as much as possible Ensures that no exposure should be without a benefit

Physiological Effects of radiation include:

- Acute
  - Absorption or intake of a relatively large amount of radiation
  - Over a short amount of time (seconds, minutes, or hours)
- Chronic
  - Absorption or intake of radiation over a long period of time (years or a lifetime)
- Somatic
  - Can occur from acute or chronic exposure
  - Affects the exposed body
  - May be months or years after exposure
  - Shortened life span and aging
  - Can cause cancer
- Genetic
  - May affect future offspring
  - Direct radiation of reproductive organs
  - Cellular DNA affected—mutagenic
- Teratogenic
  - Direct irradiation of developing fetus
  - Results in death or deformity

Table 17 Radiation Dose Effects

Whole Body Absorbed Dose (rad)	Effect	Fatalities
10	None	None
100	Nausea, vomiting, and diarrhea	None
400	Death without medical intervention	LD50/30
1000–2000	Gastrointestinal syndrome	100% in 1 to 2 weeks
Less than 2000	Central nervous system	100% in a few days

8. Answer: **D**. Biological monitoring to determine effectiveness of recent changes would involve urine tests to determine the S-phenylmercapturic acid or t,t-muconic acid content after each work shift.

9. Answer: **D**. Answer D is the American Society of Heating and Air-Conditioning Engineers (ASHRAE) definition of a "Sick Building."

   If a significant number of occupants complain of eye, nose, and throat irritation, headaches, dizziness, or difficulty concentrating but recover soon after leaving the building, these are strong indicators of poor air quality. Buildings with consistently high levels of complaints are commonly called "sick buildings." A Health Hazard Evaluation (HHE) by NIOSH or a similar evaluation by a qualified IAQ test organization will indicate if the building has indoor air quality problems.

10. Answer: **C**. There are four biosafety levels:

    BSL-1—agents not known to consistently cause disease in healthy adults

    BSL-2—agents associated with human disease, hazard is from percutaneous injury, ingestion, mucous membrane exposure

    BSL-3—indigenous or exotic agents with potential for aerosol transmission; disease may have serious or lethal consequences

    BSL-4—dangerous/exotic agents that pose high risk of life-threatening disease, aerosol-transmitted lab infections, or related agents with unknown risk of transmission

11. Answer: **D**.

    Containment is the mechanism for ensuring that workers, the immediate work environment, and the community, including those outside the immediate workplace, are protected or shielded from exposure during workplace activities involving infectious or biological agents. As stated in the 5th edition of *Biosafety in Microbiological and Biomedical Laboratories* (BMBL 2009), "the term 'containment' is used in describing safe methods, facilities and equipment for managing infectious materials in the laboratory environment where they are being handled or maintained." Varying configurations of these components are used depending on the hazard category of the work. The CDC and NIH have designated four default configurations of work practices, safety equipment, and facility design as biosafety levels (BSLs) for work involving infectious agents or activities in which experimentally or naturally infected vertebrate animals are manipulated. The combination must be specifically appropriate for the operations performed, the documented or suspected routes of transmission of the agent, and the laboratory function or activity. The use of increasingly stringent procedures and more complex laboratory facilities permits higher risk activities to be carried out safely. Specific mitigation measures should be selected based on the identified risks. As a simple example, minimizing sharp objects would be a good practice for handling an agent that causes disease through percutaneous exposure. Depending on the sophistication of the mitigation measures, containment can be expensive to operate and maintain and/or procedurally burdensome, so optimizing the control measures for the identified risks ideally provide the best return on investment to improve safety.

12. Answer: **A**. The most common cold induced illnesses/injuries are hypothermia, frost bite, and trench foot. The human body is designed to work optimally at a temperature of 98.6°F ± 1.8°F. The human body is less capable of coping with heat loss than with heat gain. Exposure to cold temperatures, air temperatures less than 61°F, can reduce manual dexterity. While adaptive mechanisms (i.e., sweating and acclimation) are crucial during heat stress exposures, the physiological adaptations to cold stress have less dramatic effects. The first physiological response to cold stress is to conserve body heat by reducing blood circulation through the skin, effectively making the skin an insulating layer. The second physiological response is boosting the body's metabolism through shivering, a sign of significant cold stress and that hypothermia may be present. However, it is relatively weak as a protective mechanism. Behavior is the primary human response to preventing excessive exposure to cold stress. Behaviors include increasing clothing insulation, increasing activity, and seeking warm locations. Hazards associated with cold stress are manifested in two distinct fashions: systemic (hypothermia) and local (localized tissue damage). As hypothermia progresses, depression of the central nervous system becomes more severe. This accounts for the progression of signs and symptoms

from a sluggishness through slurred speech and unsafe behaviors to disorientation and unconsciousness. The ability to sustain metabolic rate and reduced skin blood flow is diminished by fatigue. Thus, fatigue increases the risk of severe hypothermia through decreasing metabolic heat and increased heat loss from the skin. Because blood flow through the skin is reduced to conserve heat, the skin and underlying tissues are more susceptible to local cold injury.

Cold Stress Disorders The four physical disorders that can arise from cold stress, listed in increasing order of severity, are as follows:

- Chilblains: Chilblains usually arise because of inadequate clothing during periods of exposure to cold temperatures and high relative humidity. Reddening of the skin accompanied by localized itching and swelling are the principal indications of chilblains.
- Frostnip: Frostnip, which is similar to frostbite, results from prolonged, unprotected exposures to cold temperatures above 32°F (0°C). Symptoms of frostnip are areas of pain and/or itching and a distinct whitening of the skin.
- Frostbite: Frostbite is produced from unprotected exposures to cold temperatures at or below freezing—i.e., ≤ 32°F or 0°C. Frostbite is characterized by the sequential change in skin color from white to gray to black [depending upon the temperature and the length of exposure], a reduction in the sensations of touch ranging from slight to total [again depending upon the temperature and the length of exposure], and numbness.
- Hypothermia: Hypothermia results from extreme exposures to the factors of cold stress, coupled possibly with dehydration and/or exhaustion. Alcohol and/or drug abuse can also contribute to hypothermia. A person who is experiencing hypothermia will usually show some or all the following symptoms: chills, euphoria, pain in the extremities, slow and weak pulse, body temperature of less than 95°F (35°C), fatigue, drowsiness, and unconsciousness (**Table 18**).

Table 18 Cold-Related Disorders

Disorder	Symptoms	Signs	Causes	First Aid
Hypothermia	Chills Pain in extremities Fatigue or drowsiness	Euphoria Slow, weak pulse Slurred speech Collapse Shivering Unconsciousness Body temperature <95°F (35°C)	Excessive exposure Exhaustion or dehydration Subnormal tolerance (genetic or acquired) Drug/alcohol abuse	Move to warm area and remove wet clothing Modest external warming (external heat packs, blankets, etc.) Drink warm, sweet fluids, if conscious Transport to hospital
Frostbite	Burning sensation at first Coldness Numbness Tingling	Skin color white or grayish yellow to reddish violet to black Blisters Response to touch depends on depth of freezing	Exposure to cold Vascular disease	Move to warm area and remove wet clothing External warming (e.g., warm water) Drink warm, sweet fluids, if conscious Treat as a burn, do not rub affected area Transport to hospital
Frostnip	Possible itching or pain	Skin turns white	Exposure to cold (above freezing)	Similar to frostbite
Trench Foot	Severe pain Tingling, itching	Edema Blisters Response to touch depends on depth of freezing	Exposure to cold (above freezing) and dampness	Similar to frostbite

(*continued*)

Disorder	Symptoms	Signs	Causes	First Aid
Chilblain	Recurrent, localized itching Painful inflammation	Swelling Severe spasms	Inadequate clothing Exposure to cold and dampness Vascular disease	Remove to warm area Consult physician
Raynaud's disorder	Fingers tingle Intermittent blanching and reddening	Fingers blanch with cold exposure	Exposure to cold and vibration Vascular disease	Remove to warm area Consult physician

Hypothermia is related to systemic cold stress, and the other disorders are related to local tissue cooling.

Dressing properly is extremely important to preventing cold stress. The type of fabric worn also makes a difference. Cotton loses its insulation value when it becomes wet. Wool, silk, and most synthetics, on the other hand, retain their insulation even when wet.

13. Answer: **B**.

Refer **Table 19**.

Table 19 Heat Stress Disorders

Disorder	Symptoms	Signs	Causes	First Aid
Heat stroke	Chills Restlessness Irritability	Euphoria Red face Disorientation Hot, dry skin Erratic behavior Collapse Shivering Unconsciousness Convulsions Body temperature ≥104°F (40°C)	Excessive exposure Subnormal tolerance (genetic or acquired) Drug/alcohol abuse	Immediate, aggressive, effective cooling. Transport to hospital Take body temperature
Heat exhaustion	Fatigue Weakness Blurred vision Dizziness, headache	High pulse rate Profuse sweating Low blood pressure Insecure gait Pale face Collapse Body temperature: Normal to slightly increased	Dehydration (caused by sweating, diarrhea, vomiting) Distribution of blood to the periphery Low level of acclimation Low level of fitness	Lie down flat on back in a cool environment Drink water. Loosen clothing
Dehydration	No early symptoms Fatigue/weakness Dry mouth	Loss of work capacity Increased response time	Excessive fluid loss caused by sweating, illness (vomiting or diarrhea), alcohol consumption	Fluid and salt replacement
Heat syncope	Blurred vision (gray-out) Fainting (brief black-out) Normal temperature	Brief fainting or near-fainting behavior	Pooling of blood in the legs and skin from prolonged static posture and heat exposure	Lie on back in cool environment Drink water

Disorder	Symptoms	Signs	Causes	First Aid
Heat cramps	Painful muscle cramps especially in abdominal or fatigued muscles	Incapacitating pain in muscle	Electrolyte imbalance caused by prolonged sweating without adequate fluid and salt intake	Ret in a cool environment Drink salted water (0.5% salt solution) Massage muscles
Heat rash (prickly heat)	Itching skin Reduced sweating	Skin eruptions	Prolonged, uninterrupted sweating Inadequate hygiene practices	Keep skin clean Reduce heat

14. Answer: **B**. **Anthropometry** refers to the measurement of the human individual. Anthropometry involves the systematic measurement of the physical properties of the human body, primarily dimensional descriptors of body size and shape. Today, anthropometry plays an important role in industrial design, clothing design, ergonomics, and architecture where statistical data about the distribution of body dimensions in the population are used to optimize products. Changes in lifestyles, nutrition, and ethnic composition of populations lead to changes in the distribution of body dimensions (e.g., the obesity epidemic) and require regular updating of anthropometric data collections.

    Kinesiology is a scientific study of human or nonhuman body movement. Kinesiology addresses physiological, biomechanical, and psychological mechanisms of movement. Applications of kinesiology to human health (i.e., **human kinesiology**) include biomechanics and orthopedics; strength and conditioning; sport psychology; methods of rehabilitation, such as physical and occupational therapy; and sport and exercise. Studies of human and animal motion include measures from motion tracking systems, electrophysiology of muscle and brain activity, various methods for monitoring physiological function, and other behavioral and cognitive research techniques.

    Physiology is the scientific study of the normal function in living systems. A subdiscipline of biology, its focus is in how organisms, organ systems, organs, cells, and biomolecules carry out the chemical or physical functions that exist in a living system.

    Ergonomics (human factors) also known as comfort design, functional design, and systems, is the practice of designing products, systems, or processes to take proper account of the interaction between them and the people who use them. The study of people's efficiency in their working environment. The field has seen contributions from numerous disciplines, such as psychology, engineering, biomechanics, industrial design, physiology, and anthropometry. In essence, it is the study of designing equipment, devices, and processes that fit the human body and its cognitive abilities. The two terms "human factors" and "ergonomics" are essentially synonymous.

15. Answer: **C**. Substances capable of damaging the liver are called ***hepatotoxins*** (**Table 20**). The liver is the main processing organ for toxins. It may convert toxins into nontoxic forms; however, the liver may generate a more toxic by-product, which can cause cellular and tissue damage. Examples of hepatotoxins are carbon tetrachloride, chloroform, tannic acid, and trichloroethylene. Examples of chemicals that cause cirrhosis (a fibrotic disease that results in liver dysfunction and jaundice) are carbon tetrachloride, alcohol, and aflotoxin. Other effects can range from tumors to enlargement of the liver and fat accumulation. The main function of the kidneys is to filter the blood and eliminate wastes. Because waste gets concentrated in the process, toxins can be at much higher levels in the kidneys. Toxins that damage this organ are known as ***nephrotoxin***s. Most heavy metals fall into this category, including mercury, arsenic, and lithium. Many halogenated (i.e., chlorinated) organic compounds are also nephrotoxins such as tetrachloroethylene, carbon tetrachloride, and chloroform. Other chemicals that damage the kidneys include carbon disulfide, methanol, toluene, and ethylene glycol. Substances capable of producing blood disorders are called ***hematoxins***. Chemicals that affect the bone marrow, which is the source of most of the components of blood, are arsenic, bromine, methyl chloride, and benzene. Chemicals that affect platelets, which are cell fragments that help in the process of blood clotting, are aspirin, benzene, and tetrachloroethane. Chemicals that affect white blood cells, which

help the body defend against infection, are naphthalene and tetrachloroethane. ***Lacrimators*** are chemicals that can cause instant tearing at low concentrations. Examples are tear gas and MACE. Other chemicals can cause cataracts, optic nerve damage, and retinal damage by circulating through the bloodstream and reaching the eye. Examples of these are naphthalene, methanol, and thallium.

Table 20 Categories of Hazards in Industrial Toxicology

Class of Hazard	Affected Organ	Possible Signs and Symptoms	Selected Examples
Irritants	Exposed tissues (e.g., mucous tissues)	Pain, fluid accumulation	Acids and acid vapors, sulfur dioxide, ozone, ammonia, chlorine
Simple Asphyxiants	Body cells (O_2 is blocked from the lungs)	Confusion, collapse, unconsciousness	Nitrogen, argon, helium, carbon dioxide, methane (natural gas)
Chemical Asphyxiants	Body cells (interferes with oxygenation of body cells)	Confusion, headache, collapse, unconsciousness	Carbon monoxide, hydrogen sulfide, inorganic cyanides
Anesthetics or Central Nervous System Depressants	Central nervous system	Dizziness, drowsiness, collapse, unconsciousness	Liquids and vapors of many organic solvents (e.g., alcohols, ethers, esters, chlorinated hydrocarbons, toluene, xylene, benzene)
Agents that can cause lung illnesses (e.g., fluid accumulation, tissue scarring, cancer)	Lungs, linings of either the lungs or the abdomen	Breathlessness, chest pain, cough, weakness	Asbestos, crystalline silica (e.g., quartz), coal, radioactive substances, beryllium and its compounds, welding fumes, cotton fibers, arsenic and its compounds, hydrogen fluoride, phosgene, nitrogen dioxide
Carcinogens (agents that are known or suspected of causing cancer in humans)	Various organs, depending on the agent	Pain, coughing, tumors, various other symptoms	Confirmed carcinogens include: asbestos, radioactive substances, polycyclic aromatic hydrocarbons (PAHs), arsenic, and its compounds, benzene, hexavalent chromium compounds, coal tars and pitches, vinyl chloride Suspected carcinogens include: acrylonitrile, benzidine-based dyes, benzo[a]pyrene, beryllium and its compounds, cadmium and its compounds, carbon tetrachloride, creosote, ethylene oxide, formaldehyde gas, 2,3,7,8- tetrachloro-dibenzo[p] dioxin (TCDD), trichloroethylene, tetrachloroethylene, and crystalline silica dust
Nephrotoxins	Kidneys	Symptoms vary for different agents	Most heavy metals and their compounds (e.g., lead, mercury, chromium, uranium), some halogenated hydrocarbons (e.g., trichloroethylene, chloroform, carbon tetrachloride), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), polychlorinated biphenyls (PCBs)

Class of Hazard	Affected Organ	Possible Signs and Symptoms	Selected Examples
Hepatotoxins	Liver	Symptoms vary for different agents	Some halogenated hydrocarbons (e.g., carbon tetrachloride, chloroform, trichloroethylene and tetrachloroethylene), ethyl alcohol, allyl alcohol, urethane monomer, hydrazine, cerium and its compounds, beryllium and its compounds, and some pharmaceuticals
Chemical Allergens (sensitizers)	Various tissues, especially skin and eyes	Itching, swelling, inflammation	Formaldehyde, beryllium and its compounds, toluene-2,4-diisocyanate (TDI), creosote, some acrylates, epoxy resins and components, coal tar and its derivatives, some organic dyes, turpentine, some woods, poison ivy and oak, white sumac, some pharmaceuticals
Genotoxic and fetotoxic agents	Genotoxic: affects the genetic material of reproductive cells Fetotoxic: affects a fetus	Genotoxins: may be few immediate signs Fetotoxins: deformity or loss of a fetus	Benzene, toluene, xylene, ethyl alcohol, carbon disulfide, carbon monoxide, lead and its compounds, mercury and its compounds, arsenic and its compounds, cadmium and its compounds, radiation and radioactive substances, chlorinated phenoxyacetic acids, paraquat, diquat, PCBs, TCDD, ethylene oxide, dinitrobenzene, and some pharmaceuticals

16. Answer: **B**.

Musculoskeletal disorders (MSDs) affect the muscles, nerves, blood vessels, ligaments, and tendons. Workers in many different industries and occupations can be exposed to risk factors at work, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures and performing the same or similar tasks repetitively. Exposure to these known risk factors for MSDs increases a worker's risk of injury (**Table 21**). MSDs are very difficult to define within traditional disease classifications.

Table 21 Examples of Musculoskeletal Disorders

Body Parts Affected	Symptoms	Possible Causes	Workers Affected	Disease Name
thumbs	pain at the base of the thumbs	twisting and gripping	butchers, housekeepers, packers, seamstresses, cutters	De Quervain's disease
fingers	difficulty moving finger; snapping and jerking movements	repeatedly using the index fingers	meatpackers, poultry workers, carpenters, electronic assemblers	trigger finger
shoulders	pain, stiffness	working with the hands above the head	power press operators, welders, painters, assembly line workers	rotator cuff tendinitis

(*continued*)

Body Parts Affected	Symptoms	Possible Causes	Workers Affected	Disease Name
hands, wrists	pain, swelling	repetitive or forceful hand and wrist motions	core making, poultry processing, meatpacking	tenosynovitis
fingers, hands	numbness, tingling; ashen skin; loss of feeling and control	exposure to vibration	chain saw, pneumatic hammer, and gasoline powered tool operators	Raynaud's syndrome (white finger)
fingers, wrists	tingling, numbness, severe pain; loss of strength, sensation in the thumbs, index, or middle or half of the ring fingers	repetitive and forceful manual tasks without time to recover	meat and poultry and garment workers, upholsterers, assemblers, VDT operators, cashiers	carpal tunnel syndrome
back	low back pain, shooting pain or numbness in the upper legs	whole body vibration	truck and bus drivers, tractor and subway operators; warehouse workers; nurses aides; grocery cashiers; baggage handlers	back disability

These disorders have received many names, such as:

- Repetitive motion injuries
- Repetitive strain injuries
- Cumulative trauma disorders
- Occupational cervicobrachial disorders
- Overuse syndrome
- Regional musculoskeletal disorders
- Soft tissue disorders

Most of the names do not accurately describe the disorders. For example, the term "repetitive strain injuries" suggests that repetition causes these disorders, but awkward postures also contribute. These terms are used synonymously; however, MSD is used in current literature. Work-related MSDs can be prevented. Ergonomics, fitting a job to a person, helps lessen muscle fatigue, increases productivity, and reduces the number and severity of work-related MSDs.

Bureau of Labor Statistics (BLS) defines musculoskeletal disorders (MSDs) to include cases where the nature of the injury or illness is pinched nerve; herniated disc; meniscus tear; sprains, strains, tears; hernia (traumatic and nontraumatic); pain, swelling, and numbness; carpal or tarsal tunnel syndrome; Raynaud's syndrome or phenomenon; musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is overexertion and bodily reaction, unspecified; overexertion involving outside sources; repetitive motion involving microtasks; other and multiple exertions or bodily reactions; and rubbed, abraded, or jarred by vibration.

The risk of MSD injury depends on work positions and postures, how often the task is performed, the level of required effort and how long the task lasts. Risk factors that may lead to the development of MSDs include:

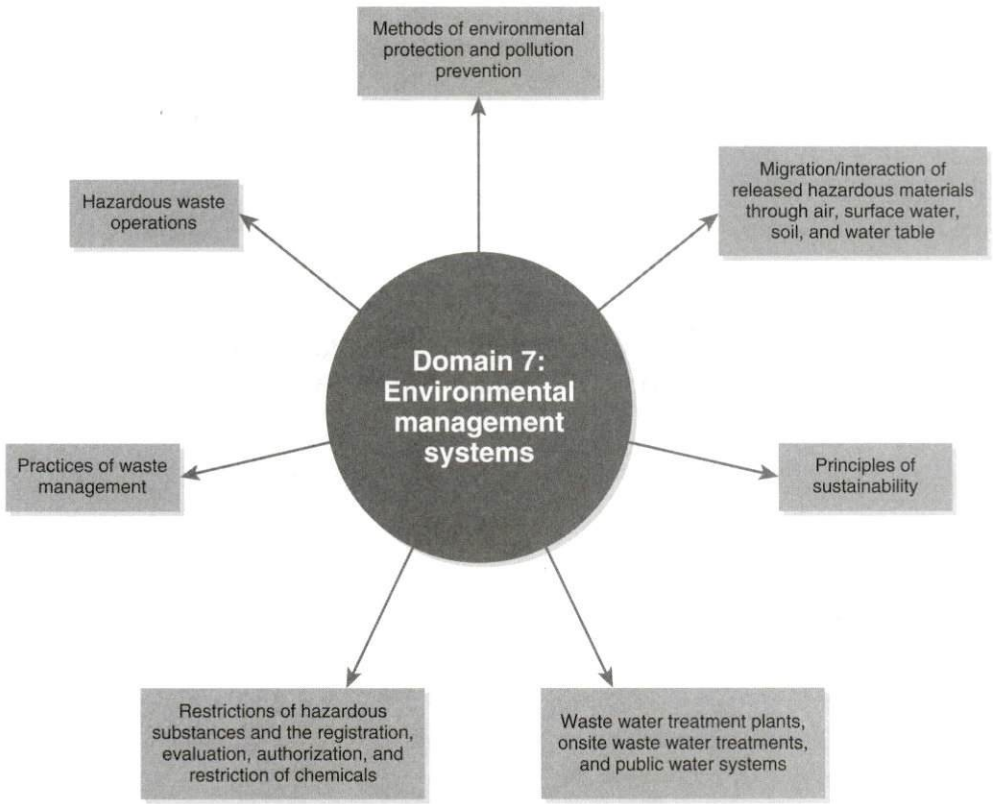
- **Exerting excessive force**. Examples include lifting heavy objects or people, pushing or pulling heavy loads, manually pouring materials, or maintaining control of equipment or tools.
- **Performing the same or similar tasks repetitively**. Performing the same motion or series of motions continually or frequently for an extended period of time.
- **Working in awkward postures or being in the same posture for long periods of time**. Using positions that place stress on the body, such as prolonged or repetitive reaching above shoulder height, kneeling, squatting, leaning over a counter, using a knife with wrists bent, or twisting the torso while lifting.
- **Localized pressure into the body part**. Pressing the body or part of the body (such as the hand) against hard or sharp edges or using the hand as a hammer.

- **Cold temperatures**. In combination with any one of the above risk factors may also increase the potential for MSDs to develop. For example, many of the operations in meatpacking and poultry processing occur with a chilled product or in a cold environment.
- **Vibration**. Both whole body and hand-arm vibration, can cause many health effects. Hand-arm vibration can damage small capillaries that supply nutrients and can make hand tools more difficult to control. Hand-arm vibration may cause a worker to lose feeling in the hands and arms resulting in increased force exertion to control hand-powered tools (e.g., hammer drills, portable grinders, chainsaws) in much the same way gloves limit feeling in the hands. The effects of vibration can damage the body and greatly increase the force which must be exerted for a task.
- **Combined exposure to several risk factors**. May place workers at a higher risk for MSDs than does exposure to any one risk factor (OSHA, *Ergonomics: Identify Problems*).

To reduce the chance of injury, work tasks should be designed to limit exposure to ergonomic risk factors. Engineering controls are the most desirable, where possible. Administrative or work practice controls may be appropriate in some cases where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls. Personal protection solutions have only limited effectiveness when dealing with ergonomic hazards.

Chronic wasting disease (**CWD**) is a transmissible spongiform encephalopathy (TSE) of mule deer, white-tailed deer, elk, and moose. As of 2016, CWD had only been found in members of the deer family. CWD is typified by chronic weight loss leading to death. No relationship is known between CWD and any other TSE of animals or people. Although reports in the popular press have been made of humans being affected by CWD, a study by the Centers for Disease Control and Prevention suggests, "[m]ore epidemiologic and laboratory studies are needed to monitor the possibility of such transmissions." The epidemiological study further concluded, "[a]s a precaution, hunters should avoid eating deer and elk tissues known to harbor the CWD agent (e.g., brain, spinal cord, eyes, spleen, tonsils, lymph nodes) from areas where CWD has been identified.

Domain 7: Environmental Management Systems



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Key Themes

Blueprint reference

Domain 7: Environmental Management Systems

- Environmental protection and pollution prevention methods
  - air pollution(EPA, CAA (permitting), Hazardous Air Pollutants (HAPS, greenhouse gases), water pollution (EPA CWA, NPDES), soil pollution (EPA TSCA, FIFRA), local permitting
  - Containment (EPA, USTs, Surface impoundments, facilities)
- Hazardous waste management practices (EPA, MACT, BACT)
  - Generation (waste determination, segregation and separation), treatment technologies (physical and chemical methods), storage (containment, labeling), disposal (Solid waste, Hazardous Waste) (EPA TSDF, RCRA)
  - Shipping, (DOT, EPA, placarding, labeling, packaging, dangerous goods (UN IMO, IATA)
- Hazardous material releases (OSHA HAZWOPER; EPA, EPCRA, CERCLA, SARA)
  - Environmental fate (air, surface water, soil)
  - Response and waste site operations Health and Safety Program (HASP)
- Sustainability principles (ISO14001, EPA)
  - Environmental Management Systems (ISO 14001)
  - Life Cycle
  - Waste hierarchy of control. (EPA, ISO)

Key CSP Blueprint Themes: Domain 7

Domain 7 Quiz 1 Questions

1. **Underground storage tanks (USTs) must have a method to provide corrosion protection. Of the following options, which is *least acceptable*?**

   A. Add interior lining to the tank.
   B. Add cathodic protection.
   C. Clad or coat unprotected steel USTs.
   D. Combine cathodic protection interior lining.

2. **Which electrical devices *most likely* contain polychlorinated biphenyl (PCBs)?**

   A. Transformers, capacitors, and fluorescent light ballasts
   B. Fuses, wiring, and meters
   C. Circuit breakers, panel board, and Unistrut
   D. Meters, relays, and switches

3. **A process that seeks to verify documented expectations, typically regulations and policies, by conducting interviews, reviewing records, and making firsthand observations is called a/an:**

   A. site visit.
   B. environmental audit.
   C. environmental site assessment.
   D. evaluation assessment and standardization.

4. **ISO 14001 certification assures the organization level of conformity with its specific environmental policy. The *least effective* demonstration of conformity with ISO 14001 guidelines is:**

   A. seeking regulatory compliance enforcement officers for determining compliance to regulatory standards.
   B. seeking authentication of declaring best practices by stakeholders having an interest in the organization.
   C. seeking evidence-based self-declaration of conformance by an independent auditing external to the business.
   D. seeking documentation and registration of environmental management system by an external certification.

5. **Organic azides differ in degrees of stability and sometimes pose a disposal problem. Which of the following *best* describes the hazards of disposal of azides down a laboratory sink?**

   A. Produces toxic fumes
   B. May clog waste collection systems
   C. Causes fire when mixed with water
   D. Becomes highly explosive when in contact with metals

6. In the effort of continuous improvement related to ISO 14001, the goal is to eliminate emissions and discharges in operations. But in practice, environmental policies reflect which general guideline?

A. BACT
B. EVABAT
C. NPDES
D. RCRA

7. Operations for environmental spill response include planning, personal protective equipment, mitigation, and:

A. decontamination.
B. recovery.
C. litigation.
D. restoration.

8. With respect to pollution prevention, soil columns are classified by:

A. particle size.
B. mineral content.
C. permeability.
D. organic content.

9. An environmental Life Cycle Assessment (LCA):

A. is a stable procedure with few changes over time.
B. is generally simple and low cost for small firms.
C. is a systematic process for evaluating the environmental impact of products or services.
D. requires governments to develop enforcement-based environmental regulations.

10. The *most commonly* cited violation of environmental regulations is:

A. oil spills.
B. improper handling of asbestos.
C. waste dumping into oceans, lakes, rivers, and streams.
D. mislabeling chemicals and hazardous waste.

11. The airborne release of hazardous materials into the surrounding atmosphere can be studied using vapor-cloud dispersion models. The two *primary* types of vapor-cloud dispersion models are plume and:

A. explosion.
B. puff.
C. fast release.
D. sustained release.

12. Which reason is *most associated* with hazardous material releases from underground storage tanks?

A. Tampering
B. Piping failure
C. Soil subsidence
D. Thermal shock

13. Adding flanges parallel to the face of exhaust hoods has the effect of reducing flow rates needed to achieve a given capture velocity for airborne contaminants. In practice, what percentage of flow rate reductions can flanges provide?

A. 25%
B. 33%
C. 50%
D. 75%

14. The certification process for new building construction and renovations that include a rating system designed to guide and distinguish high performance buildings that have less of an impact on the environment and are healthier to work within is called:

A. GREEN.
B. ALARA.
C. LEED®.
D. ASHARE.

15. Pollution prevention is driven *most* by:

A. laws.
B. regulations.
C. business interests.
D. public demand.

16. Sustainable development is *best* defined as:

A. a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met.
B. meeting the needs of the world's current population without making it impossible for the world's future citizens to meet their needs.
C. advancement of the principles and goals of sustainable development through partnerships, collaboration, and outreach.
D. the interfaces with economics through the social and ecological consequences of economic activity.

17. Many of the terms have specific meanings in the pollution prevention context, which of the following terms *best* describes the storage and distillation of a spent solvent?

A. Disposal
B. Preconsumer recycled content
C. Closed loop recycling
D. Postconsumer recycled content

18. Any activity that decreases or prevents the creation of a waste or that decreases the toxicity of the waste stream without treatment is called:

A. waste minimization.
B. source reduction.
C. REDOX.
D. waste reduction.

19. Environmental management guidelines are generally composed of a series of interlinking and supporting components that include:

A. a set of principles, tools to achieve environmental objectives, management programs, a management framework.
B. a set of regulatory standards, tools to achieve environmental objectives, management programs, a management framework.
C. a set of principles, tools to achieve environmental objectives, management programs.
D. a set of regulatory standards, tools to achieve environmental objectives, a management framework.

20. What is the process by which clumps of solids in water or wastewater aggregate through biological or chemical action in order to be separated?

A. Dewatering
B. Flocculation
C. Neutralization
D. Disinfections

Domain 7 Quiz 1 Answers

1. Answer: **C**. In the *Hazardous Materials Desk Reference*, it is considered impractical to coat or clad unprotected steel USTs. Answer choice A, B, & D are acceptable methods for corrosion protection.

2. Answer: **A**. Polychlorinated biphenyl (PCBs) are found in certain electrical devices such as transformers, capacitors, fluorescent light ballasts, etc., as well as in heat transfer enclosures and investment casting waxes in foundries.

   A "PCB transformer" is a transformer that is known, or assumed under TSCA, to contain PCBs at concentrations greater than 500 parts per million (ppm). "PCB-Contaminated Transformers" known, or assumed under TSCA, to contain between 50 and 499 ppm PCBs are also subject to EPA regulations.

   In 1978, the EPA under TSCA banned the use of PCBs in light ballasts, transformers, and capacitors; however, it is still possible to find equipment containing PCBs.

   PCBs and PCB Items in service or projected for disposal: The written annual document log must be prepared for each facility by July 1 covering the previous calendar year (January through December).

3. Answer: **B**. This is the definition of an environmental audit, sometimes called a compliance audit. An environmental site assessment is a process that seeks to characterize a physical property or operation from an environmental view with an overall objective of understanding site-specific conditions. Information is collected through interviews, record reviews, and firsthand observations. It may also involve testing environmental media and facility characteristics. These definitions are not used consistently throughout the profession, so ensure you are clear about specified definitions with all parties engaged in operations.

4. Answer: **A**. ISO 14001 is applicable to any organization that wishes to establish, implement, maintain, and improve an environmental management system, to assure itself of conformity with its stated environmental policy, and to demonstrate conformity with ISO 14001 by:

   - making a self-determination and self-declaration;
   - seeking confirmation of its conformance by parties having an interest in the organization, such as customers;
   - seeking confirmation of its self-declaration by a party external to the organization; or
   - seeking certification/registration of its environmental management system by an external organization.

   All the requirements in ISO 14001 are intended to be incorporated into any environmental management system. The extent of the application will depend on factors such as the environmental policy of the organization, the nature of its activities, products and services, and the location where and the conditions in which it functions.

5. Answer: **D**. An azide is a compound of hydrogen or a metal ion and the monovalent $-N_3$ radical. For example, lead azide PbN_3, one of the most important azides, can decompose explosively when subjected to shock and heat. Lead azide forms violent explosive salts if mixed with carbon disulfide. Sodium azide (NaN_3) is a powerful mutagen. The azides should never be poured down the sink because they can decompose explosively on heating and can form shock sensitive and highly explosive mixtures if exposed to other heavy metals or hydrogen. For example, phenyl azide ($C_6H_5N_3$, azidobenzene) is used as a heat-sensitive explosive.

6. Answer: **B**. The detailed aspects for significance are determined by an organization establishing and maintaining an Environmental Management System (EMS). According to the ISO 14001 *Environmental Systems Handbook*, clause 4.2 Environmental Policy, top management shall define the organization's environmental policy and ensure that it is appropriate to the nature, scale, and environmental impacts of its activities, products or services within the defined scope of the EMS. The Economic Viable Application of Best Available Technology (EVABAT) is an acronym for the use of technology to control environmental impacts without causing an organization financial hardship.

Reproduced from ISO 14001, *Conformity Assessment Techniques*.

7. Answer: **A**. Industry best practices incorporate incident planning, written plans, and practice exercises as essential elements of a successful emergency response. Best practices include general concepts such as planning, PPE, mitigation, and decontamination, but these must be adapted to provide for any site-specific conditions and contingencies.

8. Answer: **A**. Any soil, sand, gravel, or fractured rock consists of solid particles and empty spaces (voids) in between the particles. Because a soil column is composed of a variety of minerals and rocks, it is classified by particle size.

9. Answer: **C**. As a means of relieving government of costly enforcement-based environmental regulations, some countries are establishing product-oriented incentives that are intended to yield environmental benefits. The basis for evaluating such incentives is the province of Life Cycle Assessment (LCA). ISO 14040, the Life Cycle Assessment Guideline, defines LCA as a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle.

10. Answer: **D**. Mislabeling of chemicals and hazardous waste is probably the most commonly cited violation and one that can most easily cause an environmental accident according to the National Safety Council's Accident Prevention Manual for Administration and Programs.

11. Answer: **B**. After a release, the airborne materials are carried away by the wind in a characteristic plume or puff. The plume model describes the steady-state concentration of material released from a continuous source. The puff model describes the temporal concentration of material from a single release of a fixed amount of materials. A wide variety of parameters affect atmospheric dispersion of toxic materials:

    - Wind speed
    - Atmospheric stability
    - Ground conditions, buildings, water, trees
    - Height of the release above ground level
    - Momentum and buoyancy of the initial material released

12. Answer: **B**. According to EPA studies, the releases from underground storage tanks (USTs) are typically associated with these problems: (1) piping failure, (2) corrosion, (3) spills and overfilling.

13. Answer: **A**. A flange is a surface at and parallel to the hood face that provides a barrier to unwanted airflow from behind the hood. A flange around a hood opening has the effect of decreasing the required flow rate to achieve a given capture velocity. In practice, flanging can decrease flow rate (or increase velocity) by approximately 25%.

14. Answer: **C**. With higher public expectations for corporate environmental stewardship and increased demand for ***"green"*** (environmentally friendly) products and services, corporate leaders began taking a fresh look at their environmental management programs. Many have found that undertaking a serious pollution prevention effort is a successful business response because it reduces their regulatory burden, increases public confidence, reduces long-term risk, and nearly always cuts costs. Designed primarily for new construction office buildings, the ***Leadership in Energy and Environmental Design (LEED®)*** certification process has been applied to many other commercial building types. LEED® certification is a performance-oriented rating system where building projects earn points for satisfying criterion designed to address specific environmental impacts inherent in the design, construction, operations, and management of a building. The LEED® certification system is organized into six environmental categories: (1) Sustainable Sites, (2) Water Efficiency, (3) Energy and Atmosphere, (4) Materials and Resources, (5) Indoor Environmental Quality, and (6) Innovation and Design.

15. Answer: **C**. Unlike most areas of environmental management, pollution prevention is driven more by business interests than by the existing laws and regulations. Pollution prevention projects that show powerful and positive impacts on the bottom line demonstrate that environmental managers can add real business value and go beyond forestalling liabilities and costs through compliance and preparedness.

16. Answer: **B**. Sustainable development has been defined by the United Nations World Commission on Environment and Development as meeting the needs of the world's current population without making it impossible for the world's future citizens to meet their needs. The global nature of this definition often makes implementation challenging within business organizations. Those businesses that are ready to make sustainable development operational begin by transforming principles, behaviors, and practices involved in their basic internal workings. Those base principles and behaviors have to do with: transparency in business objectives and practices; governance practices, including business environmental ethics; social responsibility programs, including community, workforce, and other involved stakeholder's environmental health and safety processes based on continuous improvement. Sustainable development, like EMS, requires the development of indicators (leading or lagging) and metrics against which to measure and verify improvements in the categories mentioned. These measures go together with the concept of the triple bottom line, under which companies are evaluated by stakeholders not only on financial performance but also on environmental and social performance. As an extension of this, many businesses now include environmental and social performance in their annual reporting to shareholders. Environmental aspects that readily lend themselves to the development of metrics include: consideration of residuals (e.g., air emissions, waste water, and solid and hazardous waste); energy and material inputs and outputs associated with a process; life-cycle environmental costs of the product or service produced.

17. Answer: **C**. *Closed loop recycling* is a system in which a process waste is conveyed through closed systems to tank storage and then recycled in tanks before returning the reprocessed material to the production system. An example could be the storage and distillation of a spent solvent. *Disposal* means either the destruction of a waste (for example, incineration, energy recovery, or chemical reaction) or putting it in the ground (for example, landfilling or land application). *Preconsumer recycled content* is the fraction of feedstock used in manufacturing a material that is derived from wastes captured during or just after the manufacturing process. An example is repulping scrap paper shaved from the ends of a paper roll to produce the next batch. *Postconsumer recycled content* means the fraction of feedstock used in manufacturing a material which is derived from materials that have been used by the public, discarded, and collected for reprocessing.

18. Answer: **B**. *Source reduction* means any activity that decreases or prevents the creation of a waste or which decreases the toxicity of the waste stream without treatment. It can also mean an activity (other than treatment or ordinary recycling) that prevents a contaminant from entering any waste stream (including fugitive emissions) or being otherwise released into the environment. It is the preferred management strategy. *Waste minimization* means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed. It includes any source reduction or recycling activity that results in the reduction of the total volume or the toxicity of hazardous waste generated, so long as the reduction is consistent with the goal of minimizing present or future threats to human health and the environment. *Pollution prevention (P2)*, as used by the US Environmental Protection Agency (EPA), means source reduction. In addition, the terms pollution prevention and waste minimization are often used interchangeably. *Waste reduction* means any activity that decreases the amount of waste materials that require waste management efforts.

    Waste stream means the continuing production of abandoned materials that are collected and managed for the purpose of disposal or recycling.

19. Answer: **A**. Environmental management guidelines are generally composed of a series of interlinking and supporting components:

    - A set of *principles* to help understand environmental management;
    - A series of *tools* that can be used to achieve environmental objectives;
    - A series of *management programs* traditionally used to solve environmental issues; and
    - A *management framework* to integrate environmental issues into the core business processes and decision-making.

    Some tools have been specifically developed as environmental management guidelines (ISO 14001, for example); some have been adopted from other management practices.

20. Answer: **B**. According to the EPA dictionary:

- **Flocculation:** Process by which clumps of solids in water or sewage aggregate through biological or chemical action so they can be separated from water or sewage.
- **Dewater:** Remove or separate a portion of the water in a sludge or slurry to dry the sludge so it can be handled and disposed of. Remove or drain the water from a tank or trench.
- **Neutralization:** Decreasing the acidity or alkalinity of a substance by adding alkaline or acidic materials, respectively.
- **Disinfections:** A chemical or physical process that kills pathogenic organisms in water, air, or on surfaces. Chlorine is often used to disinfect sewage treatment effluent, water supplies, wells, and swimming pools (*RCRA Glossary of Terms*).

Domain 7 Quiz 2 Questions

1. A large generator is *least likely* subject to hazardous waste regulations when the waste is:

A. determined by the generator as a hazardous waste and properly stored.
B. listed by authorities as exhibiting a hazardous waste profile by characteristic.
C. untreated solid waste is segregated and disposed of in a remote permitted landfill.
D. mixtures of an acutely hazardous waste effectively diluted by a non-hazardous waste stream.

2. Any activity which decreases or prevents the creation of a waste or which *decreases* the toxicity of the waste stream without treatment is called:

A. waste minimization.
B. source reduction.
C. oxidation reduction.
D. waste reduction.

3. Which are the colors on a corrosive placard?

A. Red, Yellow
B. Red, White
C. Black, White
D. Yellow, Black

4. What is the *most useful* indicator for determining the adequacy of water treatment and the integrity of the distribution system?

A. Viscosity
B. Turbidity
C. Clarity
D. Total coliforms

5. Considering the waste hierarchy of controls, which is the *least desirable*?

A. Source reduction/elimination
B. Recovery/reuse/recycle
C. Waste exchange/energy recovery
D. Treatment/destruction/disposal

6. Which is the gas with the *most impact* on the greenhouse effect?

A. Methane
B. Carbon monoxide
C. Carbon dioxide
D. Sulfur dioxide

7. Generally, system life cycle phases include:

A. concept, development, operation and disposal.
B. initiation, development, design, evaluation.
C. analysis, design, production, disposal.
D. concept, sustainment, reliability, disposal.

8. What UN agency impacts international hazardous waste transportation overseas?

A. IATA
B. IMO
C. IAIA
D. UNCE

9. Who is ultimately responsible for hazardous waste from start to finish?

A. Shipper of the manifested hazardous waste
B. Chemical manufactures of the hazardous waste constituents
C. Large and small quantity generators of the hazardous waste
D. Hazardous waste Treatment and storage and disposal facility

10. Methods used for oil, halogenated and non-halogenated solvent recovery include:

A. distillation, carbon adsorption, ultrafiltration.
B. ion exchange, distillation, filtration.
C. activated carbon, solvent extraction, ion exchange.
D. reverse osmosis, ultrafiltration, electrolysis.

Domain 7 Quiz 2 Answers

1. Answer: **C**. A waste will be subject to the hazardous waste regulations if it meets any of the following conditions: ***Characteristic Waste***—Waste exhibiting any of the four characteristics of a hazardous waste: (1) D001 ignitibility by closed cup flash point, (2) D002 corrosivity by pH ≤ 2.0 or pH ≥ 12.5 or Liquids that corrode steel > 0.25 in/yr at 130°F, (3) D003 reactivity by instability, or (4) D004-D0043 toxicity by Toxic Characteristic Leachate Procedure (TCLP). ***Listed Hazardous Waste***—Wastes specifically listed in Subpart D of the regulations: Nonspecific Source (F-Listed); Specific Source (K-Listed); Acute Hazardous Waste (P-Listed); Toxic Hazardous Waste (U-Listed). ***Mixtures***—The waste is a mixture of a listed hazardous waste and a nonhazardous waste. ***Declared to be Hazardous***—The waste has been declared to be hazardous by the generator.

2. Answer: **B**. *Source reduction* means any activity that decreases or prevents the creation of a waste or that decreases the toxicity of the waste stream without treatment. It can also mean an activity (other than treatment or ordinary recycling) that prevents a contaminant from entering any waste stream (including fugitive emissions) or being otherwise released into the environment. It is the preferred management strategy. *Waste minimization* means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed. It includes any source reduction or recycling activity that results in the reduction of the total volume or the toxicity of hazardous waste generated, so long as the reduction is consistent with the goal of minimizing present or future threats to human health and the environment. *Pollution prevention (P2)* means source reduction. In addition, the terms pollution prevention and waste minimization are often used interchangeably. *Waste reduction* means any activity that decreases the amount of waste materials that require waste management efforts. *Waste stream* means the continuing production of abandoned materials that are collected and managed for disposal or recycling (EPA). Unlike most areas of environmental management, pollution prevention is driven more by business interests than by the existing laws and regulations. Pollution prevention projects can show powerful and positive impacts on the bottom line.

3. Answer: **C**. DOT hazard class 8 is for corrosives and is black and white (**Table 22**).

Table 22 United Nations Hazard Classification System

Class 1	**Explosives**[1]
Division 1.1	Explosives with a mass explosion hazard. A mass explosion is one that affects almost the entire load instantaneously.
Division 1.2	Explosives with a projection hazard but not a mass explosion hazard.
Division 1.3	Explosives with a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.
Division 1.4	Explosives with a minor explosion hazard. The explosive effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected.
Division 1.5	Very insensitive explosives. This division is comprised of substances that have a mass explosion hazard but are so insensitive that there is very little probability of initiation.
Division 1.6	Extremely insensitive articles that do not have a mass explosive hazard.
Class 2	**Gases**
Division 2.1	Flammable gases
Division 2.2	Nonflammable, nonpoisonous compressed gases
Division 2.3	Poisonous gases
Class 3	**Flammable and Combustible Liquids**
Class 4	**Flammable Solids**
Division 4.1	Flammable solids
Division 4.2	Spontaneously combustible materials
Division 4.3	Materials that are dangerous when wet
Class 5	**Oxidizers**
Division 5.1	Oxidizers
Division 5.2	Organic peroxides
Class 6	**Poisonous Materials**
Division 6.1	Poisonous materials
Division 6.2	Infectious substances
Class 7	**Radioactive Materials**
Class 8	**Corrosive Materials** 
Class 9	**Miscellaneous Hazardous Materials**

Emergency Response Guidebook. Retrieved from www.phmsa.dot.gov/.

4. Answer: **D**. Total coliforms are a group of related bacteria that are not harmful to humans. A variety of bacteria, parasites, and viruses, known as pathogens, can potentially cause health problems if humans ingest them. EPA considers total coliforms a useful indicator of other pathogens for drinking water. Total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system (*Drinking water requirements for states and public water systems. Revised total coliform rule and total coliform rule.* United States Environmental Protection Agency).

   Coliform bacteria counts are an indicator of the disease potential of a wastewater stream. Although coliform bacteria are not necessarily pathogens and they are naturally present in feces or warm-blooded animals, the presence of large number of coliform is an indication that other disease-carrying bacteria can be present (*Accident Prevention Manual for Business and Industry: Environmental Management*, 2nd Edition).

5. Answer: **D**. EPA developed the nonhazardous materials and waste management hierarchy (**Figure 24**) in recognition that no single waste management approach is suitable for managing all materials and waste streams in all circumstances. The hierarchy ranks the various management strategies from most to least environmentally preferred.

   According to EPA, the hierarchy places emphasis on reducing, reusing, and recycling as key to sustainable materials management. Source reduction, also known as waste prevention, means reducing waste at the source, and is the most environmentally preferred strategy. It can take many different forms, including reusing or donating items, buying in bulk, reducing packaging, redesigning products, and reducing toxicity. Source reduction also is important in manufacturing. Light weighting of packaging, reuse, and remanufacturing are all becoming more popular business trends. Purchasing products that incorporate these features supports source reduction. Recycling is a series of activities that includes collecting used, reused, or unused items that would otherwise be considered waste; sorting and processing the recyclable products into raw materials; and remanufacturing the recycled raw materials into new products. Consumers provide the last link in recycling by purchasing products made from recycled content. Recycling also can include composting of food scraps, yard trimmings, and other organic materials. Energy recovery from waste is the conversion of nonrecyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery. This process is often called waste-to-energy (WTE). Converting nonrecyclable waste materials into

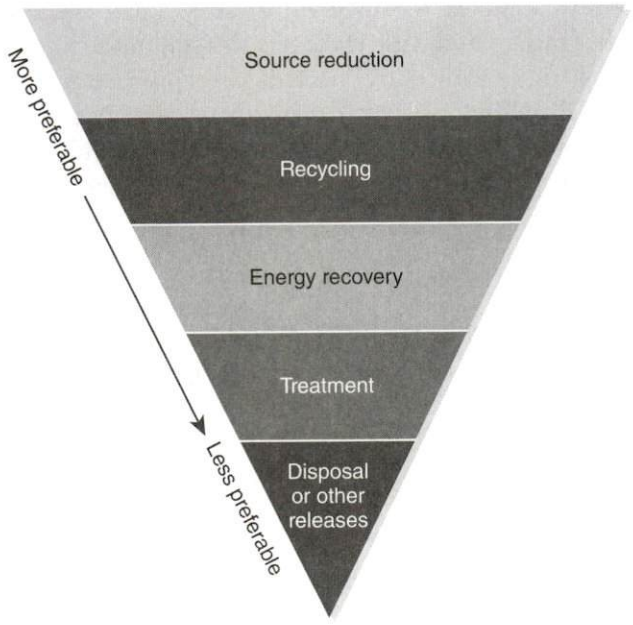


Figure 24 Hazardous Waste Management Hierarchy

United States Environment Protection Agency. *Sustainable materials management: Non-hazardous materials and waste management hierarchy.* https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

electricity and heat generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil sources and reduces methane generation from landfills. After energy is recovered, approximately 10% of the volume remains as ash, which is generally sent to a landfill. Prior to disposal, treatment can help reduce the volume and toxicity of waste. Treatments can be physical (e.g., shredding), chemical (e.g., incineration), and biological (e.g., anaerobic digestor). Landfills are the most common form of waste disposal and are an important component of an integrated waste management system. Modern landfills are well-engineered facilities located, designed, operated, and monitored to ensure compliance with state and federal regulations. Landfills that accept municipal solid waste are primarily regulated by state, tribal, and local governments. EPA, however, established national standards that these landfills must meet in order to stay open. The federal landfill regulations eliminated the open dumps (disposal facilities that do not meet federal and state criteria) of the past. Today's landfills must meet stringent design, operation, and closure requirements. Methane gas, a by-product of decomposing waste, can be collected and used as fuel to generate electricity. After a landfill is capped, the land may be used for recreation sites such as parks, golf courses, and ski slopes.

United States Environment Protection Agency. *Sustainable materials management: Non-hazardous materials and waste management hierarchy*. https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

6. Answer: **C**. The term "greenhouse gas" generally describes gases that are highly transparent to in coming solar radiation but are relatively opaque to long wave radiation, similar (for descriptive purpose) to glass in a greenhouse. Atmospheric gases differ greatly in their absorptive properties. The most important atmospheric constituent of the greenhouse effect is water vapor (H_20). Water vapor, together with CO_2 and clouds, create about 90% of the total effect. The remaining 10% of the greenhouse effect is due to the presence of trace amounts of ozone (0_3), methane (CH_4), and nitrous oxide (N_20) (Krieger 2000).

7. Answer: **A**. According to Haight (2012b), there are **four major phases of development in a system life cycle: (1) concept, (2) system development, (3) production and deployment, and (4) sustainment and disposal**. Each phase includes safety engineering tasks that result in a formal decision about proceeding to the next phase. A system-safety management plan should be developed during the concept phase in order to design safety into the system and maintain it throughout the system's life. Incorporating system safety early in development increases the probability that hazards can be addressed more economically and with greater efficiency. A formal decision earmarks the acceptance of risks) to that point of development or operation.

   System safety is a comprehensive approach for integrating safety as part of the design and implementing requirements throughout other phases in the life cycle of a system, product, process, or facility. The primary function of system safety is to identify and control hazards in each phase of the life cycle—from concept through decommissioning and disposal. In system development, anticipating potential hazards and conditions is a key aspect of safety engineering work. It is a challenge to anticipate the hazards of a system before it is developed; however, safety engineering activities designed into each phase promote a systematic process of anticipating and identifying hazards as the system is developed. According to Brauer (2006), "System safety is . . . the systematic, forward-looking identification and control of hazards." Safety engineers assess the existing and potential conditions that could affect a system.

8. Answer: **B**. **IMO—The International Maritime Organization (IMO)** is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. The International Maritime Dangerous Goods Code (IMDGC) relates to the safe carriage of dangerous goods by sea.

   UNEP—United Nations Environment Programme is an agency of United Nations and coordinates its environmental activities, assisting developing countries in implementing environmentally sound policies and practices.

   IAIA—The International Association for Impact Assessment is an international association of professionals involved with impact assessment, including both social impact assessment and environmental impact assessment.

IATA—The International Air Transport Association is a trade association representing airlines. IATA works closely with local governments and International Civil Aviation Organization (ICAO), a specialized agency of the United Nations, in the development of regulations. The IATA Dangerous Goods Regulations (DGR) manual is the global reference for shipping dangerous goods by air and the only standard recognized by airlines.

9. Answer: **C**. In keeping with the cradle-to-grave concept, waste continues to be the property of the generator. Any discrepancies in the waste shipment must be reported to EPA. The current hazardous waste manifest system is a set of forms, reports, and procedures designed to seamlessly track hazardous waste from the time it leaves the generator facility where it was produced, until it reaches the off-site waste management facility that will store, treat, or dispose of the hazardous waste. The system allows the waste generator to verify that its waste has been properly delivered and that no waste has been lost or unaccounted for in the process. The current Hazardous Waste Manifest is a joint undertaking by EPA and the Department of Transportation (DOT). EPA is responsible for regulating hazardous waste under a federal statute known as the Resource Conservation and Recovery Act (RCRA) (**Table 23**). This Act requires that all hazardous waste shipped off-site be tracked from **"cradle-to-grave"** using a manifest that provides information about the generator of the waste, the facility that will receive the waste, a description and quantity of the waste (including the number and type of containers) and how the waste will be routed to the receiving facility. Because hazardous waste is also regulated by the DOT under its hazardous materials laws, the Manifest was developed to meet both EPA's requirements for a manifest and DOT's requirements for "shipping papers."

Conditionally Exempt Small Quantity Generator (CESQG)

- Generated
  - Less than 100 kg/mo of any hazardous waste
  - Less than 1 kg/mo of P-listed (acutely hazardous) waste
  - Less than 100 kg/mo of cleanup waste
- Accumulated
  - Less than 1000 kg of any hazardous waste
  - Less than 1 kg of P-listed (acutely hazardous) waste
  - Less than 100 kg of cleanup waste

Small Quantity Generator (SQG)

- Generated
  - 100 and 1000 kg per month of hazardous waste
  - No more than 1 kg of acutely hazardous waste
- Have limitations on accumulation as follows:
  - Accumulation time without permit is less than or equal to 180 days.
  - Accumulation quantity is limited to 6000 kg
  - Accumulation is allowed in tanks or containers only

Large Quantity Generator (LQG)

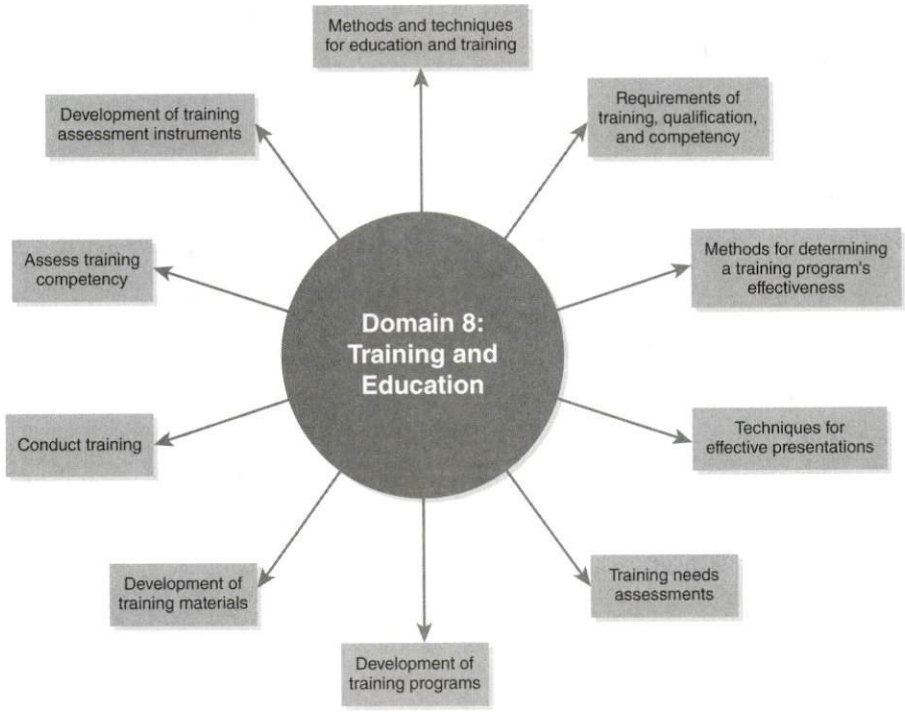
- Is subject to full Subtitle C regulation
- Generates more than SQG and CESQG
  - More than 1000 kg/mo of any hazardous waste
  - More than 1 kg/mo of acutely hazardous waste
- Accumulates more than SQG and CESQG
  - More than 6000 kg of hazardous waste
  - More than 1 kg of acutely hazardous waste
  - More than 100 kg of contaminated soil, waste, or debris

Table 23 Table of Hazardous Waste Regulations

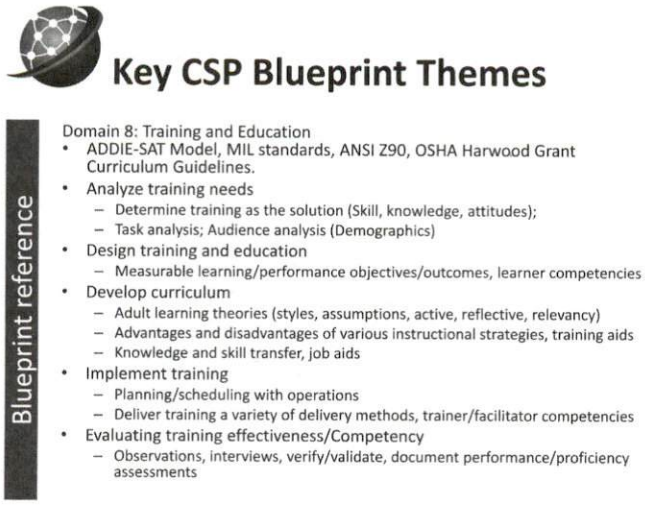
	Purpose	Basic Requirements	Extent of Coverage
RCRA	40 CFR 260 to 271 Regulate hazardous waste generators and transporters; manage treatment, storage, and disposal facilities (TSDFs) and cradle to grave regulations.	Permits, technical standards, and ground water monitoring; corrective action for releases; transportation manifest forms; and UST standards.	Hazardous wastes as defined by EPA; TSDFs; generators of more than 100 kg of hazardous wastes a month.
CERCLA	40 CFR 300.61 to 300.71 Locate, assess, and clean potential hazardous waste sites and emergency spills; grant EPS authority to initiate investigations, testing, and monitoring of disposal sites; implement site remediation.	Place a site on the National Priority List because the site poses a threat to human health and the environment.	Removal and response actions; establish strict liability resulting from hazardous wastes; finance response actions through a hazardous substance response trust fund; notification requirements for hazardous waste spills and releases; Title III of SARA Community Right-to-Know provisions.
CWA	40 CFR 121 to 135, and 403 Protect U.S. waters (surface and groundwater) from direct, indirect, and hazardous point-source pollution discharges.	Establish water-quality standards; set discharge limits.	Restrict pollutant discharges into water; impose monitoring requirements.
CAA	40 CFR 69 Protect and enhance US air quality; maintain National Ambient Air Quality Standards (NAAQS); establish National Emissions Standards for Hazardous Air Pollutants (NESHAP).	Prevent air quality deterioration; set NAAWS and emission standards.	Hazardous air pollutants and VOCs; NAAQS for NO, CO, sulfur dioxide, lead, ozone, and particulate matter.
DOT	49 CFR 172, 173, 178, 179 Establish standards for the safe transport of hazardous wastes through package and container requirements; establish a labeling system applicable to hazardous waste transportation; document transport to ensure proper treatment and disposal; notification of roadside spills	Requirements for registration, labeling, vehicle and driver safety; "manifest" documents for shipments of hazardous wastes.	Transportation of hazardous wastes.
OSHA	29 CFR Ensure safe and healthy employment conditions; address the proper management of hazardous materials in the workplace by setting standards designed to prevent injury and illness.	Address exposure limits, labeling, protective equipment, control procedures, monitoring, and measuring employee exposure, medical exams, and access to records.	Applicable to facilities with 10 or more workers; OSHA regulations addressing hazardous wastes including health standards, cancer policy, Hazard Communication Standard, and Hazardous Waste Operation and Emergency Response rules.
TSCA	Screen new chemicals; test new chemicals identified as potential hazards; regulate toxic substance disposal.	Notification of substantial risk by chemical manufacturers who become aware of a chemical threat.	Chemicals that are hazardous, toxic, corrosive, flammable, irritants, or oxidizers.

10. Answer: **A**. Recovery/reuse techniques are most appropriate for two general classes of wastes: (1) relatively concentrated organic waste, such as solvents, coolants, and waste oils; and (2) metal-containing inorganic wastes. For waste oil, halogenated solvents, and nonhalogenated solvents, four processes have been most commonly identified in conjunction with their potential for recovery: (1) *Distillation* is by far the most prevalent for solvent recovery because of the relative ease of separation by this means. Units of various sizes and temperature ranges are readily available for in-plant use. Distillation is also common for waste oil, although generally at a larger scale than is common to encounter at an individual plant because of the higher temperatures needed. (2) Until recently, *solvent extraction* has been limited to larger scale uses and to a limited number of organics, particularly phenol. Advances in equipment have expanded this usage somewhat. (3) *Carbon adsorption* is most commonly used for vapor phase solvent recovery and for low-concentration aqueous streams. In the case of absorption, solvents are attached to a suitable medium (e.g., activated carbon). (4) *Ultrafiltration*, a low-pressure membrane separation process, is applicable to cleaning coolant oils and recovery of tramp oil from aqueous coolant mixtures. The most likely candidates among inorganic wastes for recovery/reuse include the caustic and acidic waste streams resulting from metal finishing operations (e.g., caustic cleaners, phosphate solutions, plating solutions, and pickle liquors). They, of course, have some immediate value as neutralizing agents, but other possibilities include recovery of concentrated metal salts from plating baths and the sale of ferric chloride or sulfate pickle liquors to municipal wastewater treatment plants for phosphate removal. When applicable, the advantage of this approach is twofold. Not only is a waste stream recovered for a useful purpose, but the metal content is reduced or eliminated from the wastewater treatment sludge where it would have inevitably ended up. The processes that can be used for the recovery of metals include: ion exchange; membrane processes (reverse osmosis, ultrafiltration, electrolysis); and evaporation. All are proven processes, although not necessarily for all applications, and are readily available commercially. Carbon adsorption is based on a natural phenomenon in which volatile organic compounds are adsorbed from an air stream in the microscopic pores of activated carbon and released when heated for recovery. Activated carbon is the most versatile of all adsorbents because of its broad pore size distribution and pore volume. Consequently, it is suitable for solvents with a wide range of boiling points and chemical structures such as alkanes, alcohols, esters and ketones, cyclic compounds, and halogenated solvents (Krieger 2000).

Domain 8: Training and Education



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Themes: Domain 8

Domain 8 Quiz 1 Questions

1. **All the following are symptoms of group conformity or "group think" *except:***

   A. collective rationalization.
   B. acceptance of diversity.
   C. pressure for conformity.
   D. illusion of invulnerability.

2. **Which is the *least effective* method of performing a task analysis?**

   A. Observing the task
   B. Performing the task
   C. Developing a task without any preparation or advantage
   D. Reviewing company written SOPs and policies

3. **When a supervisor is evaluating a subordinate during the annual employee performance report cycle, which of the following factors is *most important*?**

   A. Safety performance
   B. Attentiveness to minutiae
   C. Measurable objective criterion
   D. Magnitude of production in comparison to peers

4. **Which of the following training methods is *primarily* used to find new, innovative approaches to issues?**

   A. Meeting
   B. Brainstorming
   C. Case study
   D. Role-playing

5. **Enabling learning objectives should define measurable skills, knowledge, or behaviors required to achieve performance objectives. Which of these is the *least measurable* objective?**

   A. The supervisor will understand how to be safe on the workplace.
   B. The worker will identify hazardous chemicals.
   C. The operator will troubleshoot a machine operating cycle.
   D. The employee will enter data into the work order system.

6. For training to be effective, training objectives should be established and measured. Which statement about training objectives is *least effective* on performance outcomes?

A. Training objectives should be reasonable and practical.
B. Training objectives must be measurable.
C. Training objectives should be obtainable.
D. Training objectives must be written.

7. A study that is a systematic analysis of an organization, or detailed job/task, to determine how training can help the organization to improve its safety, success, or efficiency or if the specific job/task can be improved is called a:

A. managerial analysis.
B. training analysis.
C. needs analysis.
D. task analysis.

8. Which of the following would be of the *greatest* importance when defining training goals?

A. Code of Federal Regulations
B. Worker interviews
C. Job task analysis
D. Critical incident analysis

9. Learner reaction to instruction is greatly impacted by facilitator behaviors. Which learner performance outcome is *least likely* to occur?

A. Observers learn by watching and imitating others; they tend to behave as they have seen others behave.
B. Observers will imitate a model who is passionate about his/her topic.
C. Observers will imitate a model when they see the model being rewarded for his/her actions.
D. Observers will imitate a model when they see the model being punished for his/her actions.

10. Learning objectives are brief, clear, and concise statements of what the learner should be able to do as an outcome of training. All the following are completed prior to designing the learning objectives *except:*

A. the needs analysis should determine if training is the solution.
B. a task analysis and supervisor discussions will identify performance requirements.
C. lesson plans should be implemented consistently to all affected workers.
D. performance criteria is established and documented.

11. In the development of an operator training program to recognize alarms for a new piece of equipment, the *least appropriate* curriculum design is:

A. a detailed course on the manufacturers wiring diagrams and equipment standards of design specifications for alarms.
B. a description of how the equipment functions, recognizing alarms, and the use of integrated operator safety devices.
C. identification of specific hazards associated with equipment and how operators protect themselves.
D. acceptable conditions when energy isolation is verified and the operator can realign the product in the equipment.

12. A common safety training technique when facilitating work team learning is the case study. Which is *most correct* about the use of a case study as a learning strategy?

A. Case studies must always involve fictitious situations or incidents so that no one group or individual will feel threatened.
B. Case studies should be written and distributed as handouts to be most effective since most tradecraft employees have short attention spans.
C. Case studies are good problem-solving tools and can be used effectively with brainstorming activities and group discussions.
D. Case studies involving real situations should only be used if they can be presented by the actual employees/responders involved in the situation or incident.

13. Adult learning theory has established universal assumptions of adult learner needs. Which statement is *least likely* considered when designing hazard awareness training?

A. Adults have experience and need to control their learning.
B. Adults need to know why learning information is relevant.
C. Adults need to be provided with written training materials to make meaning of learning content.
D. Adults need to know how to apply knowledge and skill for successful performance.

14. When developing tests and evaluations for training programs, which guideline is *least important?*

A. Test items must be reliable.
B. Evaluations are norm-referenced.
C. Test items must have criterion-related legitimacy or validity.
D. Assessment or evaluation methods should be developed prior to training delivery.

15. Safety and health training can involve many diverse delivery schemes and training techniques. Often group methods are used to increase effectiveness of training and active involvement of participants. Which of the following would be the *best* use of the role-playing?

A. For human relations training.
B. For job training in a one-on-one environment.
C. To exemplify the complexities of a step-by-step comprehensive industrial task.
D. For in-depth technical topics.

16. Which statement is *most accurate* about the conference method as a communication technique?

A. Individual understanding of the content is not important after a conference method session.
B. The conference method is inappropriate for small group problem-solving sessions.
C. The success of the conference method is largely dependent upon the skills of the facilitator.
D. The success of the conference method depends entirely on the amount of materials covered.

17. Which of the following is the *least valuable* quality of interactive computer-assisted training or distance learning?

A. Works well for organizations with small workforces
B. Functions well for organizations that cannot remove large portions of the workforce from the job at one time
C. Permits instructors to interact with each other without restrictions
D. Trainees can engage in training at their own pace

18. When selecting a communications medium for a training presentation, which features are listed in *increasing* order of learner retention?

A. Experience, auditory, words
B. Words, visual pictures, experience
C. Displays, auditory, demonstrations
D. Demonstrations, auditory, words

19. Selecting the media to be used for presenting instructional content:

A. requires only a knowledge of specific course objectives.
B. should be done only after a planning process that includes content analysis, audience analysis, and other steps.
C. partly determine what content can be included and should precede content analysis.
D. is the first step in instructional design.

20. Safety trainers often attempt to change the way an audience views their procedures or actions. A primary way to help facilitate change is by:

A. allowing everyone to express their point of view.
B. following lesson plan without interruptions.
C. allowing limited questions at end of presentation.
D. pointing out how change will affect the workplace.

Domain 8 Quiz 1 Answers

1. Answer: **B**. The following are the characteristics of "group think":

   - **Illusion of Invulnerability**: Members ignore obvious danger, take extreme risk, and are overly optimistic.
   - **Collective Rationalization**: Members discredit and explain away warning contrary to group thinking.
   - **Illusion of Morality**: Members believe their decisions are morally correct, ignoring the ethical consequences of their decisions.
   - **Excessive Stereotyping**: The group constructs negative stereotypes of rivals outside the group.
   - **Pressure for Conformity**: Members pressure any in the group who express arguments against the group's stereotypes, illusions, or commitments, viewing such opposition as disloyalty.
   - **Self-Censorship**: Members withhold their dissenting views and counterarguments.
   - **Illusion of Unanimity**: Members perceive falsely that everyone agrees with the group's decision; silence is seen as consent.
   - **Mindguards**: Some members appoint themselves to the role of protecting the group from adverse information that might threaten group complacency.

2. Answer: **C**. A task analysis is a sequential list of all the steps necessary to perform a specific job skill. This step will also help determine if training is required or not. It is used later in the training process to develop training objectives and to develop ways to test performance.

3. Answer: **C**. Employee annual performance evaluations should always be based on sound measurable objective criteria that is fully understood by both the supervisor and employee. The rating will be most valuable if the rating is discussed with the employee and directions for improvement are indicated.

4. Answer: **B**. Brainstorming is a technique of group interactions, often defined as 5–7 members, that encourages each participant to present ideas on a specific issue (**Table 24**). The method is normally used to find new, innovative approaches to issues. There are four ground rules:

   - Ideas presented are not criticized.
   - Freewheeling creative thinking and building on ideas are positively reinforced.

- As many ideas as possible should be presented quickly.
- Combining several ideas or improving suggestions is encouraged.

Table 24 Brainstorming

Advantages	Limitations	Uses	Types of Objectives
Interactive Relevant Creative Can be entertaining	Time consuming Requires skilled facilitator	Problem solving Troubleshoot Enhanced by pictures/ media	Best for knowledge-level objectives Problem solving

5. Answer: **A**. Some words that should be **avoided** when writing learning objectives are to: *know*, *understand*, *appreciate*, *learn*, *cover*, *study*. It is almost impossible to determine if a student has accomplished those objectives. Some example preferred words are **explain**, **classify compare**, **calculate**, **demonstrate**, **operate**, **measure**, **troubleshoot**, **analyze**, **develop**, **plan**. An example is "each individual will describe in their own works the three primary ISO standards that apply to safety management."

6. Answer: **D**. Training objectives should, above all, be reasonable, measurable, and obtainable. It is very desirable, but not imperative that the objectives and goals for any program be written, so as not to be misplaced or relegated to a low priority. When writing training objectives, use action verbs such as "add," "answer," "compare," "line up," etc. Avoid words such as "understand," "know," "comprehend," and "notice," as these actions are difficult to measure.

   To gain a competitive edge, training must involve more than basic job skills. Included now are advanced skills and understanding of customers and entire manufacturing system. The training is linked to strategic business goals and specific objectives and uses an instructional designed process to ensure effective training that compares favorably with training programs found in other companies.

7. Answer: **C**. This is the definition of a needs analysis and will help safety inspectors decide between training and nontraining needs. The primary question that must be answered, "Is this a problem that training will resolve or is there a better solution?" After defining the performance discrepancy, instead of training, a new set of work instructions may solve the problem.

   An example could be to hang out a PPE required sign to remind personnel that PPE is required when they operate a machine. An analytical approach to support the needs analysis would be to complete an operational hazard analysis.

8. Answer: **C**. Most training experts rate job task analysis as the primary aid in developing course training goals and content.

9. Answer: **D**. According to Snyder, 2018 a facilitators actions have a major impact on how a learner reacts to the training environment. Usually adults tend not to model behavior that is punished. To avoid conflicting values, safety training objectives should be relevant to the work environment.

10. Answer: **C**. Learning objectives are always completed before you develop a lesson plan.

11. Answer: **A**. During a training session, an instructor must explain what the operator needs to know, not all the extraneous data connected with specific equipment. If the learning objective is how to operate the equipment, they may not need a detailed course on engineering. In this context, the trainer would want to "teach them how to tell time, not how to build a watch."

12. Answer: **C**. The case study is an especially effective technique for safety and health training since it often illustrates the multicausal aspects of accidents, as well as the tragic consequences. The case study is an excellent problem-solving technique that *facilitates interactive learning*. Normally case studies are presented to a group that has the goal of evaluating mistakes made in a situation and providing real-world solutions. The technique is particularly effective when the group is allowed to come to the conclusion that they can benefit from mistakes of other organizations and thus prevent accidents.

The case study is an excellent tool for developing analytical skills. A major disadvantage to the case study is that a preexisting case may not actually relate to a specific training situation. Common instructional strategies are listed in **Table 25**.

Table 25 Case Study

Advantages	Limitations	Uses	Types of Objectives
Interactive Relevant Explore complex issues Applies new knowledge Can be entertaining	Time consuming. May not see relevance	Develop analytic and problem-solving skills Enhanced by pictures/ media	Best for knowledge-level objectives Problem solving

13. Answer: **C**. The facilitator of adult learning is a guide to adults who are involved in an educational journey. Being technically proficient is not enough, a trainer must possess personality characteristics, interpersonal skills, and positive behaviors. A trainer's attitude is a major motivational condition that has a great impact on creating a conducive learning environment.

    Dr. Malcolm Knowles's theory of andragogy is an attempt to develop a theory specifically for adult learning. Knowles emphasizes that adults are self-directed and expect to take responsibility for decisions. Adult learning programs must accommodate this fundamental aspect. Andragogy makes the following assumptions about the design of learning:

    1. Adults need to know why they need to learn something,
    2. Adults need to learn experientially,
    3. Adults approach learning as problem-solving, and
    4. Adults learn best when the topic is of immediate value.

    In practical terms, andragogy means that instruction for adults needs to focus more on the process and less on the content being taught. Strategies such as case studies, role-playing, simulations, and self-evaluation are most useful. Instructors adopt a role of facilitator or resource rather than lecturer or grader.

    - **Six Characteristics of Adult Learning:**
      1. Are autonomous and self-directed
      2. Have a foundation of life experiences and knowledge
      3. Are goal-oriented
      4. Are relevant
      5. Are practical in nature
      6. Need to be shown respect
    - **Four Adult Learning Needs:**
      1. Need to know why—application to immediate challenges
      2. Need to apply experience—opportunity to share and discuss
      3. Need to be in control of their learning—flexible environment, voice concerns
      4. Want to learn things that will make them more effective and successful

14. Answer: **B**. **Reliability** is a measure of how well a test item discriminates the knowledge level of the participants. Evaluations for training purposes are **NOT norm-referenced**. Norm-referencing means that how well a trainee scores depends on how well or how poorly other trainees perform. Evaluations for training purposes **should always be criterion-referenced**. This means performance is measured against a preset standard. The test must measure what it is supposed to measure. The evaluation tool should always be developed before training begins. Pretest and posttest should cover equivalent subject matter. However, it should not be the same test or test questions. Well-developed multiple-choice questions on knowledge assessment tests permit the most objective pass or fail decisions to be made and calculate the most reliable performance statistics. After the training is completed, ensure trainee feedback along with statistical data to ensure continuous improvement.

15. Answer: **A**. Role-playing is ideally suited for human relations education or training. It allows students to become participants in a "drama" or "play" that depicts the interaction of humans during stressful or error provocative situations (**Table 26**). The technique is **not** suited for problem solving or technical training.

Table 26 Role Play Strategy

Advantages	Limitations	Uses	Types of Objectives
• Creates a learner-centered environment • Employs learner creativity • Elicits empathy • Addresses complex issues • Can be entertaining	• Participants may be resistant • Risk of embarrassing participants • Easily distracted, difficult to maintain control • Requires intense focused on the objective • Requires a skilled facilitator	• Useful as a capstone exercise to bring together learned concepts • Promotes an understand others' perspective • Excellent for active participants	• Excellent for affective and problem-solving exercises

16. Answer: **C**. One of the most valuable group techniques is the conference method. The strength of the conference method is in the individual knowledge and experience of the participants. The number of members should be kept small to allow for maximum exchange of ideas. The establishment of goals and objectives is crucial to the success of this method. But more than anything else, this teaching method hinges on the capability of the facilitator or instructor. The facilitator logs the objectives and keeps information and opinions flowing during sessions (**Table 27**).

After the conference, the facilitator distributes recommendations and informs members of actions taken as a result. Shortfalls associated with this method include the trusting a facilitator to ensure that the conference does not become a bull session and recognizing that if management does not follow up on recommendations, then the group will not likely support future efforts.

Table 27 Guided Discussion Strategy

Advantages	Limitations	Uses	Types of Objectives
Encourages participation Shows respect for participants' knowledge Stimulates interest Allows instructor to check for understanding Useful in many situations	Can be dominated by one individual or faction Susceptible to drift or "mission creep" Can be difficult to focus on objectives Can degenerate into a lecture or chaos Does not give trainer complete control	Can be used as an icebreaker Can be used to generate ideas Can be used to solve problems Can be used for review Best to use with small groups—or a large group divided into small groups Useful for both active participants and reflective observers.	Best for comprehension and problem-solving objectives

17. Answer: **C**. According to the NSC, the valuable attributes of interactive computer-assisted training, sometimes called computer-based training (CBT), or distance learning, are as follows:

- Workers can work at their own pace.
- Records of all training can be automatically kept.
- Correct answers are required before a student can proceed.
- Workers receive training as time is available.
- Instructors can guide workers step by step through the entire lesson plan.
- This method works extremely well for organizations with a small workforce or that cannot remove large groups from their jobs at any one time.

When someone completes coursework away from an actual training facility, it is generally called distance learning. This is an umbrella term for many types of learning, including online training and training available through the mail. Before implementing CBT or any type of training, a needs analysis should be completed to ensure that the best method is being selected.

18. Answer: **B**. Learning styles include sight, touch, and hearing. Facilitators should invoke a variety of strategies that stimulate various learning styles. The scale in increasing order of learning retention includes: Less effective = 1; More effective = 10

    1. Words, spoken or written
    2. Auditory aids
    3. Still pictures
    4. Motion pictures
    5. Live television
    6. Displays
    7. Familiarization
    8. Demonstration
    9. Simulations
    10. Actual experience

19. Answer: **B**. The target audience is the group of learners. A good training needs analysis provides the trainer with intelligence about target audience demographics. Relevant details include:

    - Educational background
    - Level of experience with the training topic
    - Job duties and responsibilities
    - Risk factors
    - History of training
    - Length of employment
    - Organizational climate
    - Attitudes toward training
    - Mastery of prerequisite skills/knowledge/abilities
    - Medical requirements

    The more a trainer knows about the target audience, the more appropriate the training will be. To avoid delivering a workshop that is too elementary or too advanced for an audience, the trainer can make adjustments in the instructional strategies. These adjustments can vary from peer groups or individuals; the purpose is that they can accomplish the learning objective.

    Selecting the media to use for presenting instructional content should be done only after a planning process that includes content analysis, audience analysis, and other steps. OSHA's publication training guidelines (**Figure 25**) follow a model that consists of:

    1. Determining If Training Is Needed
    2. Identifying Training Needs
    3. Identifying Goals and Objectives
    4. Developing Learning Activities
    5. Conducting the Training
    6. Evaluating Program Effectiveness
    7. Improving the Program

20. Answer: **A**. During any training situation when attempting to change habits or procedures, the trainee will have questions as to why it is necessary and why the recommended way is best. When the trainee is permitted to share ideas, evaluate the material, and become involved, their overall acceptance of course material will increase.

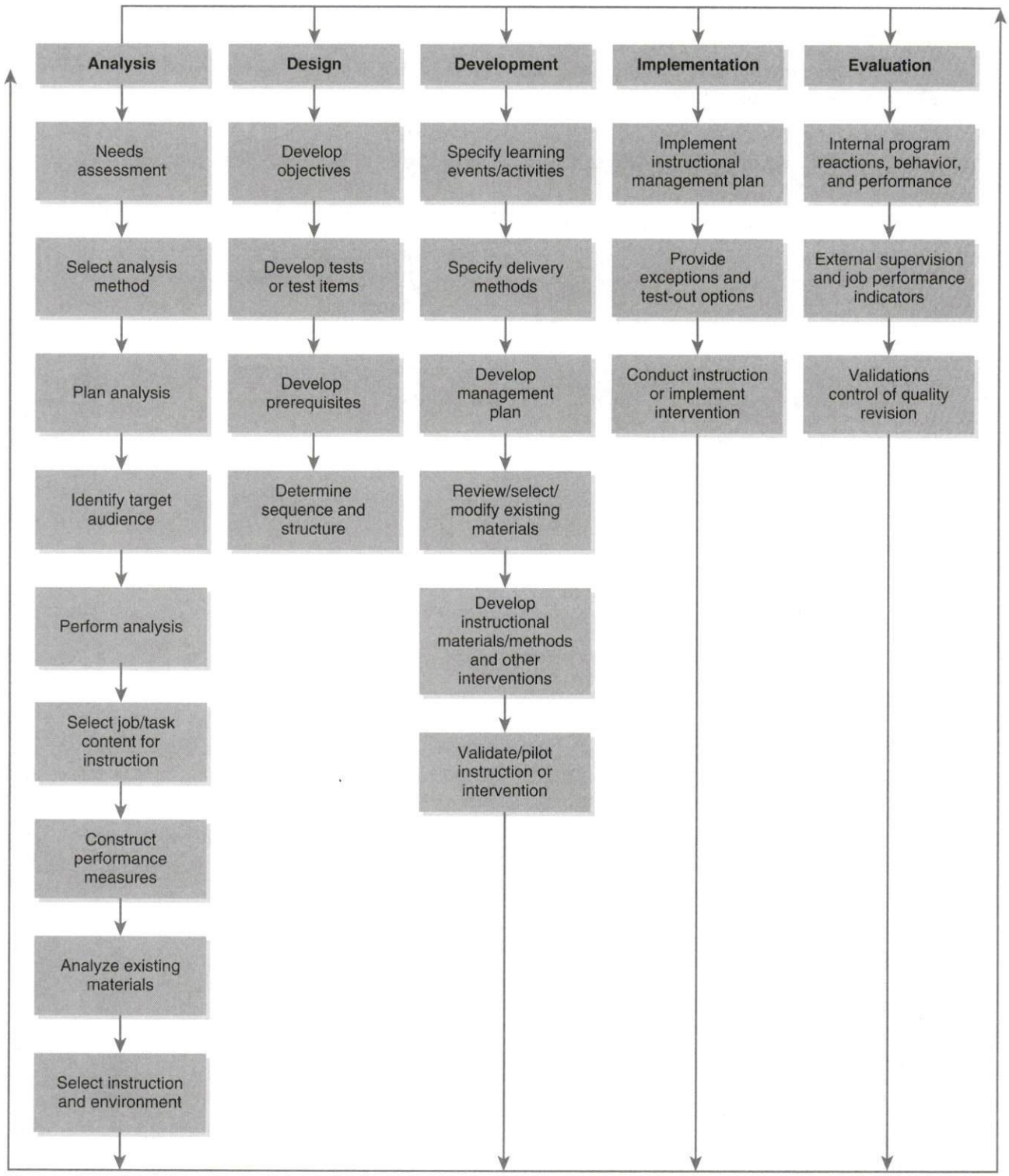


Figure 25 Systems Approach to Training and Instructional Systems Design Models

Domain 8 Quiz 2 Questions

1. Successful adult learning is evaluated *least effectively* by:

A. learner demonstrating application of knowledge.
B. instructor providing a video of a previous experience.
C. observing the learner practice a new skill.
D. discussing feedback with the supervisor about how new skills have improved performance.

2. A supervisor is conducting training on the use of air-purifying respirators to several crews of disaster site workers. For program reliability, it is *most important* for the trainer to:

A. dress for the occasion.
B. become a subject-matter expert on respirators.
C. use an abundance of visual aids.
D. use a well-prepared lesson plan.

3. The *primary* benefit of safety training is:

A. reduction of production costs.
B. improved safety performance.
C. fewer incidents/accidents.
D. reinforcement of operational organization goals.

4. During a training, needs assessment does *not* include:

A. development of instructional strategies.
B. identifying the problem or need before designing a solution.
C. cost–benefit analysis of training solutions.
D. evaluating the impact of a training solution before development.

5. Which of the following techniques is true concerning the "pre- and post-testing" method?

A. Pre- and post-tests should be identical.
B. Pre- and post-tests should not be used.
C. Pre- and post-tests should cover the same objectives.
D. Pre- and post-tests should cover different objectives.

6. On the third day of a five-day course, a new trainer arrives to teach the remainder of the class. The trainer identifies that two of the people seated next to each are being disruptive. The *first* option for managing the disruptive behavior is:

A. identify the disruptive persons to the entire class before the next break; warn if the behavior continues they will be removed and senior management will be notified by e-mail.
B. arbitrarily rearrange the entire class seating placements during break to separate the disruptive students.
C. make eye contact, move towards the disruptive behavior, and if the behavior continues, speak privately with the disruptive persons at a break, seeking resolution.
D. make an example of the disruptive person by making them stand in the back of the room, explaining to the class that disruption won't be tolerated.

7. Which situation would *likely* require a solution other than safety training?

A. Worker refuses to follow safety rules
B. Workers that are new hires
C. Experienced worker transferring to a new job
D. New procedures will be implemented

8. An effective safety training program must have the following components: performance based, established implementation plan, measured, and:

A. apply to both individual and group settings.
B. use audio-visual presentations supported by printed materials.
C. transfer knowledge prior to hazardous exposures.
D. delivered only by specially trained and highly skilled instructors.

9. The *first* phase in designing a successful safety training program is to:

A. design learning objectives.
B. conduct a training needs assessment.
C. develop instructional strategies.
D. plan for a conducive learning environment.

10. Safety professionals designing and delivering safety training programs should incorporate essential training principles that include clearly stated objectives, organized and logical content, and:

A. use humor to reinforce the message.
B. provide a comfortable training environment.
C. align the training to fit individual needs.
D. overemphasize the importance of training.

11. The training implementation phase includes instructor costs, student costs, materials costs, and:

A. facilities costs.
B. curriculum development costs.
C. recordkeeping costs.
D. marketing costs.

12. The training method that provides the *most information* retention is:

A. reading.
B. listening.
C. active.
D. seeing.

13. Which training is *most appropriate* for supervisors?

A. Training in the safe use of products
B. Training in doing a job correctly and safely
C. Training when the job changes
D. Training in hazards and controls

14. There are three general adult learning theories; cognitive, behavioral, and motivational. Which is a *primary* principle of the cognitive theory?

A. Addresses how external factors influence behavior and learning
B. Uses routine and frequent reinforcement
C. Addresses how people process and remember information
D. Recognizes that people want to learn for largely personal and internal reasons

15. Training and education are often used interchangeably but have different meanings. The *major* distinction between training and education is:

A. education focuses on learning about, and training focuses on learning how.
B. training focuses on learning about, and education focuses on learning how.
C. education is more focused on application of skills, and training is focused on building knowledge.
D. training develops knowledge for future use, and education provides relevant skills for immediate use.

16. **You are facilitating a one (1)-hour training session and arrive five (5) minutes before the start of class to find that your presentation did not synchronize with the company server. Participants are taking their seats and you do not have access to the presentation. What is the *best* course of action?**

    A. Cancel the training session.
    B. Reschedule the training session for a later time.
    C. Get into your facilitator toolkit and begin the training.
    D. Ask a participant familiar with the topic to deliver the training.

17. **Storytelling is a useful training strategy to bring context to a situation. The *most important* aspect of the story is that it must be:**

    A. factual.
    B. relevant.
    C. a first-person experience.
    D. humorous.

18. **Training is needed for a new process rollout. The training program has been designed, materials are appropriate and purchased, and the training has been conducted. What remains to be completed?**

    A. Learning objectives
    B. Program evaluation
    C. Curriculum design
    D. Needs analysis

19. **Which training method allows for the *least amount* of student–instructor interaction?**

    A. Lecture
    B. Role-playing
    C. Case study
    D. Facilitated discussion

20. **What is *most important* when facilitating individualized instruction as part of a self-directed, distance learning strategy?**

    A. Ensure technical competency of the learner.
    B. Control the progress to meet the learning objectives.
    C. Evaluate knowledge gained through standardized testing.
    D. Know the learner's knowledge gaps.

Domain 8 Quiz 2 Answers

1. Answer: **B**. Adults want satisfactory answers to the following questions to accept and apply learning.

    - Why is it important?
    - How can I apply it?
    - How does it work?
    - What do I need to know?

    The best way to evaluate learning is to observe a change in behavior.

    Showing a video to the learner will not provide any information regarding their learning.

2. Answer: **D**. The use of a lesson plan will provide standardization to a presentation and avoid omission of essential material. The lesson plan also helps the instructor conduct the class according to a timetable and should provide for student participation or involvement. Presenting technical information requires training and practice. The most practical method of delivery is using a manuscript. The effectiveness of a technical presentation depends upon the trainee as well as the instructor. The trainees will be much more open to learning if the instructor succeeds in eliciting a sense of disequilibrium among the trainees.

3. Answer: **B**. According to the NSC, the goal of effective training is learning that leads to improved on-the-job performance. Other benefits include reduction in rejected production items, improvement in housekeeping, and lowering the number of preventable accidents. After a training program has been conducted, what is actually applied on the job will be influenced most by the expectations of superiors, peers, and subordinates.

4. Answer: **A**. According to the NSC, a needs assessment helps to:

   - Distinguish between training and nontraining needs
   - Identify the problem or need before designing a solution
   - Save time and money by ensuring that solutions effectively address problems they are intended to solve
   - Identify factors that will impact training before its development

   Hagan, P. E. *Accident Prevention Manual for Business & Industry: Administration & Programs*, 12th ed, National Safety Council, 2001.

   After the needs assessment, training goals are developed and during that process candidates will determine what knowledge the trainee needs to know to eliminate the problem. Remember, if the outcome is to tell time, then trainees should learn how to tell time, not how to build a watch.

5. Answer: **C**. Pre-and post-testing as a measurement of the learning, the tests should cover the same areas but be phrased differently. Each pre- and post-test question item should be written for each course learning objective. For ease in assessing the course learning, you should match the question item as closely as possible to the learning objectives.

6. Answer: **C**. Setting classroom expectations at the very beginning of a class is one of the best methods of classroom management. Hang a flip chart or poster or dedicate a section of white board if you have the space, and list expected classroom behaviors. Refer to this list when disruptions occur. Using a flip chart or white board can be especially useful because you can involve students in the construction of the list on the first day and in that way get buy-in. Start with a few of your own expectations and ask the group for additional suggestions. When all agree on how the classroom is to be managed, disruptions are minimal.

   A list of expectations may include:

   - Set the tone: "We are all adults and professionals…"
   - Start and end on time
   - Turn off or silence cell phones
   - Save texting for breaks
   - Respect the contributions of others
   - Be open to new ideas
   - Resolve differences calmly
   - Stay on topic

   Unless you've got a purposefully disruptive student in your classroom, disruptions are likely to be minimal. We're talking about disruptions like chatting in the back of the room, texting, or someone who is argumentative or disrespectful.

   Try one, or more, if necessary, of the following tactics:

   - Make eye contact with the disruptive person
   - Remind the group of the agreed-upon norms
   - Move toward the disruptive person
   - Stand directly in front of the person
   - Be silent and wait for the disruption to end
   - Acknowledge the input, put it in your "parking lot" if appropriate, and keep moving forward to meet the learning objectives.
     - "You may be right."
     - "Thanks for your comment."
     - "How about if we park that comment and come back to it later?"

- Ask for help from the group
  - "What does everyone else think?"
- Call for a break and speak with the person(s) privately, seeking resolution.
- Rearrange the seating as part of a learning activity.

For more serious problems, or if the disruption persists:

- Call for a break and speak with the person(s) privately, seeking resolution.
- Confront the behavior, not the person.
- Speak for yourself only, not the class.
- Seek to understand the reason for the disruption.
- Ask the person to recommend a solution.
- Review your expectations of classroom behavior, if necessary.
- Try to get agreement on expected norms.
- Explain any consequences of continued disruptions.

7. Answer: **A**. Safety training the right solution to a performance problem involving the lack of skills, knowledge, or abilities. However, training is not intended to correct performance issues such as a worker refusing to follow safety rules.

8. Answer: **C**. To design an effective training program, the safety professional must focus on the learners' needs, analyze learner characteristics, develop specific learning objectives, create materials and schedules, and design appropriate testing and evaluation methods. The main goal is to transfer knowledge about workplace hazards before a worker is exposed to those hazards.

9. Answer: **B**. To create an effective training program, first the safety professional needs to assess current worker performance, comparing it to the desired performance.

10. Answer: **C**. Planning and development of training begin with an understanding of how people learn and what contributes to learning. The following list summarizes some principles of learning.

    - *Stimulate multiple senses*. We receive most information through vision. Hearing processes a lot of information but cannot handle information at the same rate as visual input. Incorporating visual materials into training helps the learning process.
    - *Identify the need for training*. The trainee will understand what is being learned better if objectives and strategy for training are presented clearly.
    - *Organize the content logically*. It is better to conduct training in small modules rather than large ones. What constitutes logical order depends on the material being taught. One form of order is proper sequence, where early modules establish the background for later modules. Another form of order is level of difficulty, where material progresses from easy to more difficult.
    - *Teach principles with procedures*. People will understand procedures better and retain them longer if the principle or objective for the procedures is presented first.
    - *Teach the whole process first, then detailed parts*. Trainees should learn the whole procedure first. They need to see what each step leads to. Then they can go through the details of the process.
    - *Make sure trainees have time to practice but keep practice periods short*. When trainees are learning skills and the criterion for success is meeting some performance standard, trainees need time to practice. Short practice periods with breaks are more effective than long practice sessions.
    - *Ensure participation when performance is the goal*. When training occurs in group arrangements, some trainees hold back from participating. An instructor must watch for this and find ways to involve everyone.
    - *Give trainees knowledge of results*. Trainees need to know how they are doing. It is better to evaluate trainees in small increments and give them results of evaluations rather than delay evaluation and results.
    - *Reward correct performance*. There are many forms of feedback. Positive is generally better than negative. Praise and verbal comments can be used when trainees do things correctly. Accurate and immediate feedback is better than delayed and general feedback.

- *Keep trainees interested and challenged.* Instructors can use various techniques to increase participation and interest in subject materials. Ask questions and stimulate discussion, and when there are skills involving several people, role-playing exercises help maintain interest.
- *Simulation should duplicate actual conditions.* When procedures and settings are simulated, they should accurately represent real situations as much as possible. Unrealistic simulation can lead to incorrect behavior in real contexts.
- *Unique or unusual material is retained longest.* Use of examples and real situations helps people visualize what is taught. Dramatic and exotic style may be entertaining, but care must be given to make sure such activity is meaningful.
- *Provide relearning to sustain knowledge and skill.* The idea of a learning curve tells us that the more skilled a person becomes, the slower the rate of improvement. After training, the knowledge or skill achieved by the end of training decays with time. Creating opportunities to relearn, update, or evaluate skills and knowledge will help keep performance at desired levels.
- *Fit training to individual needs.* The knowledge or skill of each trainee can be assessed through pretests, interviews, and other evaluations. When there is too great a range in knowledge and skill in the same training session, few trainees are well served. With self-paced instruction and criterion-based training, individuals can achieve the desired level of knowledge or skill at their own pace. Slow learners or those with elementary skills are not intimidated by others who are advanced. Computer-based instruction and training systems allow for customized instruction and repeating of sessions to match the needs of individuals.

11. Answer: **A**. Safety training costs can be broken down into three major categories—(1) development, (2) implementation, and (3) other life cycle costs. Development costs include curriculum development and materials. Implementation costs include instructor cost, student cost, material cost, and facility cost. Other life cycle costs include recordkeeping and training evaluations, revisions, software licensing and maintenance fees, information technology support, internal salaries.

12. Answer: **C**. Active training can be defined as a two-way interactive learning processes with continual feedback to achieve the purpose of the learning objective(s). Active training is a method of education that uses unconventional means to motivate students to become more involved, physically and mentally, in applying material/content. Active training is an effective teaching method that takes into account different learning styles and social components (**Table 28**). Characteristics include:

- Learning by doing/hands-on
- Contingent (step-by-step)
- Individual has control over what/how much they learn
- Facilitates participation

Table 28 Demonstration/Practice Strategy

Advantages	Limitations	Uses	Types of Objectives
Provides hands-on experience/practice Incorporates multiple senses and learning styles Proficiency evaluated through demonstrated performance	Requires significant preparation Is time consuming May increase safety risks May require a cadre of instructors	Useful for any hands-on skills Useful for troubleshooting Works well only with small groups Excellent for active participants	Best with application-level/psychomotor objectives Useful for problem-solving with equipment (troubleshooting)

13. Answer: **D**. Supervisors and managers represent company and employer responsibilities. Not only do they need to understand the hazards and controls for their workers but they need to know what training they must administer. They need to understand the regulatory and legal responsibilities for safety that the

employer or company retains, and they need to know what responsibilities they have under normal and special procedures. If supervisors and managers have contract relationships with other companies and their employees, the supervisors and managers must learn how to deal with safety matters through contract chains of command.

14. Answer: **C**. This section will focus on three learning theories: (1) cognitive, (2) behavioral, and (3) motivational. Each theory will help instructors create effective training programs regardless of whether they deliver training in the classroom or via technology. Learning theories are the foundation from which training is derived, and they have shaped learning as we know it today. Learning theories help trainers understand why certain concepts are important and provide rationale as why specific training activities are used. Cognitive theories describe how people process and remember information. This area is where one can find answers to questions like: How do people learn? Why do workers sometimes forget information? Behavioral theory is especially important because it describes why it is important to reinforce principles after training. Behavior-based principles are used by companies to create a safety culture, and these principles have direct application to training. Equally important is motivation theory, because it describes ways trainers can make safety training interesting and relevant to learners.

15. Answer: **A**. Training is more immediate, skills-oriented, and focused on application as compared to education, which is the process of building a base of knowledge. In OHS, both strategies are important. Organizations often focus on skills based or traditional training. Training in hazard communication typically might focus on how to read an SDS and labels, handle workplace chemicals, etc. Education in hazard communication could focus on historical perspective, and on examining case studies of OSHA fines or major chemical exposure events.

16. Answer: **C**. First, facilitators should arrive early, at least 30 minutes before the start of training to get set up (mentally and technologically), check the learning environment, verify materials are in order, and greet participants as they arrive. It is always a good idea to carry a backup memory stick with a copy of the presentation. To be an effective trainer/facilitator, one must have a go-to facilitator toolkit. While multimedia presentations are great tools, death by PowerPoint is the result of this technology being overused as a crutch for poor facilitation skills. Some of the best presentations delivered by skilled facilitators have been out of spontaneity due to technical difficulties. However, such disruption can be disastrous for a one-dimensional, inflexible, or novice instructor. Bottom line: Have a backup plan.

    One of the pitfalls of instruction is that trainers tend to develop training programs that accommodate the way the trainer learns best, not the way the participants learn best. The key to accommodating learning styles is that instructional strategies and media should be selected as a means to help the learner and not as a convenience for the instructor. The best training stimulates multiple senses in the learner and should be a blend of various learning strategies:

    - Lecture
    - Brainstorm
    - Case study
    - Demonstration
    - Role-play
    - Guided discussion
    - Self-directed/distance learning
    - Learner discovery/individualized instruction
    - Interactive computer-based training (CBT)
    - Activity-based hands-on/demonstration
    - e-learning/m-learning
    - Hybrid/blended

    Many people recognize that each person prefers different learning styles and techniques. Learning styles group common ways that people learn. Everyone has a mix of learning styles. Some people may find that they have a dominant style of learning, with far less use of the other styles. Others may find that they use different styles

in different circumstances. There is no right mix. Nor are your styles fixed. You can develop ability in less dominant styles, as well as further develop styles that you already use well.

Giving consideration to learning styles helps trainers to:

- Recognize that everyone learns differently and the need for a variety of instructional strategies and media.
- Recognize that trainers ***also*** have preferred learning styles.
- Learner focus, not instructor focus.
- Be creative and include exercises or instructional strategies or media that help adults learn the information and appropriate for the learning objectives.
- Make real-time adjustments and employ alternative instructional methods best suited to the learners and accomplish the learning objectives.
- Empathize with training participants.

By recognizing and understanding learning styles, skilled trainers can use a variety of techniques best suited to the audience and learning objectives. This improves the speed and quality of training.

The ANSI Z490-2009 Criteria for Accepted Practices in Safety, Health and Environmental Training is a well-constructed standard specific to SH&E training.

Competency is having the skills, knowledge, and abilities to perform the task as determined by the employer.

Competent training professional is a person prepared by education, training, or experience to develop and implement various elements of a training program. Also known in the Z490 standard as a "training professional."

Trainer is the person who delivers a training event.

Trainer criteria represents the criteria for safety, health, and environmental trainers shall be specified during training development. Criteria shall include subject-matter expertise and training delivery skills.

17. Answer: **B**. According to Snyder (2018), and many others, a facilitators actions have a major impact on how a learner reacts to the training environment. Adult learners are relevancy oriented, pragmatic, and interested in the immediate application of knowledge (i.e., the "so-what" factor). Author Elain Biech (2015) in *Training and Development for Dummies* explains storytelling as telling an event (true or fictitious) that has a moral or lesson or demonstrated consequences. The punch line leaves the listener inspired, influenced, or improved, without explaining the learning point. The most important factor of storytelling as a facilitator is to be relevant to the audience and learning objectives.

18. Answer: **B**. The ADDIE instructional design model is the generic process traditionally used by instructional designers and training developers. The ADDIE model is at the very core of instructional design and is the basis of instructional systems design (ISD). There are various adaptations of the ADDIE model, but it generally consists of five cyclical phases:

    1. Analysis
    2. Design
    3. Development
    4. Implementation
    5. Evaluation

    These processes represent a dynamic, flexible guideline for building effective training and performance support tools. Most current ISD models are variations of the ADDIE process. Rapid prototyping is a commonly accepted improvement to this model. This is the idea of reviewing continual or formative feedback while creating instructional materials. This model strives to save time and money by catching problems while they are still easy to fix (**Figure 26**).

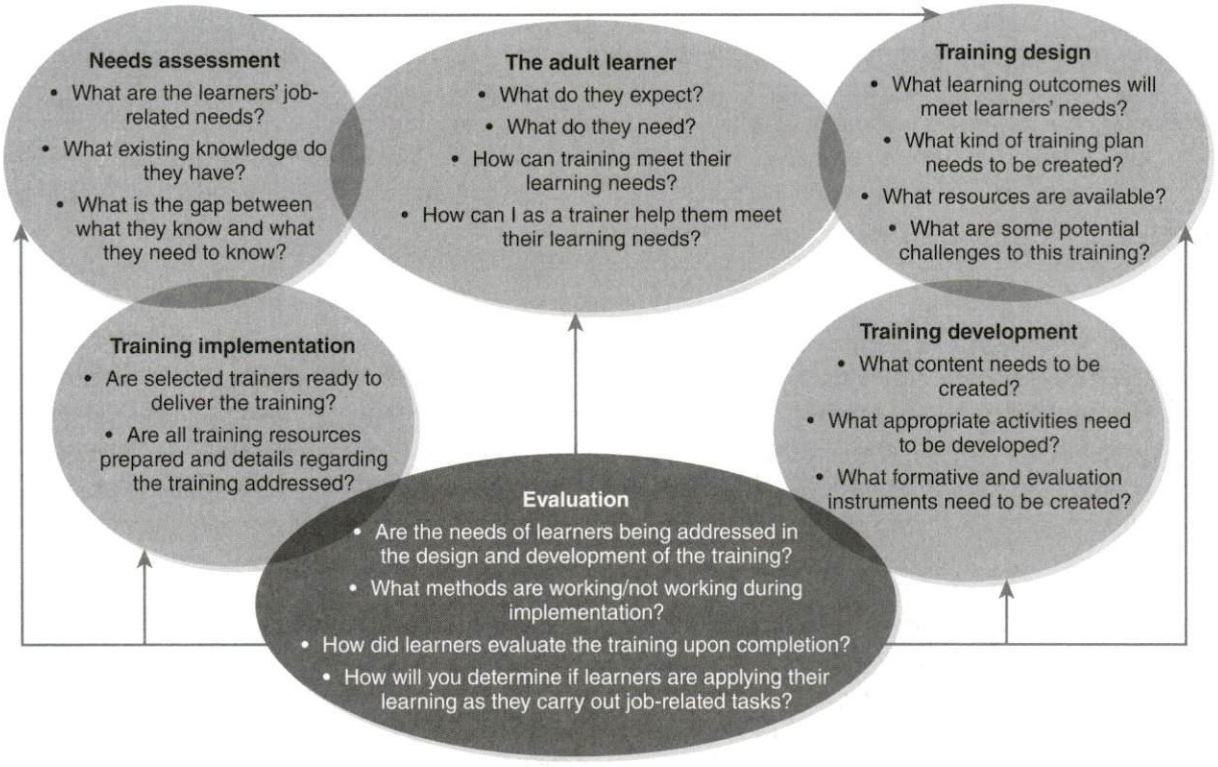


Figure 26 Creating a Training Program Using the ADDIE Model

19. Answer: **A**. The benefit of lecture is that information can be imparted to a large group in a relatively short time (**Table 29**). However, this leaves little time or opportunity for interaction between trainee and instructor.

Table 29 Lecture Strategy

Advantages	Limitations	Uses	Types of Objectives
Presents much information in a short time Provides for instructor control Good for introducing and summarizing new information Can be entertaining	Does not develop reasoning skills Makes learners dependent on instructor Is instructor-paced Tends to be overused Can be boring	Introduce new material To summarize lesson To establish instructor's expertise and leadership Excellent for reflective observers Enhanced by media	Best for knowledge-level objectives, acquisition of facts

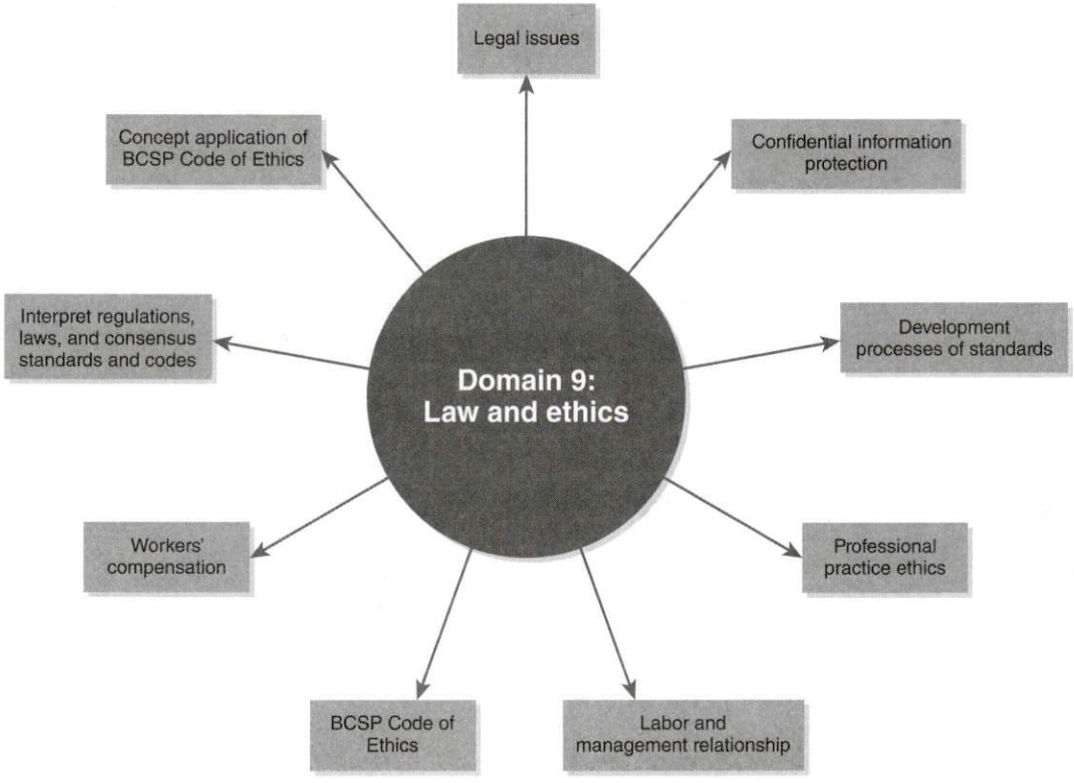
20. Answer: **D**. Self-directed learning involves having employees take responsibility for all aspects of learning when it is conducted and who will be involved. Learners master predetermined training content at their own pace without an instructor. Trainers may serve as facilitators. That is, trainers are available to evaluate learning or answer questions for the trainee. The trainer does not control or disseminate instruction. The learning process is controlled by the learner. There are several advantages and disadvantages of self-directed learning. It allows trainees to learn at their own pace and receive feedback about the learning performance. For the company, self-directed learning requires fewer trainers, reduces costs associated with travel and meeting rooms, and makes multiple-site training more realistic. Self-directed learning provides consistent training

content that captures the knowledge of experts, makes it easier for shift employees to gain access to training materials, and is likely to become more common in the future as companies seek to train staff flexibly, take advantage of technology, and encourage employees to be proactive in their learning rather than driven by the employer. A major disadvantage of self-directed learning is that trainees must be willing and comfortable learning on their own. That is, trainees must be motivated to learn. From the company perspective, self-directed learning results in higher development costs, and development time is longer than with other types of training programs.

Several steps are necessary to develop effective self-directed learning:

1. Conduct a job analysis to identify the tasks that must be covered.
2. Write trainee-centered learning objectives directly related to the tasks. Because the objectives take the place of the instructor, they must indicate what information is important, what actions the trainee should take, and what the trainee should master.
3. Develop the content for the learning package. This involves developing scripts (for video) or text screens (for computer-based training). The content should be based on the trainee-centered learning objectives. Another consideration in developing the content is the media (e.g., paper, video, computer, website) that will be used to communicate the content.
4. Break the content into smaller pieces ("chunks"). The chunks should always begin with the objectives that will be covered and include a method for trainees to evaluate their learning. Practice exercises should also appear in each chunk.
5. Develop an evaluation package. This should include evaluation of the trainee and evaluation of the self-directed learning package. Trainee evaluation should be based on the objectives (a process known as "criterion referencing"). That is, questions should be developed that are written directly from the objectives and can be answered directly from the materials. Evaluation of the self-directed learning package should involve determining ease of use, how up to date the material is, if the package is being used as intended, and whether trainees are mastering the objectives.

Domain 9: Law and Ethics



Modified from CSP 10 Examination Blueprint, Board of Certified Safety Professionals.



Key CSP Blueprint Themes

Blueprint reference

Domain 9: Law and Ethics

- Legal issues, interpretations, regulations
  - Tort, negligence, civil, criminal, contracts, disability terminology, expert witness testimony
  - Regulatory and voluntary consensus standards' development
- The ethics related to data collection and use
  - Justification, defensibility, discovery
  - Protecting confidential information, privacy, trade secrets
- Labor and management relations
- Applied BCSP Code of Ethics
  - Situational analysis

Key CSP Blueprint Themes: Domain 9

Domain 9 Quiz 1 Questions

1. An employee was injured on the job and had lost workdays associated with the injury. Upon returning to work, the employee was physically unable to perform the previous job. Another job was provided but for less pay. Which legal doctrine would keep said employee from suing his/her employer?

A. Exclusive remedy
B. Gross negligence
C. Tort
D. Special damage

2. A company representative visits a vendor to price some specific monitoring equipment. However, at the time of the visit, no purchase agreement is made. Later, the vendor mails a proposed contract for the equipment and states that the offer is valid until July 1 and acceptance will be contingent upon a signed contract signed returned by U.S. mail. On June 15, a copy of the signed contract is faxed to the company. Is there a valid contract?

A. No, an offer was not made and accepted.
B. Yes, a fax can be used in lieu of the U.S. Postal Service.
C. Yes, an offer was made and accepted before July 1.
D. No, the acceptance was not as stated in the offer.

3. The term used that indicates the product manufacturer is liable for injury due to a defect, without proof of negligence or even fault is:

A. negligence.
B. strict liability.
C. privity.
D. res ipsa loquitur.

OCR Version

4. Insurance contracts are unilateral, meaning that only the insurer makes legally enforceable promises in the contract. The insured is not required to pay premiums, but the insurer is required to pay benefits under contract if the insured has paid the premiums and met certain other basic provisions. Which terms represent the general parts of an insurance contract?

A. Declarations, definitions, insuring agreement, exclusions, conditions, endorsements
B. Incontestability, definitions, conditions, declarations
C. Investigation, exclusions, conditions, privity
D. Endorsements, definitions, executor, declaration

5. An implied warranty is an inference by a wholesaler or manufacturer that merchandise is suitable for a specific function or purpose. The statement of warranty can be made in many ways and could include all the following *except:*

A. selling the merchandise for that function.
B. marketing that the merchandise will satisfy that function.
C. referencing the owner's manual statements that it will accomplish that purpose.
D. making the merchandise appear to accomplish the purpose.

6. Which of the following identifies the four mandatory elements for any legal contract?

A. Consent, legal tender, parties, consideration
B. Management, labor, money, contract
C. Agreement, consideration, purpose, legal tender
D. Agreement, consideration, purpose, competent parties

7. Three fundamental legal principles that can be used by plaintiffs in product liability cases include:

A. carelessness, strict legal responsibility, res ipsa loquitur.
B. strict liability, express guarantee, implied warranty.
C. negligence, strict liability, breach of warranty.
D. negligence, strict legal responsibility, tort.

8. Which of the following characteristics of a product recall is the *most important*?

A. Quick response
B. Written detailed plan
C. Action sheets for each department
D. Detailed procedures for notifying authorities and advertising which products are defective

9. Safety professionals may need to have insurance protection, depending on business status. Out of numerous types of coverage, one specific to safety consultants is professional liability that covers all the following *except:*

A. errors and omissions.
B. fire damage.
C. libel and slander.
D. negligence.

10. An agreement or contract in which one party agrees to hold the other free from the responsibility for any liability or damage that might arise out of the transaction involved is called a:

A. strict liability.
B. hold harmless agreement.
C. negligence.
D. exclusive remedy.

11. A food processing plant has a storm water containment pond that is not fenced. If a child drowns in the pond, what is the legal doctrine a plaintiff could use in a lawsuit?

A. Attractive nuisance
B. Res ipsa loquitur
C. Obvious peril
D. Foreseeability

12. A Certified Safety Professional (CSP) must accept responsibility for their continued professional development by acquiring and maintaining competence through continuing education, experience, professional training, and:

A. monitoring safety websites.
B. maintaining a presence on social networks.
C. keeping current on relevant legal issues.
D. keeping a regular Internet blog.

13. A CSP works with a large safety and occupational health staff. The CSP has been asked to perform hygiene sampling, even though the CSP has had no formal training or education on sampling. According to the BCSP Code of Ethics, what should the CSP do *first* in this situation?

A. The CSP does not have an ethics concern under BCSP professional conduct guidelines and should continue the sampling.
B. The CSP may continue the sampling but should advise the BCSP that a possible ethics violation occurred.
C. The CSP should perform the sampling but should contact BCSP after completion to verify if an ethics violation occurred.
D. The CSP should not perform the sampling because doing so may violate the BCSP Code of Ethics.

14. An employee was injured on the job and was sent to an occupational physician who ordered "no work for three days, then return to work without restrictions." The employee's disability is called:

A. temporary total disability.
B. temporary partial disability.
C. permanent partial disability.
D. permanent total disability.

15. Employee unions can impact safety:

A. negatively, when there is insistence for engineering control as a substitute for disciplinary action.
B. negatively, when union leaders have a role in safety training.
C. positively, when employees bargain for safety incentive programs based upon reducing accident rates.
D. positively, when workers have more direct involvement in reducing workplace hazards.

16. As a CSP, you are working as a consultant for a company and identify a condition that poses serious risk to the employees. You notify the client of serious safety concerns, and he tells you that he does not have the money to fix the condition. The *most ethical* response to this situation is to:

A. report the situation to OSHA.
B. keep good documentation of this situation.
C. discuss the situation with the client to find a solution.
D. You have informed the client, and your responsibility has ended.

17. You are conducting a safety inspection of a manufacturing plant in southwest Missouri. The site visit is designed to fulfill two purposes: (1) mentor a university safety degree intern and (2) determine regulatory compliance of the facility. During the inspection, you observe an employee, without eye protection, working at a bench installing parts. This is not a hazardous operation, but it is a posted "eye protection" area. Which is the *best* course of action?

A. Contact the supervisor and discuss the situation.
B. Test the safety intern's skills by letting her handle the situation.
C. Confront the employee and determine why eye protection is not being used.
D. Note the discrepancy, and do not discuss it until the out brief when the CEO and the supervisor are both present.

18. The plaintiff's attorney contacts a CSP with specific subject matter expert witness for a highly publicized court case. The attorney offers to compensate the CSP with 5% of the settlement if the plaintiff's case is successful. The *most ethical* action is to:

A. accept the offer with an additional upfront retainer fee.
B. reject the offer and report the attorney to the BCSP.
C. counter the offer with an hourly fee schedule.
D. counter the offer, requesting 10% of the settlement.

19. You are working for the general contractor and assisting subcontractors with job safety analysis on a multiemployer job site. The electricians identified a new pipefitter task that would assist the plumbers with installing water lines. The pipefitters stated that the union agreement precluded them from assisting the plumbers. What is the *best* course of action to resolve the issue of task responsibility?

A. Assign the responsibility to all trades.
B. Negotiate the tasks with the union representatives.
C. Assign the task responsibility to only the pipefitters.
D. Notify the general site management staff to resolve the issue and communicate the policy to the appropriate parties.

20. You are representing a general contractor at the site and called to assist with an underground pipe installation. The trench is 15-foot deep in class C soil. The final connections have been made, and all workers and protection systems have been removed. The project manager states that if the project is completed by today's deadline the company will receive an on-time bonus. A subcontractor notifies you that he has left an expensive laser pipe level in the trench and needs the tool to continue a task. Which is the *best* advice to the decision-makers?

A. Inform the project manager of the risks and direct the trench-competent person to escort the subcontractor into the trench to retrieve the equipment and stand by as the entry attendant.
B. Advise the project manager of the risks for workers entering an unprotected trench and the risk of damage to the installation when attempting to retrieve the subcontractor's equipment remotely.
C. Direct the equipment operator to close the trench and inform the project manager that the subcontractor's tools are not the general contractor's responsibility.
D. Advise the subcontractor to enter the trench during the next break to retrieve the equipment and be careful not to collapse the trench or be witnessed.

21. Professional ethics refers to:

A. a set of principles and standards that guide the actions of professionals that are often referenced in civil or criminal cases involving professional conduct.
B. the laws that the professional must comply with or face possible civil and criminal charges.
C. a set of bylaws established to assure the members of an organization must follow.
D. voluntary rules expected of members of professional associations.

22. Management has increased work hours and is pushing for more productivity. As a CSP, you are concerned about some of the safety risks associated with this production schedule. You should:

A. report concern to the U.S. Department of Labor (DOL).
B. tell workers to launch a work slowdown.
C. inform/communicate increased hazards due to increased production and verify that risk is acceptable.
D. not challenge management; accept the production schedule.

23. As a salaried safety professional for a large company, you are obligated to be a faithful agent to your employer. You have recently purchased a substantial financial interest as a limited partner in a medium-sized safety consulting firm. Your employer recently acquired a new business that had hired your consulting firm to perform a safety compliance audit, and you were assigned the task. After disclosing the conflict of interest to your boss, she permits you to perform the work. Is this an acceptable resolution?

A. Yes, the conflict of interest has been addressed in accordance with your employer's code of ethics.
B. No, because this situation does not avoid circumstance where compromise of conduct or conflict of interest may arise related to safety responsibilities.
C. Yes, there is not a conflict of interest if the issue was fully disclosed to your employer.
D. No, because the situation can cause you to be honest, fair, and impartial and act with responsibility and integrity.

24. You are part of an interview team to fill a new facility safety manager position. The candidate claims to be a CSP but is *not* listed on the BCSP website as a credential holder. You should:

A. notify BCSP and give them all the pertinent information.
B. tell the person to stop using the CSP designation.
C. do nothing as the person if the person is qualified in other areas.
D. notify the corporate attorney to pursue legal action.

25. You are conducting an audit in a supervisor's area, and he is a friend of yours. You identify significant hazards in his department, and the supervisor tells you he will fix the hazards by the end of the day. Which is *best* course of action?

A. Write it in the report and note the conversation with supervisor.
B. Write it in the report and note the hazard was corrected.
C. Omit the hazard finding from the report since he said he would fix it by the end of the day.
D. Notify the supervisor's boss of the hazard and ask her to verify the hazard has been abated.

Domain 9 Quiz 1 Answers

1. Answer: **A. Exclusive Remedy:** State workers' compensation statutes gave employees a definite remedy for injuries and diseases arising out of or suffered during their employment. In exchange for a definite recovery, the workers' compensation remedy is exclusive, that is, with just a few exceptions, a worker's right of recovery against the employer is limited to the benefits provided by the workers' compensation law. The employee may not sue in tort.

   A legal doctrine that an employer who is normally immune from tort actions by employees because of workers' compensation laws, may be held liable for additional damages as a party who has committed a wrongful or negligent act beyond its role as employer.

   Example: An employee of an aerosol shaving cream manufacturer is injured by an exploding can while handling stock. The manufacturer is liable to the employee under workers' compensation laws, but it may also be held responsible for manufacturing a defective can. The employee then may choose to bring a civil suit, where the potential recovery is greater than the statutory remedy of workers' compensation.

   Special Damages: Special damages are one sustained rather than implied by law. They are either added to general damages arising from an act injurious in itself; such as when some loss arises from the uttering

of slanderous words, actionable in themselves; or are such as arise from an act not actionable in itself, but injurious only in its consequences; such as when the words become actionable only by reason of special damage ensuing. To constitute special damage, the legal and natural consequence must arise from the tort—not from a mere wrongful act of a third person or a remote consequence.

The exercise of reasonable care in the handling and preservation of a product in their possession so that it will not later cause injury to a user is the definition of "responsibility for handling." a person may be held liable for actions that result in injury or damage only when he was able to foresee dangers and risks that could be reasonably anticipated is the definition of "foreseeability."

A wrongful act, or failure to exercise due care, for which civil legal action can result is the definition of tort. The concept that a producer of a product is liable for injuries due to defects, without the necessity for plaintiff to show negligence or fault is known as "strict liability."

2. Answer: **D**. To be a valid contract, all requirements outlined in the offer must be completed.

3. Answer: **B**. Strict liability is the concept whereby the plaintiff need not show negligence or fault to prove liability.

Negligence is the failure to exercise a reasonable amount of care or to carry out a legal duty so that injury or property damage occurs to another. An example would be if you were a landlord and did not provide adequate security and the renter was robbed. In product safety work, *Privity* is defined as "a direct relationship between the injured party and the party whose negligence caused an accident." Early English law held that there could be no negligence without *privity*. However, this rule was broken in the United States in the early 1900s when Judge Benjamin Cardozo ruled that an automobile manufacturer was liable for an injury accident involving a failed wheel. The automobile manufacturer based its defense on the *privity rule*. The company had sold the car to a dealer, had no contract with the injured party, and was therefore not liable to the plaintiff. The dealer was not liable since he had not built the car. The ruling however indicated that the car manufacturer had a duty to inspect the product sold for defects; anything less was negligence.

A manufacturer or distributor would not have to label a large blade hunting knife because the product involves an **obvious peril**, sometimes called an obvious hazard that is well known to the public.

The term **res ipsa loquitur** (the thing speaks for itself) is involved in accidents where the damage producing agent was under the sole control of the defendant and the accident would not have happened if the defendant would have exercised proper control.

Foreseeability involves the liability for actions that a normal person would have known to exist and would have taken precautions to prevent.

Tort is a wrongful act or a failure to exercise due care that results in damage or injury in the broadest sense.

4. Answer: **A**. The parts of an insurance contract include:

- Declarations—identify who is an insured, insured's address, insuring company, what risks or property are covered, policy limits (amount of insurance), any applicable deductibles, policy period, and premium amount. These are usually provided on a form that is completed by the insurer based on the insured's application and attached on top of or inserted within the first few pages of a standard policy form.
- Definitions—define important terms used in policy language.
- Insuring agreement—describes the covered perils, or risks assumed, or nature of coverage, or makes some reference to the contractual agreement between insurer and insured. It summarizes the major promises of the insurance company, as well as stating what is covered.
- Exclusions—negates coverage from Insuring Agreement by describing property, perils, hazards, or losses arising from specific causes that are **not** covered by the policy.
- Conditions—provisions, rules of conduct, duties, and obligations required for coverage. If policy conditions are not met, the insurer can deny the claim.
- Endorsements—additional forms attached to the policy form that modify it in some way, either unconditionally or upon existence of some condition. Endorsements can make policies difficult to read

for nonlawyers; they may modify or delete clauses located several pages earlier in the standard insuring agreement, or even modify each other. Because it is very risky to allow nonlawyer underwriters to directly rewrite core policy language with word processors, insurers usually direct underwriters to modify standard forms by attaching endorsements preapproved by counsel for various common modifications.

5. Answer: **D**. Implied warranty is the implication by a dealer that the product will serve a specific purpose. The implication must be made by:
   - placing it on sale for that purpose.
   - advertising it for that purpose.
   - indicating in books or manuals that it will operate in a manner that could reasonably be interpreted as being suitable for that purpose.

6. Answer: **D**. A legal contract must have four parts:
   - Agreement
   - Consideration
   - Purpose
   - Competent parties

7. Answer: **C**. The three basic legal principles that can be used in most states are:
   - Negligence, which tests the conduct of the defendant
   - Strict liability and implied warranty, which test product quality
   - Express warranty and misrepresentation, which test product performance against the manufacturer/seller's representations. This may be referred to as breach of warranty.

8. Answer: **B**. The single most important part of a successful product recall is the establishment of a detailed written plan that outlines individual and company responsibilities and actions. This "Emergency Action Plan" must encompass all aspects of a recall and could include items such as communication of a warning if necessary; details of the hazard; instructions for continued usage or return; removal and modification of existing products from inventory; compensation for injury; investigation of the causes of error, lack of warning, or design, etc.

9. Answer: **B**. Safety Consultants Professional Liability covers errors and omissions, libel and slander, negligence, oral and written publication of information that causes damage and infringement upon copyrighted materials. Safety Consultants Commercial General Liability covers bodily injury/property damage, fire damage, and medical expenses.

10. Answer: **B**. A ***Hold Harmless (Indemnity) Agreement*** is used between two parties to establish that the indemnitee is protected from any unforeseen liabilities, losses, claims, or damages during their involvement in an activity. A Hold Harmless Agreement is developed to prevent lawsuits by assigning liability in a contract. Hold harmless means that if there is a problem and a suit later, one party shields or "holds harmless" the other. A hold harmless clause is a statement in a legal contract stating that an individual or organization is not liable for any injuries or damages caused to the individual signing the contract. An individual may be asked to sign a hold harmless agreement when undertaking an activity that involves risk for which the enabling entity does not want to be legally or financially responsible.

    Strict liability is the concept whereby the plaintiff need not show negligence or fault to prove liability.

    Negligence is the failure to exercise a reasonable amount of care or to carry out a legal duty so that injury or property damage occurs to another. An example would be you were a landlord and did not provide adequate security and the renter was robbed.

    Exclusive remedy: State workers' compensation statutes gave employees a definite remedy for injuries and diseases arising out of or suffered in the course of their employment. In exchange for a definite recovery, the workers' compensation remedy is exclusive, that is, with just a few exceptions, a worker's right of recovery against the employer is limited to the benefits provided by the workers' compensation law. The employee may not sue in tort.

11. Answer: **A**. The **attractive nuisance** doctrine applies to the law of torts in the United States. It states that a landowner may be held liable for injuries to children trespassing on the land if the injury is caused by an object on the land that is likely to attract children. **Tort** is a wrongful act or a failure to exercise due care that results in damage or injury in the broadest sense. A manufacturer or distributor would not have to label a large blade hunting knife because the product involves an **obvious peril**, sometimes called an "obvious hazard" that is well known to the public. The term **res ipsa loquitur** (the thing speaks for itself) is involved in accidents where the damage producing agent was under the sole control of the defendant and the accident would not have happened if the defendant would have exercised proper control. **Foreseeability** involves the liability for actions that a normal person would have known to exist and would have taken precautions to prevent.

12. Answer: **C**. According to the BCSP Code of Ethics, a CSP should accept responsibility for their continued professional development by acquiring and maintaining competence through continuing education, experience, professional training and keeping current on relevant legal issues.

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13. Answer: **D**. According to the BCSP Code of Ethics, a CSP should undertake assignments only when qualified by education or experience in the specific technical fields involved.

    - UNDERTAKE assignments only when qualified by education or experience in the specific technical fields involved. Accept responsibility for their continued professional development by acquiring and maintaining competence through continuing education, experience, professional training, and keeping current on relevant legal issues.

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14. Answer: **A**. Most workers' compensation laws recognize four classes of disability: (1) temporary total, (2) permanent partial, (3) permanent total, and (4) death. Some states recognize an additional class: temporary partial. Definitions for and interpretations of each class vary by compensation law.

    Temporary Total Disability Temporary total disability applies to a worker who is completely unable to work for a time because of a job-related injury. Eventually, the person recovers fully and returns to full job duties. No disability or reduction in work capacity remains after recovery. Most disability cases are temporary total cases.

    Temporary Partial Disability This classification applies to injured workers who are unable to perform their regular job duties during the recovery period but are able to work at a job requiring lesser capabilities. After recovery, the worker returns to work with full capability.

    Permanent Partial Disability This classification refers to a worker who endures some permanent reduction in work capability but is still able to retain gainful employment. Examples of permanent partial disability include the *loss* of a body member, such as a hand, eye, or finger or the *loss of use* of a body member, such as an eye, or permanent reduction in the movement or functionality of an elbow or other joint.

    Permanent Total Disability This refers to a worker injured on the job and no longer able to work, even after medical and rehabilitative treatment. In many states, certain disabilities are classified as permanent total disability. Defined impairments typically include loss of both eyes, loss of both legs, and loss of both an arm and a leg.

    Workers' compensation laws provide payments for medical expenses, burial expenses, loss of wages, and impairments. Most provide payment for physical and vocational rehabilitation. Some provide for mental rehabilitation. Injured employees receive compensation for their loss of earnings, which can occur under all the types of disability. Most laws provide a percentage of the average weekly earnings of the injured employee. Payment schedules usually have upper and lower limits. Because disability income is not usually subject to income tax, a claimant receives only a portion of regular earnings. The percentage may vary by type of disability, number and ages of dependents, and other criteria. Some states limit loss-of-wage payments to a maximum length of time (usually for temporary total disability).

15. Answer: **D**. Unions are important participants in a safety culture. They want to eliminate injuries that harm their members. To do that, unions favor changes to the workplace that make it safer. Unions have challenged the reliance of some employers upon the discipline of individual workers for safety-related behaviors. Unions assert that the disciplining of individuals for errors is far less effective than a program of preincident planning, risk assessment, and engineering controls. A fail-safe device or design makes the errors less likely to cause injuries. The desirable investment in workplace design change that the union prefers would render the machine quieter, the floor safer, and the equipment guards impregnable to removal or evasion. This emphasis shifts the issues away from discipline of errant people to the needs for engineers to devise built-in constraints on people's capacity for accepting risk or making foolish judgments.

    Unions' effectiveness in collective bargaining for safety issues varies with economic situations, and with the urgency felt by an individual local bargaining team to assert safety issues. *If the union is able to win concessions on safety issues, the enhanced union–management effort probably increases the likelihood that workers will support the culture and act with greater awareness of safety.* If work teams are used, the training of work teams for safety should include the support of union leadership such as the local president or shop steward for the safety program.

16. Answer: **C**. Professional responsibility is to advise the client of the risks of serious injuries and help the client to find a solution.

17. Answer: **A**. The first action should be to contact the supervisor who has control of the workplace and discuss the infraction. Further action may include some of the other solutions presented in the above options.

18. Answer: **C**. You must avoid the appearance of a "conflict of interest" to maintain your credibility. A flat fee shows that you have no stake in the case outcome.

19. Answer: **D**. It is important for a safety professional to realize when issues are beyond his/her control. For management/labor operational conflicts, it is best to direct the issue to management for resolution.

20. Answer: **B**. Your primary responsibility is to inform the decision-makers of the risk exposure to workers entering an unprotected trench. Then help the decision-maker explore solutions to achieve acceptable level of risk.

    Entering an unprotected 15-foot-deep excavation is clear violation of the regulations and advising the contractor to enter an unprotected trench, actively or tacitly, is unethical. After communicating the risks of entering an unprotected trench, a fair resolution may be attempting to retrieve the subcontractor's equipment remotely, such using a backhoe, providing that the risk of damage to the project is acceptable. If an option is not legally, or theoretically acceptable, then another good measure is to determine if it is balanced. The decision to tell the subcontractor, "tough—it is your own fault," is perhaps not balanced or fair. Nor is exposing workers to unacceptable risk for production gains. A skilled backhoe operator may be able to retrieve the equipment remotely without damage and complete the project on time.

21. Answer: **A**. Ethics refers to a set of principles and standards that guide the actions of professionals that are often referenced in civil or criminal cases involving professional conduct. A basic definition of ethics is: moral principles or practice. Professional ethics require consideration of additional areas including, professional values, culture, acceptable standards of behavior, and legality. Professionals will likely face ethical dilemmas during their career. Some day-to-day ethical dilemmas are simple to determine the correct course of action; others are not as clear.

22. Answer: **C**. Informing/communicating to upper management the increased hazards due to increased production and verifying that risk is acceptable and the best solution.

23. Answer: **B**. Most employer codes of ethics require you to disclose to your employer any conflicts of interest. Once you disclose the conflict of interest, your employer has the option to require you to resolve the conflict of interest by ending the relationship/situation that causes the conflict of interest or your employer can elect to allow the situation to continue. As per the BCSP and many other professional codes of conducts, certified professionals must avoid any perceptions of conflicts of interest even when their own company's codes of ethics are met.

24. Answer: **A**. If you have difficulties finding an individual or question an individual's certification status, please contact our office at bcsp@bcsp.org or at +1 317-593-4800. To report unauthorized use, use the BCSP complaint form. Individuals who have used BCSP credentials without authority are listed in the directory when you click the Unauthorized Use. The Unauthorized Use Directory is a listing of individuals who have claimed to hold BCSP credentials but do not. BCSP receives inquiries from a variety of sources including other credential holders, employers, and membership organizations. BCSP pursues all cases in which there is clear evidence of the unauthorized use and the individual has a clear responsibility, control, or knowledge of the use. Evidence may be a business card, résumé, letter, website, or other publication. BCSP may take a variety of actions as a result of verified and unauthorized use of BCSP credentials or marks.

25. Answer: **A**. The best course of action is to note the hazard in the report, along with the conversation with the supervisor with the planned corrective actions. The BCSP Code of Ethics states:

    - BE honest, fair, and impartial; act with responsibility and integrity. Adhere to high standards of ethical conduct with balanced care for the interests of the public, employers, clients, employees, colleagues, and the profession. Avoid all conduct or practice that is likely to discredit the profession or deceive the public.
    - ISSUE public statements only in an objective and truthful manner and only when founded upon knowledge of the facts and competence in the subject matter.
    - AVOID deceptive acts that falsify or misrepresent their academic or professional qualifications. Do not misrepresent or exaggerate their degree of responsibility in or for the subject matter of prior assignments. Presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, or past accomplishments with the intent and purpose of enhancing their qualifications and their work.

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Self-Assessment 1 Questions

1. In decision theory, if you are concerned with testing the significance of the departure of an observed value in *either* a positive or a negative direction from the value indicated by our hypothesis, which test would you select?

A. A two-tailed test
B. A one-tailed test
C. A one-headed test
D. A two-headed test

2. Given the following *sample* distribution 8, 6, 5, 25, 20, 34, 78, 12, 23, 45, 35. Compute the standard deviation.

A. 11.9
B. 21.48
C. 20.48
D. 26.45

3. The *primary* factor responsible for dust gaining entrance to the alveolar regions of the lung is:

A. dust type.
B. particle size.
C. concentration.
D. mucociliary system health.

4. Which of the following *best* describes the coefficient of variation?

A. The mean divided by the square of the standard deviation
B. The standard deviation divided by the mean
C. The total of the squares of all data points
D. The square root of the standard deviation

5. The effect of local or generalized grey-blue colored impregnation of the skin tissue with silver is called:

A. asphyxia.
B. argyria.
C. atrophy.
D. hypoxia.

6. One of your subordinate safety engineers has brought you a study for review. The findings indicate a coefficient of correlation of –0.4 concerning the wearing of personal protective equipment and the prevention of injuries during a part washing operation. What do you think the study shows?

A. Strong need for more protective equipment.
B. Protective equipment is being used and is effective.
C. Protective equipment is not being used.
D. Not enough information to make a decision.

7. What are the three basic legal principles that can be used by plaintiffs in product liability cases?

A. Negligence, strict liability, res ipsa ioquitar
B. Strict liability, express warranty, implied warranty
C. Negligence, strict liability, breach of warranty
D. Negligence, strict liability, tort

8. Which of the following is a *not* a factor in cost-effectiveness analysis, but is a factor in cost-benefit analysis?

A. Cost of manpower for project
B. Cost of design and engineering
C. Cost of operation if project is not completed
D. Cost of permit fee

9. Which of the following is *not* true concerning the establishment of management goals for the Occupational Safety and Health Program?

A. Management goals should be measurable.
B. Management goals should be obtainable.
C. Management goals should be reviewed frequently.
D. Management goals should be published.

10. In decision theory, if a hypothesis is rejected when in fact it is correct, what type of error is this?

A. Type I or α error
B. Type II or β error
C. Type III or χ error
D. Type IV or δ error

11. Which of the following is *not* a principle benefit of a Job Safety Analysis (JSA)?

A. Assist the supervisor in training
B. Tool to study jobs for possible improvement
C. Instruct new personnel on a specific job
D. Replace workplace procedures

12. Which of the following is the preferred angle for fixed industrial ladders?

A. 30 to 35 degrees
B. 15 degrees
C. 30 to 45 degrees
D. 75 to 90 degrees

13. A contractor fails to guard a large excavation filled with water, and a small child drowns in the excavation over the weekend. The contractor could be found negligent under which of the following legal doctrines?

A. Common sense for contractors
B. Attractive nuisance or attractive allurement
C. Foreseeability of allurement
D. Expectability of consequence

14. The type of probability that may be specified by the obvious nature of happenings is a(n) _____ probability.

A. posteriori
B. priori
C. obvious
D. camouflaged

15. What is the failure rate of a device that has four components connected in series? Each component has a failure rate of 0.005.

A. 0.625
B. 0.05×10^4
C. 0.2
D. 0.02

16. Which of the following is true concerning the use of Halon 1211? Bromochlorodifluoromethane (Halon 1211) is considered hazardous because it may release _____ during decomposition.

A. hydrogen
B. silicone
C. hydrogen fluoride
D. bromide

17. Acetylene reacts with all of the following metals *except:*

A. copper.
B. gold.
C. silver.
D. mercury.

18. According to the National Safety Council, the average number of drownings in the United States is 2.7 per 100,000 population. What is the probability that your city of 250,000 will experience more than two drownings this year?

A. 0.964
B. 0.567
C. 0.828
D. 0.8425

19. A subcontractor is erecting scaffolding without an approved erection plan. The subcontractor is the only one involved in assembling the scaffold. The scaffold is being built and put together correctly, although not in the proper sequence, but the sub does not have a plan. Under the OSHA rules for multiemployer worksites, who would MOST likely be cited for the situation described?

A. The subcontractor
B. The general contractor and the owner
C. The subcontractor and the general contractor
D. The general contractor

20. What device is *best* suited for continuous, smooth, variable control?

A. Sensor key
B. Rotary knob
C. Rocker switch
D. Toggle switch

21. What is the preferred way to purge a 30-foot diameter tank with a flat bottom and flat top?

A. Vacuum pressure
B. Positive pressure
C. Siphon tubes
D. Bayes pump

22. During your investigation of the conditions described in the preceding question, you discover that the tank containing NaOH is made of aluminum. Does this pose any problems?

A. Yes, NaOH rapidly corrodes aluminum.
B. No, aluminum is the desired container.
C. Only if exposed to air.
D. Yes, aluminum causes the lye to become inert.

23. The *Ames test* is used to provide information about what characteristic of a material?

A. Carcinogenicity
B. Mutagenicity
C. Ignitability
D. Toxicity

24. The explosimeter or combustible gas indicator operates on which of the following principles?

A. Adsorption
B. Absorption
C. Latent heat of vaporization
D. Heat of combustion

25. What is a disease associated with slaughterhouses?

A. Neuropathy
B. Photophobia
C. Q-Fever
D. Byssinosis

26. When a liquid is used in a packed tower or scrubber and dissolves or reacts chemically with the gas or vapor that is to be removed, the process is known as:

A. adsorption.
B. absorption.
C. combustion.
D. condensation.

27. What is the audible range for an average young person with unimpaired hearing?

A. Below 20 Hz
B. Above 20,000 Hz
C. Between 20–20,000 Hz
D. Between 50–30,000 Hz

28. Which of the following diseases was associated with the wool industry?

A. Byssinosis
B. Anthrax
C. Q-Fever
D. Brucellosis

29. The term "bioaccumulation" refers to:

A. small electricity.
B. subatomic particles.
C. movement of trace metals in the food chain.
D. contamination of entire ecosystems.

30. According to Raoult's Law, if a nonvolatile solute is added to a volatile solvent, the vapor pressure is _____ and the boiling point is _____.

A. increased, increased
B. lowered, increased
C. increased, lowered
D. lowered, lowered

31. Which of the following is true concerning the 95% confidence level when conducting hypothesis testing?

A. There is a 95% chance of being correct.
B. There is a 95% chance of being incorrect.
C. One will be wrong 1 time out of every 20 decisions.
D. One will be right 19 times out of every 20 decisions.

32. Which of the following is a major safety precaution when allowing perchloric acid to evaporate in a fume/vapor hood?

A. Hood should be equipped with a waterfall
B. Chemical is very shock sensitive and should be treated with respect
C. Chemical will eat up stainless steel hardware and must not be evaporated
D. Chemical causes severe irritation of the hand and eyes and SCBA is required for evaporation

33. Which of the following is *not* a principal purpose for product warning labels?

A. Inform user of a hazard or danger.
B. Inform user of the possible effects of misuse.
C. Inform user of the legal recourse available.
D. Inform user of the ways to reduce likelihood of injury.

34. The term "consideration" in a legal contract is best defined by which of the following?

A. A value, legal tender
B. Must consider both sides in arbitration
C. Money must actually be transferred
D. Consideration of all pertinent laws must be accomplished

35. Monthly mobile crane inspection is required by OSHA 1926.550 and is based on ANSI STD B30.5. Which of the following items would *not* normally be inspected on a monthly basis?

A. Wire rope
B. Reeving
C. Lay of rope
D. Magnetite switch

36. Which of the following is the *best* definition of the OSHA term "presumed asbestos-containing material"?

A. Any material containing more than 1% asbestos
B. Any material containing at least 1% asbestos
C. Thermal system insulation and surfacing material found in buildings constructed no later than 1990
D. Thermal system insulation and surfacing material found in buildings constructed no later than 1980

37. At a symposium on measuring safety performance, speakers discussed scorecards, traffic lights, dashboards, and other reporting systems. All of these systems contain data advising management on whether performance goals with respect to safety management processes are being met. The approach to measuring leading and lagging indicators is commonly referred to as:

A. the Brunelli process.
B. the Pareto principle.
C. the Juran principle.
D. the balanced scorecard.

38. The Department of Transportation regulations found at 49 CFR part 392.5 prohibit commercial drivers from driving under the influence of alcohol or drugs. Under the provisions of these regulations, drivers must not drink alcohol on duty or be under the influence of alcohol within _____ hours before reporting for duty.

A. 24
B. 4
C. 8
D. 12

39. According to the OSHA asbestos standards, which of the following *best* describes "Class I asbestos work"?

A. Activities involving the removal of TSI, surfacing ACM, and PACM
B. Activities involving the removal of ACM, which is not thermal system insulation or surfacing material, including the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics
C. Repair and maintenance operations, where "ACM," including TSI and surfacing ACM and PACM, is likely to be disturbed
D. Maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean up dust, waste, and debris resulting from asbestos work

40. What are the DOT requirements for drug testing of a company's over the road transport drivers?

A. 10% annually
B. 25% annually
C. 50% annually
D. 100% annually

41. If one drop of solution contains 200 billion silver atoms, how many drops of solution are needed to make a pound of silver? *Note: The molecular weight of silver is 108.

A. 1.27×10^{13}
B. 2.27×10^{23}
C. 6.024×10^{23}
D. 1.27×10^{11}

42. Which of the following *best* describes the term "universal precautions"?

A. Precautions against spilling blood
B. Treat all blood as if it were infectious
C. Defines rules for clean up
D. Defines all body fluids and substances as infectious

43. How many moles of sulfuric acid are required to dissolve 100 moles of aluminum, given the balanced reaction shown below?

$$2Al + 3H_2SO_4 = Al_2(SO_4)_3 + 3H_2$$

A. 300
B. 60
C. 100
D. 150

44. Which of the following is true concerning Failure Modes and Effects Analysis (FMEA)?

A. FMEA is similar to FTA.
B. FMEA is an after-production technique.
C. FMEA never develops cause factors.
D. FMEA looks like an accounting form.

45. All of the following methods provide proper corrosion protection for underground tanks and piping *except:*

A. protective coating/wrapping.
B. cathodic protection.
C. corrosion-resistant materials.
D. deep monitoring wells located within two tank diameters.

46. Concerning flammable inside storage locations, all of the following must be provided *except:*

A. a clear isle at least 22 inches wide.
B. a raised 4-inch sill.
C. self-closing fire doors.
D. either gravity or mechanical exhaust systems.

47. The pressure in a gas cylinder is 5 psig at 32°F. The cylinder is allowed to heat to 140°F in a commercial transportation van exposed to the sun. What is the new pressure in the gas cylinder?

A. 20 psia
B. 5 psia
C. 24 psia
D. 6 psia

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

48. An elevated water tank (150 feet) would produce how much water pressure at ground level?

A. 40 psi
B. 55 psi
C. 65 psi
D. 75 psi

49. Which of the following is true concerning placement of underground flammable liquid storage tanks with respect to a property line that may be built on? The distance from the tank to the property line must be at least:

A. 1 foot for Class I liquids.
B. 5 feet for Class II liquids.
C. 5 feet for Class III liquids.
D. 3 feet for Class I liquids.

50. During a flow test on a fire supply water system, the flow at 2500 gpm has dropped the flow from 69 psi to 44 psi. What flow is available at 20 psi residual?

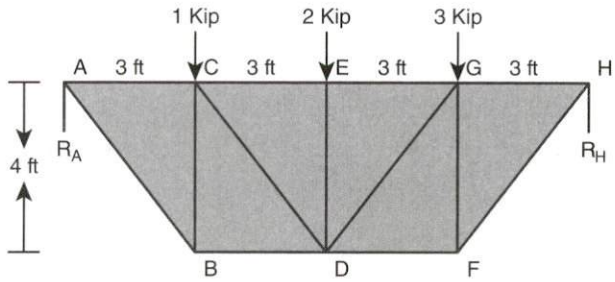
A. 1800 gpm
B. 2400 gpm
C. 3600 gpm
D. 4800 gpm

$$\frac{Q_2}{Q_1} = \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

51. What is the distance a control switch should be located from the point of operation on a delayed action machine given the following parameters: Machine action time = 0.85 sec. Operator action time = 0.25 ft/sec. Safety factor of 7.

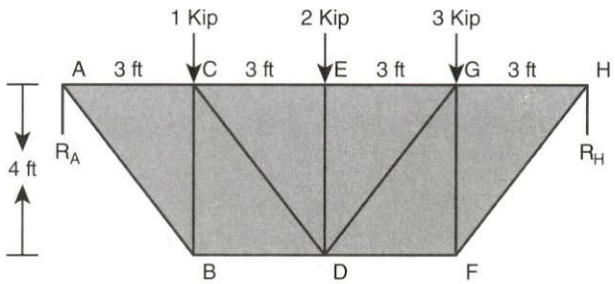
A. 1.5 feet
B. 1.25 feet
C. 1.0 foot
D. 2.2 feet

52. Which of the following truss members (as described in the previous question) could be replaced with a cable and a turnbuckle tensioning device?



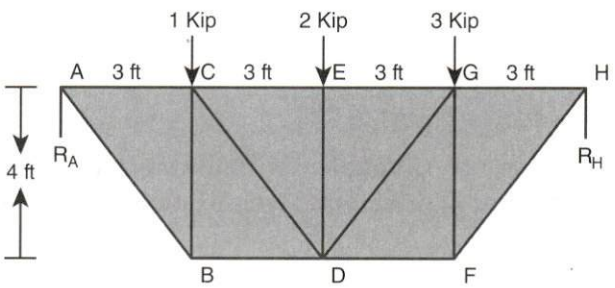
A. Members AC, CE, EG, GH
B. Members AB, CD, DG, FH
C. Members CD, DE, DG, DF
D. Members AB, CE, EG, FH

53. Which of the following truss members have compression forces applied?



A. AB, BD, DF, EG
B. AC, BC, AB, FH
C. GH, EG, CE, AC
D. AB, DC, DG, FH

54. Without regard to compression or tension, which of the following truss members have the same stress applied?



A. AB, DG
B. CE, GH
C. FH, BC
D. AC, GH

55. A large walk-in freezer has been leaking 60 cubic feet a day of gaseous Freon 12. What is the dilution volume required to reach the TLV of 120 ppm?

A. 3500 cfm
B. 350 cfm
C. 690 cfm
D. 1800 cfm

$$Q' = \frac{G}{C} \text{ and } C = \frac{LEL}{100}$$

$$Q = \frac{G}{LEL} \times 100$$

56. A fuel storage area on your site contains two tanks. Tank number one is 40 meters in diameter and 13 meters high. Tank number two is 12 meters in diameter and 4.5 meters high. The tanks are separated by 16 meters. Diking has been proposed for these tanks, and you are required by law to contain 110% of the full capacity of the larger tank. Additionally, each tank must be set back a minimum of 7.5 meters from the closest dike wall. Which of the following diking arrangements is the *best* choice for protection of the environment, while meeting all of the regulatory requirements? Assume no slope on the dike walls.

A. 1.25 meter dike walls—67 × 34 meters
B. 2.7 meter dike walls—82 × 73 meters
C. 1.5 meter dike walls—120 × 87 meters
D. 1.8 meter dike walls—120 × 85 meters

57. What is the total capacity of the larger tank?

A. 3,000,200 drums
B. 4,002,320 gallons
C. 2,056,000 gallons
D. 3,067,000 gallons

58. What is the total capacity of the smaller tank?

A. 113 cubic meters
B. 509 cubic meters
C. 2130 cubic meters
D. 5026 cubic feet

59. Without any safety factor and using the table provided below, determine the *smallest* allowable plank size for an 8-foot span with a center load of 775 lbs.

Properties of Structural Lumber—1100 Pounds Fiber Stress

Nominal Size	Dressed Size	Area of Section	Section Modulus
10 × 3	9¼ × 2½	23.125	9.635
10 × 4	9¼ × 3½	32.375	18.885
12 × 3	11¼ × 2½	28.125	11.719
12 × 4	11¼ × 3½	39.375	22.969

If less than 1500 psi, cannot be rated "scaffold grade"

A. 10 × 3 nominal
B. 10 × 4 nominal
C. 12 × 3 nominal
D. 12 × 4 nominal

60. A process is using 4 pints of solvent per hour; each pint creates about 15 ft^3 of vapor that is being liberated into a 10,000 ft^3 room. Assuming a safety factor of 5, a LEL of 1.2%, and a UEL of 7.1%, what amount of ventilation is required to reduce the concentration to nonflammable?

A. 420 cfm
B. 8.40 cfm
C. 210 cfm
D. 3345 cfm

$$Q' = \frac{G}{C} \text{ and } C = \frac{LEL}{100}$$

$$Q = \frac{G}{LEL} \times 100$$

61. A company is considering purchasing a new piece of equipment to replace an older model that is now in use. The safety-related losses with the current equipment is $25,000 per year, and the cost associated with the purchase of the new equipment is $100,000. The maintenance on the new equipment will cost about $500 more than the old equipment. Consider cost of capital is 5% and a 10-year service life with no salvage value. What is the *best* estimate of the annual benefit of purchasing the new equipment?

A. $10,550
B. $11,550
C. $12,950
D. $24,500

$$A = P \frac{i(1+i)^n}{(1+i)^n - 1}$$

62. Using the previous question, what is the maximum amount that is justified for the initial purchase and installation, assuming all other factors remain the same?

A. $90,550
B. $100,000
C. $189,200
D. $240,500

$$P = A \frac{(1+i)^n - 1}{i(1+i)^n}$$

63. Film badge detectors are used to detect the presence of all of the following forms of ionizing radiation *except:*

A. gamma.
B. beta.
C. x-ray.
D. alpha.

64. Which of the following would be the preferred agent for decontamination of a spill of HIV-infected blood?

A. Halogenated hydrocarbon-based solvent
B. Commercial germicide
C. Soap and water
D. Hydrochloric acid and water

65. Which of the following conditions would *least likely* be caused by whole body vibration of 4 to 14 cycles per second to a seated worker?

A. Increased breathing, heart rate. and oxygen consumption
B. Loss of balance, staggering gait
C. Raynaud's phenomenon
D. Loss of visual acuity

66. An energy control program is required to ensure that before any worker performs servicing/maintenance on a machine or equipment, where the unexpected startup or release of stored energy could occur and cause injury, the machine or equipment shall be isolated from the energy source. When is it permissible to only use a tagout system of protection?

A. If locks cost more than tags
B. On overlapping shift work
C. When other protective measures are in place
D. When the point of operation is higher than 7 feet above floor level

67. The requirements of NFPA 850, "Fire Protection for Electric Power Generating Plants," 1992, are used on many large, crowded construction operations as a guidance document to provide a highly protected risk in the area of fire protection. According to NFPA 850, many of the activities on these fossil-fueled electric generation plant construction sites are similar to the construction of other large industrial plants. However, an above-average level of fire protection is justified due to life safety consideration of the large number of on-site personnel, high value of materials, and length of the construction period. According to NFPA 850, fire protection water supply mains and hydrants:

A. must be in place before any construction can begin.
B. must be in place before any major construction begins.
C. are not required until project completion, but are a good idea.
D. are not required as long as an adequate supply of construction water is in place.

68. Which of the following would you *most* suspect of being exposed to cholinesterase inhibitors?

A. Pesticide applicator
B. Painter
C. Hot tar roofer
D. Parts cleaner using acetone

69. A task requiring 300 kcal/hour would be considered _____ work.

A. light
B. medium
C. heavy
D. extremely heavy

70. What is the RWL given for the following conditions: Weight to be lifted = 10 kg, Distance between body and hand grip on the object to be lifted = 60 cm, Vertical position at the beginning of the lift = 30 cm, Vertical position at end of lift = 90 cm, Frequency of lift = once every 5 minutes for one hour. *Note: Hand coupling is fair, and this job requires a twist from the "eyes front" position of 25°.

A. 4.9 kg
B. 3.6 kg
C. 6.5 kg
D. 10.9 kg

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

71. Your plant has a room devoted to the charging of lead-acid batteries involved in warehousing operations. Which of the following items is required for this location?

A. One-hour fire wall
B. Ventilated door
C. Brass nonsparking tools
D. Self-contained breathing equipment

72. During an inspection of an underground operation, you observe the tunnel atmosphere is contaminated with 2% crystalline quartz dust. What is the permissible exposure level for this exposure? The PEL for respirable dust is:

A. 10 mg/m^3.
B. 2.5 mg/m^3.
C. 1.66 mg/m^3.
D. 1.33 mg/m^3.

$$PEL = \frac{10\ mg/m^3}{\%SiO_2 + 2}$$

73. A radioisotope has a half-life of 1 year. How many years will it take to reduce the initial activity to less than 5%?

A. 2 years
B. 3 years
C. 4 years
D. 5 years

74. During an inspection, you sample continuously for an hour period and measure the following concentrations: Toluene at 12.5 ppm – TLV = 50 ppm, Acetone at 200 ppm – TLV = 500 ppm, MEK at 100 ppm – TLV = 200 ppm. What is a worker's exposure for this mixture?

A. 100%
B. 109%
C. 115%
D. 58%

$$TLV_m = \frac{C_1}{TLV_1} + \frac{C_2}{TLV_2} + \ldots + \frac{C_n}{TLV_n}$$

75. A volume of gas is 150 ml at 120°F. What is the volume at 460 degrees Rankine?

A. 116.83 ml
B. 1168.39 ml
C. 118.97 ml
D. 188.51 ml

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

76. Using the following formula, evaluate the effectiveness of the hearing protection provided to an employee who is using an ear plug assigned an NRR of 29 combined with muffs (NRR = 25) when exposed to an 8-hour TWA of 110 dBA. *Note: When two noise reduction devices are used, calculate the attenuation based on the most effective and add 5 for the second.

A. Protected TWA = 99
B. Protected TWA = 94
C. Protected TWA = 110
D. Protected TWA = 84

$$A_f = \frac{NRR - 7}{2}$$

77. Which of the following agents could be used to clean up a spill of mercury from a thermometer that has collected in the cracks of a wooden floor?

A. Ammonia
B. Nitric acid
C. Phenylmercury urea
D. Calcium polysulfide

78. What level of oxygen is required if personnel are to enter a confined space without a breathing apparatus?

A. 19.0%
B. 17.5%
C. 19.5%
D. 16%

79. Your company has a cutting area with five identical machines. The noise is monitored at 97 dB. If four machines were removed from the area, what would you expect for the new noise measurement?

A. 90 dB
B. 92 dB
C. 97 dB
D. 104 dB

$$L_w = 10 \times \log_{10}\left[\frac{W}{W_0}\right]$$

80. You are the safety director overseeing a large construction site where an excavation is made in Type A soil using a simple slope for protection. The excavation will be open less than 24 hours and is 10 feet in depth. Which of the following *best* describes the requirements of OSHA concerning the horizontal to vertical ratio of the slope?

A. Maximum allowable slope is ½:1.
B. Maximum allowable slope is ¾:1.
C. Maximum allowable slope is 1½:1.
D. Maximum allowable slope is 3:1.

81. To assess your company's loss control performance, several key performance indicators (KPI) are captured and analyzed. One of these is "Percent of operational personnel that have completed all phases of chemical safety training." This performance indicator is an example of a(n):

A. leading indicator.
B. lagging indicator.
C. optional indicator.
D. occupational indicator.

82. A trench is being cut by a subcontractor at one of your plants. The excavation will be made in cohesive soil with less than 0.5 tsf unconfined compressive strength and will use a simple slope for protection of workers. The excavation will be open for greater than 36 hours and is 14 feet in depth. Which of the following *best* describes the requirements of OSHA concerning the horizontal to vertical ratio of the slope?

A. Maximum allowable slope is 63°.
B. Maximum allowable slope is 53°.
C. Maximum allowable slope is 34°.
D. Maximum allowable slope is 18°.

83. What instrument would one use to understand the noise exposure experienced by all employees in a particular workplace with highly variable noise levels?

A. Personal noise dosimeter
B. Pressure level meter
C. Sound level meter
D. Integrating meter

84. If a worker's noise exposure is 89% after 4 hours and 50 minutes of noise exposure and assuming conditions remain constant, what would the exposure be after 8 hours?

A. 147 dB
B. 92.8 dB
C. 89.75 dB
D. 96.56 dB

85. When inspecting a natural or synthetic fiber rope sling, remove it from service if you find any of the following *except:*

A. abnormal wear.
B. paint on the sling.
C. broken or cut fibers.
D. discoloration or rotting.

86. The employer shall retain audiometric test records for:

A. 2 years.
B. 10 years.
C. the duration of the affected employee's employment.
D. the duration of the affected employee's employment plus 30 years.

87. A safety professional in an industrial facility has determined some improvements are required that will cost $100,000. He/she decides to put this in a five-year strategic plan knowing the project cost will be $150,000 in five years. How much money would need to be invested on a quarterly basis into an account that receives 10% annual interest compounded quarterly to cover the project cost?

A. $5872
B. $5761
C. $5963
D. $6020

$$F = A\left(\frac{(1+i)^n - 1}{i}\right) \qquad A = F\left(\frac{i}{(1+i)^n - 1}\right)$$

88. What principle is engaged to identify the "vital few," whether customers, customer needs, product features, or inputs assure assets and focus is concentrated where they will accomplish the *most* good?

A. Hystograph principle
B. Juran principle
C. Pareto principle
D. Smith principle

89. Occupational Exposure Limits (OELs) are published by several organizations and specify the maximum concentration of airborne contaminants to which it is believed most workers can safely be exposed to for 8 hours per day over a working lifetime without adverse health effects. The OELs published by the American Conference of Governmental Industrial Hygienists are called:

A. Permissible Exposure Limits (PELs).
B. Threshold Limit Values (TLVs).
C. Average Permitted Exposure Limits (APELs).
D. Biological Exposure Indices (BEIs).

90. A full-face piece supplied air respirator in positive pressure mode has a protection factor of:

A. 1000 APF.
B. 100 APF.
C. 10 APF.
D. 10,000 APF.

91. Using the chart below, determine the maximum use concentration (MUC) for a half-mask respirator with dust/mist filters for aluminum metal dust. The TLV for aluminum metal dust is 10 mg/m^3.

TYPE OF RESPIRATOR	Respirator Assigned Protection Factors		
	Qualitative	Quantitative	IDLH
Particulate-filter, vapor or gas, quarter or half mask. Includes combination filters.	10	Per individual max of 100	NO
Particulate-filter, vapor or gas, full face piece. Includes combination filters.	100	Per individual max of 100	NO
Powered particulate-filter, vapor or gas, full face piece, any respiratory inlet covering.	No test required due to positive pressure. Max protection is 3000 with high-efficiency filter.		NO

A. 10 mg/m^3
B. 1 mg/m^3
C. 100 mg/m^3
D. 10,000 mg/m^3

92. A canopy hood would not be considered an acceptable ventilation system for a large solvent dip tank because:

A. the hood would be unacceptably large.
B. larger fans are needed.
C. the contaminant is drawn through the breathing zone.
D. a hood would get in the way of the lifting device.

93. The determination of how much speech level interference is going to occur as a result of a new process could *best* be determined by:

A. sound level meters.
B. an impact noise analysis.
C. octave band analyzers.
D. the use of noise dosimeters.

94. An engineer frequently moves between an office and various areas of the production facility. If variations in noise levels are occurring at a rate more often than once per second, the noise is considered _____.

A. impulse
B. impact
C. continuous
D. ambient

95. Air samples taken over a 100-day period showed a mean concentration of 0.7 ppm. The range was 0.0 ppm to 1.4 ppm. The lower limit of the sampling device for the contaminant is 0.5 ppm. What assumption or conclusion can be inferred from this data?

A. There is a ±1 standard deviation chance that the contaminant is 0.7 in the work area.
B. There is a ±2 standard deviation chance that the contaminant is at or above 1.4 in the work area.
C. There is a presence of the contaminant at or below 1.4 ppm in the work area.
D. You do not have enough information to make a valid conclusion.

96. The basic components of a safety plan include:

A. handbooks, procedures, and guidelines.
B. list of actions, implementation schedule, and cost.
C. requirements, values, and conditions.
D. departmental listing, roles and responsibilities, and remedial actions.

97. The basic principle of the modern method of estimating uninsured costs of work injuries and "accidents" includes which of the following?

A. Lost time cases, doctor's cases, first-aid cases, no-injury accidents
B. Lost time cases, doctor's cases, first-aid cases, injury accidents
C. Lost time cases, doctor's cases, first-aid cases, property damage
D. Lost time cases, property damage, first-aid cases, no-injury accidents

98. A manager who utilizes an external reward and punishment system to affect performance is a_____ manager.

A. Theory X
B. Theory Y
C. MBO
D. TQM

Self-Assessment 1 Answers

1. Answer: **A**. In decision theory, we are usually concerned with testing the significance of the departure of an observed value from the value indicated by our hypothesis. This involves finding the area under the normal curve, which represents a departure either above or below the assumed figure. In other words, we are concerned with measuring the *tails* of the normal curve. If we are interested in deviation in both directions, we would use the *two-tailed* test, and if interested in deviation in one direction only, we would choose the *one-tailed* test.
2. Answer: **B**. The standard deviation indicates the variability of the data about the mean. The easiest way to compute standard deviations is to use a calculator to do it automatically. The formula for computing standard deviation can also be found in the formulas available on the computer during the CSP examination. Answer C would be the correct standard deviation if this was a total distribution—that is, all the data points were known. Answer D is the mean.
3. Answer: **B**. Particle size is the most important factor in determining reparability. It is the ability of the smaller particles to enter the respiratory tract that allows them to gain access to the lower portions of the respiratory system. The composition and concentration are important once the deposition of the particle has occurred; that may cause harm. The condition of the mucociliary system affects the ability to clear particles from the lung, once deposited.
4. Answer: **B**. The coefficient of variation is a measure of the variation around the mean and is computed by dividing the standard deviation by the mean.
5. Answer: **B**. Argyria is the effect of local or generalized grey-blue colored impregnation of the skin tissue with silver.
6. Answer: **D**. There is not enough information from which to base a decision. The coefficient of correlation of −0.4 is not conclusive, and it is not clear what protective equipment is required or if it is adequate. Concerning correlation, a result near 1 indicates that the values have a strong linear relationship. A result near 0 indicates the values are only slightly related. A value near −1 indicates that the values are very closely related, but in a negative way (increase in one is related to a decrease in the other). In safety work, a correlation of less than + or −0.6 is generally discounted.
7. Answer: **C.** The three basic legal principles that can be used in most states are:
   - Negligence, which tests the conduct of the defendant
   - Strict liability and implied warranty, which test the quality of the product
   - Express warranty and misrepresentation, which test the performance of the product against the manufacturer/seller's representations

   Of prime importance in product liability defense are data showing correlation of defects to test standards.
8. Answer: **C**. Often cost-effectiveness analysis and cost-benefit analysis are thought to be synonymous, but they have some very real differences. Cost-benefit analysis, as the name implies, compares the cost to "fix" a project with the benefit or cost of not fixing the problem. In safety and health, the problem is often a violation of codes or standards or a violation of accepted industry practice. Cost-benefit analysis often deals with "soft" numbers or intangible, abstract factors. Cost-effectiveness analysis deals almost entirely with solid, objective data. The process of cost-effectiveness analysis is the straightforward evaluation of the cost of several methods of accomplishing a given project. It has nothing to do with the cost of noncompliance or the benefit of corrective action.
9. Answer: **D**. This is a hard question because the selections all provide reasonable characteristics of Safety Program Management goals. However, the least desirable is selection "D." Safety program management goals should probably be written, but they do not have to be published. Other descriptions include specific, realistic, and time bounded.
10. Answer: **A**. The testing of hypotheses involves the formulation of a hypothesis, performing an experiment, and then applying the outcome of the experiment in a subjective manner to either accept or reject the hypothesis. During this process, one of two errors could be made:
    - If a hypothesis is *rejected* when it is in fact correct, this is a Type I or α error.
    - If a hypothesis is *accepted* when it should have been rejected, this is a Type II or β error.

11. Answer: **D**. The principle benefits of a Job Safety Analysis (JSA) are:

    - allowing the supervisor to perform training during safe, efficient operations;
    - allowing the supervisor or other person developing the JSA to meet and work with employees;
    - instruction of new employees on specific jobs;
    - instruction of current employees on the specifics of jobs performed irregularly;
    - as an accident investigation tool should a mishap occur; and
    - studying jobs to determine if improvement is possible.

    When selecting jobs to analyze, one of the primary jobs to select would be the jobs with the highest accident rates. Job satisfaction surveys determine the employees' feelings about other departments, what parts of their jobs their feelings are focused on, and areas of interpersonal difficulties.

12. Answer: **D**. The preferred angle for fixed ladders is 75–90°. The preferred angle for fixed industrial stairs is 30–35°, and 15° is the preferred angle for ramps or inclines.

13. Answer: **B**. The *attractive nuisance* or *attractive allurement* doctrine pertains to the "reasonable care" that a possessor of land owes to children. In general, the doctrine requires that one provide an extra measure of protection for children, even trespassing children. The concept embraces the notion of a tangible and visible "thing" that is both attractive (alluring) to the public and also potentially harmful. The doctrine of attractive nuisance has often been applied where small children have drowned in pits, ponds, swimming pools, etc. It also applies to unguarded or unsecured equipment or machinery.

14. Answer: **B**. *Priori* probabilities are those that can be specified by the obvious and evident nature of the events from which they emerge. For example, the chance of getting a seven from a single roll of the dice. *Posteriori* probability is developed by conducting an experiment and observing the outcome; for example, the failure of an electronic component over time.

15. Answer: **D**. For components in series, the total failure rate is the sum of the individual components' failure rate.

$$0.005 + 0.005 + 0.005 + 0.005 = 0.02$$

16. Answer: **C**. There have been extensive studies of the toxic effects of the halogenated fire suppression agents and the effects of direct exposure. However, this question deals with the decomposition products of Halon 1211, which include hydrogen fluoride (HF) and hydrogen bromide (HBr), free bromide (BR_2), hydrogen chloride (HCl), and free chlorine (Cl_2). Of these only HF was listed as a possible answer. Replacement agents for a Halon system should have the characteristics of a clean system—that is, they vaporize readily and leave no residue.

17. Answer: **B**. Acetylene is a nonpoisonous and mildly anesthetic gas. It is very flammable and forms explosive mixtures with air or oxygen. Under certain conditions, it will react with *copper, silver, or mercury* to produce acetylides, which, when subjected to impact, friction, or temperature will decompose violently.

18. Answer: **A**.

    2.7 drownings per 100,000 = 6.75 drownings per 250,000 population, and the value of "t" is 1; therefore:

$$P_0 = \frac{e^{-6.75}\ 6.75^0}{0} = 0.00117$$

$$P_1 = \frac{e^{-6.75}\ 6.75^1}{1} = 0.0079$$

$$P_2 = \frac{e^{-6.75}\ 6.75^2}{2} = 0.02667$$

$$P_{(0,1,2)} = 0.00117 + 0.0079 + 0.02667 = 0.0357$$

$$P_{(>2)} = 1 - 0.0357 = 0.964$$

19. Answer: **C**. According to the OSHA, *Advisory Committee On Construction Safety & Health (ACCSH) Multi-Employer Citation Policy, Current Policy,* for determining who gets cited, there are three classifications.

    - **CREATING EMPLOYER**—The employer who actually creates the hazard
    - **CONTROLLING EMPLOYER**—The employer who is responsible, by contract or through actual practice, for safety and health conditions on the worksite (i.e., the employer who has the authority for ensuring that the hazardous condition is corrected)
    - **CORRECTING EMPLOYER**—The employer who has the responsibility for actually correcting the hazard

    It must be shown that each employer to be cited has knowledge of the hazardous condition or could have had such knowledge with the exercise of reasonable diligence. In the case cited the subcontractor would be considered the "creating employer," and the general contractor would be the "controlling employer." In practice, it is difficult not to be cited as the controlling employer if you are a general contractor. You must show a defense that satisfies all of the following:

    - You did not create the hazard
    - You did not have the responsibility or the authority to have the hazard corrected
    - You did not have the ability to correct or remove the hazard
    - You can demonstrate that the correcting employers, as appropriate, have been specifically notified of the hazards to which his/her employees are exposed
    - You have instructed your employees to recognize the hazard and informed them how to avoid the dangers associated with it, when the hazard was known, or with the exercise of reasonable diligence could have been known

    It would appear that in this case, both the general contractor and the subcontractor would receive a citation.

20. Answer: **B**. Per the NSC *Accident Prevention Manual, Administration & Programs*, the rotary control knob is the best choice from those listed. The other three choices would be better suited for 2-position switches or quick adjustments. The toggle switch would be used for a discrete operation. A review of the control devices may be in order if you do not know the different devices and their applications.

21. Answer: **C**. The question describes a flat bottom and flat top tank indicating that this tank is **not** designed to hold pressure. Therefore, siphon action would prove the safest method of purging or draining the tank.

22. Answer: **A**. Sodium hydroxide and its concentrated solutions corrode aluminum very rapidly, as well as lead and zinc.

23. Answer: **B**. The Ames test does not measure carcinogenicity directly. It does however measure mutagenicity of a chemical. It is a widely accepted fact that almost all known mutagens are eventually found to be carcinogens.

24. Answer: **D**. If explosive meter or combustible gas indicator is of the hot wire type, it causes an oxidation to take place, determines the deviation, and indicates a measurement based on the heat released.

25. Answer: **C**. Q-Fever is a rickettsial organism that infects meat and livestock handlers. Similar to tick fever, Byssinosis is contracted by those exposed to large concentrations of cotton or flax dust. Neuropathy is a nonspecific disturbance to the central nervous system. Photophobia is a condition where light causes pain in the eyes.

26. Answer: **B**. All of the processes listed are used in air cleaning of gases and vapors. However, the method cited is that of *ABSORPTION*. *Adsorption* involves an action that takes place at the surface of the adsorbent material where gas and solid make contact. The most widely used adsorbent for cleaning air is activated carbon, which most often is placed in canisters or perforated cans or trays. Activated carbon has the ability to adsorb gases and vapors up to about 60% of its own weight. If the carbon is then heated, the captured material can then be reclaimed, making it an attractive and cost-effective process. *Combustion* is a process used for removal of gas or vapor if it can be oxidized to a harmless or odor free state. Many times, this takes the form of a direct-flame afterburner. Catalysts are also used to great effect in paint disposal, animal fats, plastics, etc. *Condensation* is

the process of lowering the temperature of the incoming air to change the vapor to a liquid state. The process uses various chillers, condensers, or refrigeration units to lower the temperature of the vapor.

27. Answer: **C**. Below 20 Hz is subaudible; above 20,000 is ultrasonic. The average measured hearing range of an unimpaired person is 20–20,000 Hz.

28. Answer: **B**. The industrial disease usually associated with wool textiles is *anthrax*. It was at one time a great danger, particularly to *wool sorters*, but has been almost completely controlled in the wool textile industry by:

    - Improvements in production methods in exporting countries where anthrax is endemic.
    - Disinfection of materials liable to be carrying anthrax spores.
    - Improvements in handling the possibly infected material under exhaust ventilation in the preparatory process.
    - Installation of washing facilities, use of personal protective equipment, and the instruction of workers (Stellman 1998).

    Byssinosis is contacted by those exposed to large concentrations of cotton or flax dust. *Q-Fever* is a rickettsial organism that infects meat and livestock handlers; it is similar to tick fever. *Brucellosis* is an infection caused by drinking unpasteurized milk from cows with Bang's disease.

29. Answer: **C**. Bioaccumulation refers to the movement and magnification of trace metals in the food chain.

30. Answer: **B**. According to Raoult's Law, if a nonvolatile solute is added to a volatile solvent, the vapor pressure is lowered, and the boiling point is increased. Raoult's Law states, "The vapor pressure of a volatile solvent in a dilute solution is proportional to its mole fraction," which, of course, means the addition of a nonvolatile solute to a volatile solvent will raise its boiling point by an amount, which is proportional to the number of moles of solute added. Likewise, the addition of a nonvolatile solute to a volatile solvent will lower its vapor pressure by an amount, which is proportional to the number of moles of solute added.

31. Answer: **A**. Pure chance will occasionally give test results, which cause us to reject or accept a hypothesis when we should not have. This error factor is called a confidence factor. It does not mean that we will be wrong or right 95% of the time; it simply means there is a 5% possibility of error due to pure chance. For example, if a hypothesis test rejected at the 5% significance level, we would be 95% confident in the results of the test. There would still remain, however, a 5% chance that we could be making a Type I error (rejecting a fair value). If answer D said it had a **chance** of being right 19 times out of 20, it would be a valid answer.

32. Answer: **A**. Perchloric acid is a very strong oxidizing agent that can cause fire and explosion hazards. The acid is not volatile until evaporated to an anhydrous state. If evaporation is conducted under a hood equipped with a waterfall, the fire and explosion hazard are negated.

33. Answer: **C**. There a generally four purposes of warning labels:

    - To inform the users of a hazard or danger of which they may not be aware, which is inherent in the use or reasonably foreseeable misuse of the product
    - To provide users with information regarding the likelihood or severity of injury from the use or reasonably foreseeable misuse of the product (i.e., inform the user the proper way to use the product)
    - To remind users of a danger at the time and place where the danger is most likely to be encountered
    - To inform users or potential users how to reduce the likelihood and or severity of injury

    Although there are many legal reasons for providing adequate warning labels on products, advice on legal recourse is not at the present time one of them. According to CPSC, a private labeler must include the identification of the private labeler, the identification of the manufacturer, and a statement of compliance of the product with all applicable standards. Legally, the burden is upon the manufacturer to provide the warning.

34. Answer: **A**. Consideration involves the transfer of something of value, which can be money or other items on which a value can be placed by competent authority.

35. Answer: **D**. The mobile monthly crane inspection would normally check the condition of all wire ropes (standing and running) as well as the reeving of load blocks. There is no magnetite switch installed on mobile cranes.

    *Note: Magnetite (which has nothing to do with this question) is a black iron oxide used as a high-density stemming material and as an aggregate in specialized concrete work. It is very heavy, with a specific gravity of 5.1.

36. Answer: **D**. OSHA 1910.1001(b) states, "PACM means presumed asbestos containing material. Presumed asbestos containing material means thermal system insulation and surfacing material found in buildings constructed no later than 1980. ACM (asbestos containing material) means any material containing more than 1% asbestos.

37. Answer: **D**. According to authors Robert Kaplan and David Norton, the balanced scorecard approach can be used to achieve safety and health performance excellence. The book *The Balanced Scorecard: Translating Strategy into Action*, was an early outline on how applying both leading and lagging indicators could be significant in achieving management goals. Many companies have adopted a version of the balanced scorecard or a comparable system, and that has brought some SH&E professionals into the process. The name of the process itself reflects, among other things, the need for a balance between the use of lagging and leading indicators. In the balanced scorecard approach, a business unit's mission and strategy are translated into tangible, measurable objectives. A balance is to be maintained between the outcome measures, the results from past efforts (the lagging indicators) and the measures that drive future performance (the leading indicators). Operational processes are selected for emphasis "that are most critical for achieving breakthrough performance." For the practice of safety, this implies that the critical processes can be, and have been, identified and that statistical indicators for breakthrough performance can be developed. This idea, focusing on the processes most critical with respect to hazards and the risks that derive from them, would enhance the effectiveness of a safety management system.

38. Answer: **B**. Reference 49 CFR 392.5 (United States Government Publishing Office, Federal Motor Carrier Safety Administration, DOT § 392.5) Alcohol prohibition:

    (a) No driver shall-
        (1) Use alcohol, as defined in 382.107 of this subchapter, or be under the influence of alcohol, within 4 hours before going on duty or operating, or having physical control of, a commercial motor vehicle; or
        (2) Use alcohol, be under the influence of alcohol, or have any measured alcohol concentration or detected presence of alcohol, while on duty, or operating, or in physical control of a commercial motor vehicle; or
        (3) Be on duty or operate a commercial motor vehicle while the driver possesses an alcoholic beverage. However, this does not apply to possession of alcohol, which is manifested and transported as part of a shipment.

    (b) No motor carrier shall require or permit a driver to-
        (1) Violate any provision of paragraph (a) of this section; or (2) be on duty or operate a commercial motor vehicle if, by the driver's general appearance or conduct or by other substantiating evidence, the driver appears to have used alcohol within the preceding four hours.

    (c) Any driver who is found to be in violation of the provisions of paragraph (a) or (b) of this section shall be placed out-of-service immediately for a period of 24 hours.
        (1) The 24-hour out-of-service period will commence upon issuance of an out-of-service order.
        (2) No driver shall violate the terms of an out-of-service order issued under this section.

    (d) Any driver who is issued an out-of-service order under this section shall:
        (1) Report such issuance to his/her employer within 24 hours; and (2) report such issuance to a State official, designated by the State, which issued his/her driver's license, within 30 days unless the driver chooses to request a review of the order. In this case, the driver shall report the order to the State official within 30 days of an affirmation of the order by either the Regional Director of Motor Carrier Safety for the Region or the Associate Administrator.

    (e) Any driver who is subject to an out-of-service order under this section may petition for review of that order by submitting a petition for review in writing within 10 days of the issuance of the order to the Regional

Director of Motor Carrier Safety for the Region in which the order was issued. The Regional Director may affirm or reverse the order. Any driver adversely affected by such order of the Regional Director may petition the Associate Administrator for review in accordance with 49 CFR 386.13.

39. Answer: **A**. Selection A, "activities involving the removal of TSI and surfacing ACM and PACM," is the definition of Class I asbestos work.

    Selection B, "activities involving the removal of ACM, which is not thermal system insulation or surfacing material, including the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics," is the definition of Class II asbestos work. Selection C, "repair and maintenance operations, where "ACM," including TSI and surfacing ACM and PACM, is likely to be disturbed" is the definition of Class III asbestos work. Selection D, "maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean up dust, waste and debris resulting from asbestos work," is the definition of Class IV asbestos work. (OSHA, *1926 Toxic and Hazardous Substances: Asbestos*)

40. Answer: **C**. DOT regulations (Federal Motor Carrier Safety Administration (FMCSA)) contained in 49 CFR Part 382.305 require annual random testing of at least 50% of the company's entire fleet for random controlled substances. Additionally, drivers should be randomly tested prior to the start of safety sensitive tasks. The minimum annual percentage rate for random alcohol testing is 10%. Other organizations, such as FTA, PHMSA, and FAA only require 25% of the subject population to be tested for random controlled substances.

41. Answer: **A**. Using Avogadro's number of 6.024×10^{23} atoms per gr-mole. The GMW or GAW (Gram Atomic Weight) of silver is 108 grams, then:

$$\frac{1 \text{ drop}}{2 \times 10^{11} \text{ atoms}} \times \frac{6.024 \times 10^{23} \text{ atoms}}{1 \text{ mole}} \times \frac{1 \text{ mole}}{108 \text{ grams}} \times \frac{454 \text{ grams}}{1\text{lb}}$$

$$\frac{2.73 \times 10^{26}}{2.16 \times 10^{13}} = 1.266 \times 10^{13} \text{ drops per lb of silver}$$

42. Answer: **B**. Selection "B" is the best choice. Universal Precautions is OSHA's required method of control to protect employees from exposure to all human blood and OPIM (defined below). The term "Universal Precautions," refers to a concept of bloodborne disease control, which requires that all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens. Selection "D" is more descriptive of the concept of Body Substance Isolation (BSI), which is an allowed control method and defines all body fluids and substances as infectious. OPIM is defined as the following human body fluids; saliva in dental procedures, semen, vaginal secretions, cerebrospinal, synovial, pleural pericardial, peritoneal, and amniotic fluids; body fluids visibly contaminated with blood along with all body fluid in situations where it is difficult or impossible to differentiate between body fluids; unfixed human tissues or organs (other than intact skin); HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture media or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.

43. Answer: **D**. $2Al + 3H_2SO_4 = Al_2(SO_4)3 + 3H_2$ The balanced chemical equation given in the question shows that two moles of aluminum are dissolved by three moles of sulfuric acid. The ratio of Al to H_2SO_4 is 2:3; therefore 100 moles of aluminum would be dissolved by 150 moles of acid.

44. Answer: **D**. Failure Modes and Effects Analysis (FMEA) is a technique in which the analyst identifies each and every component, investigates the ways each component could possibly fail, and then lists all possible results. The results are usually put on a form that looks much like an accounting form.

45. Answer: **D**. All of the methods listed will provide adequate corrosion protection except for the monitoring wells, which have little to do with the formation of corrosion.

46. Answer: **A**. Storage in inside storage rooms must comply with NFPA 30 which requires that every inside storage room be equipped with one clear aisle at least three feet wide.

47. Answer: **C**.

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2} \qquad \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{19.7}{492} = \frac{P_2}{600} \qquad P_2 = \frac{19.7 \times 600}{492} = 24 \text{ psia}$$

48. Answer: **C**. 150 feet times 0.433 pounds per square inch per foot of elevation = 65 pounds per square inch.

49. Answer: **D**. NFPA 30 specifies that underground storage tanks should be placed not less than one foot from existing building foundations. However, the distance from property lines on which you may build is *three feet*. The intent here is to ensure that the loads carried by future foundation or supports will not transfer to the tank. The three feet only applies to Class I liquids. For tanks holding Class II and III liquids the tanks can be built within one foot from property lines.

50. Answer: **C**.

$$\frac{Q_2}{Q_1} = \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

$$Q_2 = Q_1 \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

$$Q_2 = 2500 \times \frac{(69 - 20)^{0.54}}{(69 - 44)^{0.54}}$$

$$Q_2 = 2500 \times 1.438$$

$$Q_2 = 3595 \text{ gpm}$$

51. Answer: **A**.

$$S_D = \text{Delay Time} \times \text{Reaction Distance} \times \text{Safety Factor}$$

$$S_D = 0.85 \times 0.25 \text{ ft/sec} \times 7$$

$$S_D = 1.49 \text{ ft}$$

52. Answer: **B**.

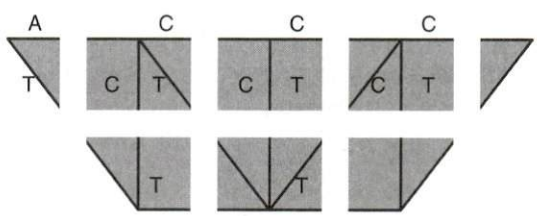


Figure 27 Truss Diagram Example 1

This question leaves a lot to be desired because it does not give us nearly enough info on the use of the truss. However, assuming the question is really asking which members are in tension, we can use the illustration of the forces in a *stable* structure that is symmetrically loaded (**Figure 27**). Caution: External forces such as wind can change the loading. The key here is when you turn the truss upside down, what was in compression is now in tension and what was in tension is now in compression.

53. Answer: **C**.

The illustration (**Figure 27**) depicts a perfectly stable structure that is symmetrically loaded and shows the forces involved.

54. Answer: **D**.

If you continue the process of resolving the truss member forces, section by section, you end up with the solution shown here. Since this truss is equally loaded, the forces are symmetrical, branching from the center. However, if one were to look at only numerical values, without regard to compression or tension, members AC and GH have the same value.

55. Answer: **B**.

Step 1: Convert the 60 ft^3 a day to cfm so that the output of the general dilution formula will be in the proper units. That is, units that agree with the answers.

$$\frac{60 \text{ ft}^3}{1 \text{ day}} \times \frac{1 \text{ day}}{24 \text{ hrs}} \times \frac{1 \text{ hr}}{60 \text{ min}}$$

$$= \frac{60}{24 \times 60} = 0.0412 \text{ cfm}$$

Step 2: Apply general dilution formula and solve. Note that the room size is not used in the equation.

$$Q' = \frac{G}{C} \quad \text{and} \quad C = \frac{TLV}{10^6}$$

$$Q = \frac{G}{TLV} \times 10^6$$

$$Q = \frac{0.0417}{120} \times 10^6$$

$$Q = 0.0003475 \times 10^6$$

$$Q = 347.5 \text{ cfm}$$

56. Answer: **D**.

Step 1: Draw and label the existing tanks. Show dimensions and limitations. For example, it is obvious for this illustration that the minimum width of the diking must be 83 meters or greater to comply with regulatory requirements. Additionally, it should be noted that the capacity of the dike will have to be reduced by the area occupied by the small tank, since that space will not be available to contain fuel from the large tank.

Step 2: Calculate capacity of large tank and multiply by 110% to establish the total volume of fuel to be contained by the dike.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{\pi (40)^2 \times 13}{4} = 16{,}336 \text{ m}^3$$

$$V_t = 16{,}336 \times 1.1 = 17{,}970 \text{ m}^3$$

Step 3: Determine the area occupied by the smaller tank since that space is not usable and must be subtracted from the space available for containment.

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{\pi \times (12)^2}{4} = 113 \text{ m}^2$$

Step 4: Evaluate the options provided by the answers. Select one and calculate the capacity to see if it will contain 110% of the volume of the big tank. We initially selected answer "C" because it was the biggest area that met the requirements. Selection "A" was obviously too small. Selection "B" was not wide enough to meet the requirements.

Step 5: Compute the area provided by the dimensions of option "C."

$$A = L \times W$$

$$A = 120 \times 87 = 10{,}440 \text{ m}^2$$

Step 6: Subtract the area of the smaller tank since it occupies space that cannot be used to contain fuel from the larger tank.

$$\begin{array}{r} 10{,}440 \\ -113 \\ \hline 10{,}327 \text{ m}^2 \end{array}$$

Step 7: Multiply by the height of the dike to arrive at a total volume. This volume is too small to hold 110% of the big tank computed in step 2, which was 17,970 m^3.

$$V = A \times H$$

$$V = 10{,}440 \text{ m}^2 \times 1.5 \text{ m}$$

$$V = 15{,}660 \text{ m}^3$$

Step 8: Compute the area provided by the dimensions of option "D."

$$A = L \times W$$

$$A = 120 \times 85 = 10{,}200 \text{ m}^2$$

Step 9: Subtract the area of the smaller tank since it occupies space that cannot be used to contain fuel from the larger tank.

$$\begin{array}{r} 10{,}200 \\ -113 \\ \hline 10{,}087 \text{ m}^2 \end{array}$$

Step 10: Multiply by the height of the dike to arrive at a total volume. This volume is large enough to hold 110% of the big tank computed in step 2, which was 17,970 m^3.

$$V = A \times H$$

$$V = 10{,}087 \text{ m}^2 \times 1.8 \text{ m}$$

$$V = 18{,}157 \text{ m}^3$$

*Note: These questions are pretty straight forward; however they do consume a lot of time and offer a lot of chances for error. You may want to consider passing this one by the first time through the test and coming back to it.

57. Answer: **B**.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{\pi \times (40)^2 \times 13}{4} = 16{,}336 \text{ m}^3$$

$$\frac{1.06 \text{ qt}}{1 \text{ ltr}} \times \frac{1 \text{ gal}}{4 \text{ qt}} \times \frac{1000 \text{ ltr}}{1 \text{ m}^3} = 265 \text{ gal/m}^3$$

$16{,}333 \times 265$ gal per cubic meter = 4,002,320 gallons

58. Answer: **B**.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{\pi \times (12)^2 \times 4.5}{4}$$

$$V = 508.9 \text{ m}^3$$

59. Answer: **B**.

Step 1: Solve for maximum bending moment in in-lbs.

$$M = \frac{Pl \times 12}{4}$$

$$M = \frac{775 \times 8 \times 12}{4}$$

$$M = \frac{74{,}400}{4} = 18{,}600 \text{ in/lbs}$$

Step 2: Calculate section modulus using 1100 psi lumber.

$$S = \frac{M}{F_b}$$

$$S = \frac{18{,}600}{1100}$$

$$S = 16.9$$

Step 3. From **Table 30**, select the smallest section modulus that is greater than 16.9.

Table 30 Properties of Structural Lumber—1100 Pounds Fiber Stress

Nominal Size	Dressed Size	Area of Section	Section Modulus
10 × 3	9¼ × 2½	23.125	9.635
10 × 4	9¼ × 3½	32.375	18.885
12 × 3	11¼ × 2½	28.125	11.719
12 × 4	11¼ × 3½	39.375	22.969

60. Answer: **A.**

Step 1: Convert the 15 ft^3 per pint to cfm and apply safety factor.

$$cfm = \frac{4 \text{ pints}}{60 \text{ min}} \times \frac{15 \text{ ft}^3}{1 \text{ pint}} \times 5(SF)$$

$$cfm = 5$$

Step 2: Apply general dilution formula and solve. Note that the room size is not used in the equation because we are not concerned with how long it takes to get to LEL.

$$Q' = \frac{G}{C} \quad \text{and} \quad C = \frac{LEL}{100}$$

$$Q = \frac{G}{LEL} \times 100$$

$$Q = \frac{5}{1.2} \times 100$$

$$Q = 417 \text{ cfm}$$

61. Answer: **B**. The cost benefit will be the total annual savings. To calculate the yearly savings, subtract the new maintenance cost from the safety-related losses to get the annual savings (25,000 – 500 = 24,500) and then calculate the annual cost of the equipment. Finally, subtract the yearly savings from the annual cost to yield the answer.

$$i = 0.05 \quad n = 10 \quad P = \$100{,}00 \quad A = \ ?$$

$$A = P\frac{i(1+i)^n}{(1+i)^n - 1}$$

$$A = 100{,}000 \times \frac{0.05 \times (1+0.05)^{10}}{1.05^{10} - 1} = \$12{,}950$$

$$\$24{,}500 - \$12{,}950 = \$11{,}550$$

62. Answer **C**. The maximum acceptable investment is calculated by taking the annual savings ($24,500) and converting it to a present value.

$$i = 0.05 \quad n = 10 \quad A = \$24{,}500 \quad P = \ ?$$

$$P = A\frac{(1+i)^n - 1}{i(1+i)^n}$$

$$A = 24{,}500 \times \frac{(1+0.05)^{10} - 1}{0.05 \times (1+0.05^{10})} = \$189{,}183$$

63. Answer: **D**. Alpha radiation is a nonpenetrating form of radiation. Alpha cannot be detected by the film badge, which requires penetration of the surface covering the film before a measure can be made. A pocket dosimeter measures a person's accumulated radiation dose and is considered the best device for this purpose. A pocket dosimeter is frequently used in conjunction with a film badge.

64. Answer: **B**. The preferred decontamination agent for spills of HIV-infected blood is a commercial germicide.

65. Answer: **C**. Raynaud's syndrome (White finger or Dead fingers) is a segmental vibration disorder. It occurs in the fingers of the hand used to hold or guide a vibrating tool. The hand used to hold the tool experiences a reduced blood circulation and when combined with cold causes the fingers to become white. Generally,

the vibrations that cause Raynaud's phenomenon are in the 40 to 125 cycle per second range. Whole body vibration approaches resonance in a seated human in the 3 to 15 cycles per second range. Symptoms include those listed in the question as well as increased electrical activity of the brain.

66. Answer: **C**. If a tagout system is used it must provide full employee protection. This means that the employer must demonstrate that the tagout system will provide a level of safety equivalent to that obtained by using a lockout program. Generally, this means the removal of an actuating device (i.e., the handle on a valve, the removal of a fuse, or circuit switch, etc.).

67. Answer: **B**. According to NFPA 850, "Fire Protection for Electric Power Generating Plants," 1992, fire protection water supply mains and hydrants should be permanently installed during the early stages of construction. If this is not possible, temporary systems should be installed, tested, and maintained at a high state of reliability.

68. Answer: **A**. Pesticide applicators and mixers, loaders, and others working with concentrated pesticides who are exposed to diluted pesticides for many hours should be particularly aware of the dangers of organophosphate and carbamate pesticides and cholinesterase inhibitors. Cholinesterase is an enzyme in the blood. It affects the red blood cells and plasma ChE levels. Organophosphate and carbamate pesticides affect this enzyme and cause lower red blood cell and plasma ChE levels. Affected individuals may exhibit pesticide poisoning symptoms such as fatigue, listlessness, and headaches. Severe exposures can result in death. Users of these pesticides should be in a cholinesterase testing program.

69. Answer: **B**.

Table 31 Physical Work Classification According to Energy Expenditure and Heart Rate

Classification	Energy Expended (kcal/min)	Heart Rate (beats/min)
Light work	2.5	90 or less
Medium work	5	100
Heavy work	7.5	120
Very heavy work	10	140
Extremely heavy work	15	160 or more

According to Table 31, 300 kcal/hour (5 kcal/min) would be considered medium work.

70. Answer: **C**.

$$\text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM}$$

$$\text{RWL (kg)} = 23\left(\frac{25}{\text{H}}\right)(1 - .003|\text{V} - 75|)\left(.82 + \frac{4.5}{\text{D}}\right)(1 - 0.0032 \times \text{A})\ (\text{FM})(\text{CM})$$

$$\text{RWL (kg)} = 23\left(\frac{25}{60}\right) \times (1 - .003 \times 45)\left(.82 + \frac{4.5}{60}\right)(1 - 0.0032 \times 25) \times\ (1) \times (.95)$$

$$\text{RWL (kg)} = 23 \times 0.417 \times 0.865 \times 0.895 \times 0.92 \times 1 \times 0.95$$

$$\text{RWL (kg)} = 6.49\text{kg}$$

71. Answer: **A**. The battery charging room should be provided with adequate ventilation, an eye wash station, and be separated from other operations by a 1-hour fire wall.

72. Answer: **B**.

$$\text{PEL} = \frac{10 \text{ mg/m}}{\%SiO_2 + 2}$$

$$\text{PEL} = \frac{10 \text{ mg/m}^3}{2 + 2}$$

$$\text{PEL} = \frac{10 \text{ mg/m}^3}{4} = 2.5 \text{ mg/m}^3$$

73. Answer: **D**. The activity after three years will be 12.5% of the initial activity. After four years, the activity will be 6.25% of the initial activity. Five years will see the activity down to 3.13% of the initial.

74. Answer: **D**.

$$\frac{12.5}{50} = 0.25$$

$$\frac{200}{500} = 0.4$$

$$\frac{\frac{100}{200}}{1.15} = 0.5$$

$$\frac{(1.15 \times 4) + (0 \times 4)}{8} = .575$$

75. Answer: **C**.

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

$$\frac{150}{580} = \frac{V_2}{460}$$

$$V_2 = \frac{150 \times 460}{580} = 118.97$$

76. Answer: **B**.

When trying to evaluate the impact of high noise levels on the human ear, it is very difficult to determine the effectiveness of hearing protectors. Hearing protectors are evaluated under laboratory conditions specified by ANSI Z24.22 and ANSI S3.19. However, in field conditions, the Noise Reduction Rating (NRR) given hearing protectors often is provided a safety factor of 2 or reduced by 50%. This is necessary because field conditions never equal laboratory conditions. Additionally, when two noise reduction devices are properly worn, an additional 5 dB (doubling) of protection is provided. After the field attenuation is calculated, it is subtracted from the 8-hour TWA value to obtain the protected TWA (sound level reaching the cochlea).

The base line for the exam is the federal OSHA standard of 90 dBA and 85 dBA if the individual has had a threshold shift.

$$A_f = \frac{NRR - 7}{2} + 5$$

$$A_f = \frac{29 - 7}{2} + 5$$

$$A_f = 11 + 5$$

$$A_f = 16$$

$$\text{Protected TWA} = TWA_8 - A_f$$

$$\text{Protected TWA} = 110 - 16$$

$$\text{Protected TWA} = 94 \text{ dBA}$$

77. Answer: **D**. Small spills of mercury can be cleaned up using calcium polysulfide with excess sulfur by sprinkling the powder into cracks or inaccessible sites. The powder will combine with the mercury and can then be removed by vacuum or other methods. Mercury is reactive with ammonia and nitric acid.

78. Answer: **C**. According to OSHA a minimum of 19.5% oxygen content is required before entry into a confined space is allowed without the use of supplied air.

79. Answer: **A**.

Step 1: Select formula for sources and solve.

$$L_W = 10 \times \log_{10}\left[\frac{W}{W_0}\right]$$

$$L_W = 10 \times \log\left[\frac{1}{5}\right]$$

$$L_W = -7\text{dB}$$

Step 2: Add result to initial reading. $\text{dB} = 97 + -7$

$\text{dB} = 90$

80. Answer: **A**. OSHA 1926, Subpart P, Appendix B requires an excavation in Type A soil that is open less than 24 hours and is 12 feet or less in depth to have a maximum allowable slope of ½:1, or about 63°.

1926 Subpart P App A

"Type A" means cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater.

"Type B" means cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa).

"Type C" means cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less.

OSHA 1926 Subpart P App B, Paragraph 13

Table B-1 Maximum Allowable Slopes

Soil or Rock Type	Maximum Allowable Slopes (H:V)(1) for Excavations Less Than 20 Feet Deep
STABLE ROCK	VERTICAL (90°)
TYPE A (2)	3/4:1 (53°)
TYPE B	1:1 (45°)
TYPE C	1 1/2:1 (34°)

(1) Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.

1926 Subpart P App B, Paragraph 14

(2) A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).

81. Answer: **A**. Leading indicators (such as risk assessments) provide data on how well the loss control system is expected to perform in the future. In this particular case, there is evidence that when a lower fraction of operational personnel have been trained, the company's loss control performance decreases.

82. Answer: **C**.

$$\text{Tan}^{-1}\left(\frac{1}{1.5}\right) = 33.6 \text{ degrees}$$

OSHA 1926, Subpart P, Appendix B requires an excavation in Type C soil that is 20 feet or less in depth to have a maximum allowable slope of 1½:1.

83. Answer: **D**. The simplest measuring device is the handheld sound level meter. If noise levels are fairly constant throughout the day. Sound level meters are acceptable for assessing a workshop where employees spend most of their time in a fixed location next to a changing noise source(s). But for workers who are mobile, a personal noise dosimeter that can follow workers where they go is preferred. If the noise is too variable to follow with a sound level meter, one could use an integrating meter. This meter can integrate, or average, the changing noise levels over a period of time to produce a time average noise level. Time averaging is the way the instrument makes its eyeball average reading except that it does so scientifically using a set of rules defined in the standards so that it is repeatable under many different circumstances.

84. Answer: **B**.

Step 1: Determine dose for 8-hour exposure.

$$\frac{T_1}{D_1} = \frac{T_2}{D_2}$$

$$D_2 = \frac{D_1 T_2}{T_1}$$

$$D_2 = \frac{89 \times 8}{4\frac{50}{60}} = \frac{712}{4.83} = 147.4$$

Step 2: Compute TWA.

$$\text{TWA} = 90 + 16.61 \times \text{LOG}\left[\frac{D\%}{100}\right]$$

$$\text{TWA} = 90 + 16.61 \times \text{LOG}\left[\frac{147.4}{100}\right]$$

$$\text{TWA} = 90 + 16.61 \times 0.1685 = 92.8$$

85. Answer: **B**. According to OSHA 1910.184, natural and synthetic fiber rope slings shall be removed from service if any of the following conditions are present:
    - abnormal wear
    - powdered fiber between strands
    - broken or cut fibers
    - variations in the size or roundness of strands
    - discoloration or rotting
    - distortion of hardware in the sling

86. Answer: **C**. 1910.95 (m)(3)(ii) Audiometric test records shall be retained for duration of the affected employee's employment.

87. Answer: **A**.

$$i = .10 \div 4 = .025 \quad n = 5 \times 4 = 20 \quad F = \$150{,}000 \quad A = \ ?$$

$$A = F\left(\frac{1}{(1+i)^n - 1}\right)$$

$$A = 150{,}000 \times \left(\frac{.025}{(1+.025)^{20} - 1}\right) = \$5{,}872$$

Key strokes for the TI-30X IIS

$$150\ 000 \times .025/(1.025\text{^}20 - 1) = 5{,}872$$

Keystrokes for the HP10BII

1. 150 000 (FV KEY)
2. 2.5 (I/YR KEY)
3. 20 (N KEY)
4. (PMT KEY) for the answer

To solve the next two problems, compare the costs related to each option based on "common ground." Relate everything to a present value.

88. Answer: **C**. This is the definition of the Pareto principle, sometimes referred to as the 80-20 rule that indicates that 80% of problems come from 20% of the operations. It is also true that 20% of corrective actions and risk reduction actions can mitigate 80% of the risk when the risk is identified.

89. Answer: **B**. The National Institute of Occupational Safety and Health (NIOSH) has developed a number of **Recommended Exposure Limits (RELs)**, which are promulgated to guide OSHA in future rulemaking. Finally, the American Industrial Hygiene Association (AIHA) publishes voluntary guidelines called WEELs, "Workplace Exposure Evaluation Levels." OSHA is very slow to adjust to new data and new views and is subject to extreme political pressures. Thus, enforceable **Permissible Exposure Limits (PELs)**, in particular, rarely change. Many responsible employers also follow the guidelines established by the **American Conference of Governmental Industrial Hygienists called Threshold Limit Values® (TLVs).** These are updated yearly and often provide more current values for controlling employee exposure.

Lacking a PEL, REL, WEEL, or TLV®, some manufacturers or employers will develop their own recommended exposure limits, based on toxicity testing or their handling experience.

Occupational exposure limits (OELs) for chemical compounds are defined against several different time bases. Most TLVs and PELs are defined as 8-hour time weighted average exposures. Many RELs are based on a 10-hour exposure period. Historically, the TLVs have also included Short Term Exposure Limits (STELs), which were a 15-minute average of exposure, but this concept has largely been dropped in recent years. Only a few compounds retain STEL limits. Another common limit is the "Ceiling" limit, abbreviated simply as "C," which is a concentration of the chemical agent, which is usually intended as an absolute limit, a value never to be exceeded even for a short time.

90. Answer: **A**. Assigned Protection Factor (APF) means the workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by this section (**Table 32**).

Table 32 Assigned Protection Factors

Type of Respirator	Quarter mask	Half mask	Full facepiece	Helmet/ Hood	Loose-fitting facepiece
1. Air-Purifying Respirator	5	10	50	—	—
2. Powered Air-Purifying Respirator (PAPR)	—	50	1000	25/1000	25
Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	—	10	50	—	—
• Continuous flow mode	—	50	1000	25/1000	25
• Pressure-demand or other positive-pressure mode	—	50	1000	—	—
Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	—	10	50	50	—
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	—	—	10,000	10,000	—

Occupational Safety and Health Administration. *3352-02 2009 Assigned Protection Factors for the Revised Respiratory Protection Standard*. https://www.osha.gov/Publications/3352-APF-respirators.pdf

91. Answer: **C**. The MUC for respirators is calculated by multiplying the APF for the respirator by the PEL. The MUC is the upper limit at which the class of respirator is expected to provide protection.

    The Protection Factor for a half-mask respirator from the chart is 10.

$$\begin{aligned} \text{MUC} &= \text{TLV} \times \text{APF} \\ &= 10\ \text{mg/m}^3 \times 10 \\ &= 100\ \text{mg/m}^3 \end{aligned}$$

    End-of-service-life indicator (ESLI) means a system that warns the respirator user of the approach of the end of adequate respiratory protection (e.g., the sorbent is approaching saturation or is no longer effective).

92. Answer: **C**. Since canopies are above the worker, the contaminant must travel very close to, and most of the time through, the worker's breathing zone.

93. Answer: **C**. Speech occurs in the 500–2000 Hz range. To identify the noise levels in this frequency range requires an octave band analyzer.

94. Answer: **C**. If the occurrence of the sound is greater than once per second, the sound is considered to be continuous and should be measured as continuous sound. Ref. OSHA 29 CFR 1910.95.

95. Answer: **C**. The sampling instrument is at or near its capabilities and its measurements are suspect at best. The device has detected some level of the contaminant; however, using this information to perform any valid statistical analysis is not possible. The only real conclusion is that there is a presence of the contaminant and that it is at or below the detection limits of the device.

96. Answer: **B**. According to numerous safety texts, a safety plan must have these basic elements: list of actions, implementation schedule, and cost.

97. Answer: **A**. According to Grimaldi and Simonds in "*Safety Management*," the basic principle of the modern method of estimating uninsured costs of work injuries and "accidents" includes lost time cases, doctor's cases, first-aid cases, and no-injury accidents.

98. Answer: **A**. The *Theory X* manager (according to McGregor's Theory) holds that people must be motivated to work by external reward and punishment because they are unmotivated toward work.

A *Theory Y* manager assumes all workers are basically interested and motivated to work and therefore have a reduced need for an external reward system (**Figure 28**).

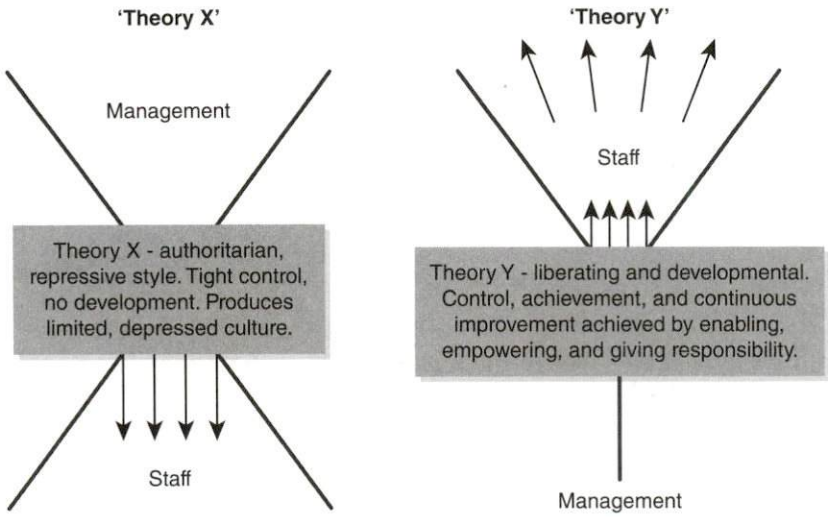


Figure 28 Theory X and Theory Y: Motivational Management Styles by McGregor

Management by objectives (*MBO*) is a process of joint objective setting between a superior and subordinate. It is also known as management by results. The managers meet the following performance objectives:

1. Target a key result to be accomplished
2. Identify a date for achieving results
3. Offer a realistic (measurable) and attainable challenge
4. Make as specific and quantitative as possible

A TQM manager manages with an organization-wide commitment to continuous work improvement, product quality, and totally meeting customer needs, by applying them to all aspects of the operation. Under TQM, an employee's initiative to work safely is achieved by instilling a commitment to quality teamwork and continual improvement. These managers are of several types. The line manager is responsible for activities making direct contributions to the production of the organization's product. The staff manager has special technical expertise to advise and support the line manager. Function managers are responsible for a support area such as finance, marketing, personnel, etc.

A safety professional can have line authority if he works under the plant manager in an operational extension (extended or extension) capacity. They should also be sensitive to changes in management styles and be able to characterize them so that they can understand them and develop programs accordingly.

Self-Assessment 2 Questions

1. In addition to the OSHA "Log of Occupational Injuries and Illnesses," what other records does OSHA require an employer to maintain?

A. Workers' compensation forms
B. Insurance forms
C. OSHA Form 301 or equivalent
D. Accident rates

2. Which of the following organizations is responsible for design of pressure vessels in the United States?

A. ANSI
B. ASME
C. UL
D. ASSE

3. You are the safety director for a company that manufactures fiberglass reinforced plastic FRP fuel tanks. The company has factories that manufacture the components and an installation group that installs them on the client's property. Which of the following regulatory agencies would be *most concerned* with your operations?

A. EPA and TSCA
B. EPA and OSHA
C. OSHA and ASME
D. EPA and NFPA

4. Which of the following agencies would have regulatory authority over a container of chemicals used in your plant without a proper label?

A. NRC
B. OSHA
C. DOT
D. PHC

5. Which is the *best* overall technique for a manager to use to have good working relations among subordinate supervisors?

A. Avoid showing partiality toward any of the subordinate supervisors.
B. Ensure each subordinate supervisor understands his or her responsibilities and those of fellow subordinate supervisors.
C. Conduct in-service training programs for subordinate supervisors who have difficulty working with others.
D. Conduct an in-service training program in human relations for subordinate supervisors.

6. Which of the following would be an example of "dangerous instrumentality"?

A. Automobile
B. Chainsaw
C. Motorcycle
D. Firearm

7. A standard commercial liability insurance policy contains two integral components: (1) a policy jacket and (2) a coverage part. The coverage part contains a schedule of hazards, which lists the manual classifications of liability exposures, the rating basis, rates, and the premiums. This coverage part also contains the insuring agreements, additional definitions, exclusions, and any other specific conditions of the coverage. All of the following coverage parts are valid and available to business firms *except:*

A. CGL, OL&T.
B. CGL, APCL.
C. OCP, SL.
D. OCP, GL.

8. Within the United States, breathing air in industrial applications is highly regulated and any compressed air or compressed oxygen used for respiration must meet certain minimum requirements. Who is the regulator that provides this oversight and what grade is required for use as breathing air?

A. Industrial and Aviator Air Purity Code C-64, Grade 1
B. Compressed Gas Association, Grade D
C. Mine Safety & Health Association, Grade B
D. National Institute of Occupational Safety & Health, Grade A

9. Which of the following manufacturing production "lines" would be the *most conducive* to safe operations?

A. Straight process line
B. Product layout line
C. Just in time assembly line
D. Multiple product layout line

10. Pick the term that completes this statement: Man can perform more complex operations than a machine because he is more _____.

A. accurate
B. intelligent
C. emotional
D. flexible

11. An audit of safety and health program management has revealed that the program has failed to accomplish the stated objective of accident prevention. Accident rates are very poor, as is morale and discipline. Supervisors openly defy management authority and varying standards exist throughout the company. Which of the following training solutions would you suggest?

A. Over a 6-month period, train all workers in hazard recognition using outside consultants.
B. Immediately start behavior-based training for workers and supervisors using in-house management expertise.
C. Train all managers in hazard avoidance, recordkeeping, and conflict resolution.
D. Train all managers and supervisors in principles of management.

12. An employee is required to wear a hearing aid to operate a commercial motor vehicle. Under a special arrangement, this driver will operate a delivery van that will ferry parts between several industrial areas, with each participating plant paying a share of the salary and expenses. Which of the following is true concerning this arrangement and driver?

A. The driver is not covered by OSHA under this arrangement.
B. DOT will not allow a hearing-impaired driver.
C. Passengers must not be carried in this vehicle.
D. DOT requires the driver to wear a hearing aid and carry a spare battery.

13. The use of testing during safety training provides an opportunity to determine the effectiveness of the education effort. Before and after testing is often used as a measure of effectiveness. Which of the following techniques is true concerning the *"before and after testing"* method?

A. Before and after tests should be identical.
B. Before and after tests should not be used.
C. Before and after tests should cover the same areas but the questions should be phrased differently.
D. Before and after tests should be very comprehensive.

14. A major shortcoming of the behavioral approach to safety involves the lack of:

A. behavior-based methods to involve management.
B. employee involvement in the planning process.
C. attention to design and engineering aspects of hazard prevention.
D. a feedback loop to report the status of safe and unsafe actions by observers.

15. Which of the following *best* describes a "builder's risk" form of insurance coverage?

A. A maritime policy for shipbuilders
B. Coverage for property damage or injuries during construction
C. Protection for the building or structure under construction as well as the construction machinery and equipment
D. Protection for personnel only during construction of oceangoing vessels

16. Which of the following terms *best* describes the M&C insurance coverage?

A. Maintenance and Construction
B. Major and Catastrophic
C. Manufacturers and Contractors
D. Minor and Corollary

17. Financial reports indicate the strength and weakness of a company as well as provide an indication of the profit motive of the organization as a whole. The financial report is a tool frequently used by the management community, where it is analyzed by _____and interpreted by _____.

A. safety, security
B. accounting, finance
C. accountants, management executives
D. management executives, accountants

18. Which of the following *best* describes the phrase "completed operations liability"?

A. The liability of a contractor prior to the project, task, or undertaking completion
B. The liability of the contractor that remains after all of the work has been completed and abandoned
C. The liability of the contractor will cease when the work is completed and accepted by the owner
D. The liability of the contractor will cease when the work is completed and accepted by the owner only if the work has not been negligently performed and privity exists

19. Which of the following *cannot* require the recall of a manufactured product?

A. State judge
B. Federal judge
C. NIOSH
D. CPSC

20. Which of the following correctly describes the workers' rights concerning OSHA violations?

A. Workers have no rights under OSHA.
B. Workers can appeal the abatement date of OSHA citations.
C. Workers have the right to appeal the citation penalty.
D. Workers have the right to negotiate the corrective actions recommended by the compliance officer.

21. The Classical Approach to Management and the Bureaucratic Management Model have all of the following key concepts *except:*

A. small span of control, heterogeneous assignment, centralized control.
B. organizational structure, hierarchy of authority, complete description of duties and responsibilities.
C. open dynamic environment, group interaction, self-direction.
D. stability and tenure, unity of command, subordination.

22. The Management Oversight and Risk Tree (MORT) methodology generally focuses on which of the following concerns?

A. Assumed risks and hazard evaluation
B. Management errors and risk evaluation
C. Decision analysis and assumed risks
D. Oversights and omissions and management system errors

23. XYZ company is installing a new process that uses a chemical substance that was not previously used in the company. What should be the safety professional's first action to evaluate the health hazards associated with the chemical?

A. Recommend the process area be ventilated.
B. Purchase PPE for all exposed employees.
C. Set up a monitoring protocol.
D. Check the SDS to determine the health hazards.

24. What is the recommended technique for a mid-level manager to use to ensure good working relationships with their subordinate supervisors?

A. Avoid treating one or more supervisors better than the rest.
B. Send all subordinate supervisors to human relations training.
C. Ensure each supervisor understands their responsibilities and the responsibilities of their fellow supervisors.
D. Send all subordinate supervisors to management training.

25. A ____is a graphic or tabular representation of the components of risk itself; for example, a frequency vs. likelihood or a consequence vs. severity.

A. risk matrix
B. loss scenario matrix
C. benefit-cost matrix
D. probability matrix

26. During an audit, the auditor must demonstrate impartiality. What is the *best* method to demonstrate impartiality?

A. Being certified
B. Being totally familiar with the area being audited
C. Not being responsible for the activity being audited
D. Signing a document that he or she will not be partial during the audit

27. When performing an audit of a company's management system using ISO 14000 and OHSA's 18001 standards, what provides minimally acceptable verification that the company is reviewing new requirements for applicability to the organization?

A. A six-month-old report from an outside auditor stating that the company is in compliance
B. A memo for record with the review date and a statement that it does or does not apply
C. A letter from the corporate attorney indicating that the company is in compliance with all requirements
D. Having an OSHA inspection within the last year

28. When calculating the ventilation for a paint spray booth, you should reduce the concentration to 25% of the LFL. What is the minimum required air per liter for chemical X using the following properties?

Chemical Properties	X
LFL	2.1%
UEL	8.2%
SG	0.622
MW	79
Specific Volume (SV)	0.212 m^3 of vapor/liter of liquid "X"

A. 4.0 m^3/L
B. 9.5 m^3/L
C. 39.5 m^3/L
D. 95 m^3/L

29. ISO 14001 is applicable to any organization that wishes to establish, implement, maintain, and improve an environmental management system, to assure itself of conformity with its stated environmental policy, and to demonstrate conformity with ISO 14001 by all the following *except:*

A. seeking by declaration that is conformance is adequate.
B. seeking confirmation of its conformance by parties having an interest in the organization, such as customers.
C. seeking confirmation of its self-declaration by a party external to the organization.
D. seeking certification/registration of its environmental management system by an external organization.

30. OSHA, in the Process Safety Management of Highly Hazardous Materials, requires employers to establish a compliance audit capability. The standard calls for employers to certify that they have evaluated compliance with process safety requirements at least every _____ years.

A. 2
B. 3
C. 4
D. 5

31. Which of the following is the *most accurate* concerning the listing of a material as a carcinogen on the Safety Data Sheet (SDS)?

A. If there is a report anywhere listing the chemical as a carcinogen, then it must be listed as a carcinogen on the SDS.
B. If the substance is identified as an IARC Group 3 or higher, it must be listed on the SDS as a carcinogen.
C. If the substance is identified on the National Toxicology Program "Annual Report on Carcinogens," it must be listed on the SDS.
D. If the agent was listed in an in vitro study as a possible group for carcinogen risk according to IARC

32. Which of the following professionals is dedicated to the art and science of anticipation, recognition, evaluation, and control of those environmental factors in the workplace that may cause sickness and impaired health and well-being?

A. Industrial hygienist
B. Industrial toxicologist
C. Health physicist
D. Medical pathologist

33. Employers must furnish hearing protection to all employees exposed to an 8-hour time-weighted average of 85 decibels or greater. If the employee has experienced a standard threshold shift, the employer must ensure that hearing protectors are worn. Which of the following *best* describes the "standard threshold shift"?

A. Hearing change of 5 dB or more at 2000, 4000, and 6000 cps
B. Hearing change of 20 dB or more at 2000, 3000, and 4000 Hz
C. Hearing change of 15 dB or more at 4000, 6000, and 8000 cps
D. Hearing change of 10 dB or more at 2000, 3000, and 4000 Hz

34. Which of the following correctly identifies the sequence of steps in Task-Based Machine Risk Assessment and Reduction?

A. (1) Identify the hazards associated with tasks; (2) eliminate the hazard; (3) determine the limits of the machine; (4) establish the probability of a hazardous event; (5) determine the level of risk; (6) determine the tasks to be performed; (7) determine the minimum required measures
B. (1) Determine the life cycle of the machine; (2) determine the desired degree of risk reduction; (3) identify the and rate their severity; (4) establish the probability of a hazardous event; (5) determine the level of risk; (6) reduce hazards severity; (7) determine the limits of risk
C. (1) Determine the limits of the machine; (2) determine the tasks to be performed over the life cycle of the machine; (3) identify the hazards associated with these tasks and rate their severity; (4) for each hazard, establish the probability of a hazardous event; (5) determine the level of risk. If it is not tolerable—continue; (6) eliminate the hazard or reduce its severity (lessen energy or toxicity); (7) determine the appropriate type and minimum required level of performance of protective (safeguarding) measures to provide the desired degree of risk reduction
D. (1) Determine the appropriate type and minimum required level of performance of protective measures to provide the desired degree of risk reduction; (2) determine the tasks to be performed over the life cycle of the machine; (3) identify the hazards associated with these tasks and rate their severity; (4) determine the limits of the machine; (5) determine the level of risk. If it is not tolerable—continue; (6) lessen energy or toxicity; (7) for each hazard, establish the probability of a hazardous event

35. Which of the following key label elements are standardized under the Globally Harmonized System (GHS)?

A. Product identifier, supplier identifier, chemical identity
B. Hazard pictograms, signal words, hazard statements
C. Precautionary information, product identifier, hazard statements
D. Signal words, chemical identity, hazard pictograms

36. Once a chemical has been classified, the hazard(s) must be communicated to target audiences. The exhibited pictogram represents which hazard class?

A. Carcinogen
B. Irritant
C. Acute toxicity
D. Environmental toxicity



OSHA, Hazard Communication Standard Pictogram, U.S. Department of Labor.

37. According to NFPA, which of the following is the tactic that should be employed by the owner to ensure proper protection of property from fire during the erection of a new facility on plant property?

A. Make personal daily visits to the superintendent's job shack.
B. Carry fire insurance worth twice the value of the construction loan or fair market value of the new building.
C. Designate a person to be responsible for the fire protection program.
D. Establish a program of prefire plans, daily surveillance, and automatic protection whenever possible.

38. The process that uses carbon to remove contaminants or undesirable odors is known as:

A. adsorption.
B. absorption.
C. combustion.
D. condensation.

39. Which of the following is considered to be the hardest factor to compute when performing cost-benefit analysis?

A. Future savings
B. Direct costs of mishaps
C. Costs of material
D. Determining lost time costs

40. The identification and evaluation of hazards before loss occurs is called:

A. systems safety.
B. traditional safety management.
C. accident prevention.
D. industrial hygiene.

41. The purpose of graphs is to depict data pictorially; therefore, data points are approximated (i.e., they are not exact). The purpose of tables is to show which of the following?

A. Exact numbers
B. Approximations
C. The results of complex computations
D. The relationships of several factors

42. The term "dry chemical" fire extinguishing agent is associated with flammable liquids. What material is the term "dry powder" associated with?

A. Electrical insulation
B. Exotic chemicals
C. Metals
D. Fibers

43. During the establishment of the company lockout-tagout program, you have: trained employees, provided locks and tags, and developed a generic general-purpose servicing procedure. You have had no accidents involving the unexpected activation or reenergization of machines or equipment during the last 10 years. Under which of the following situations could you still be cited by OSHA, under the requirements in 1910.147?

A. There are no equipment or machines with stored energy.
B. Locks used for lock-out are color coded red.
C. Tags do not have employee pictures.
D. Several machines have multiple energy sources.

44. Which of the following correctly evaluates the Boolean expression shown below?

$$(A + A) \bullet (A + B) = A + B$$

A. A and not-A or A and B equals A and B.
B. A plus not-A and A plus B equals A plus B.
C. A plus A BAR and A plus B equals A plus B.
D. A or not-A and A or B equals A or B.

45. In addition to the metal fumes, metal oxides, and the products of combustion from vaporized paints and coatings from the welded items, what hazardous gas is produced during electric arc welding?

A. Hydrogen peroxide
B. Diacetyl
C. Ozone
D. Diethylamine

46. The driver of a commercial motor vehicle must comply with many stringent DOT requirements found in 49 CFR. Which of the following statements is *not* true regarding the DOT requirements?

A. Discounting emergencies, drivers must not drive more than 10 hours in any one period.
B. The use of radar detectors and CB radios is discouraged, but not illegal.
C. Drivers must maintain a logbook, current for 7 days.
D. Drivers may not be in control of a commercial motor vehicle for any period of time after having been on duty 15 hours following 8 consecutive hours off duty.

47. Which of the following *best* describes the term "ischemia"?

A. Buildup of lactates in the muscle tissue
B. Pooling of blood
C. Scarring of the lung tissue
D. Muscle disease most predominate in old age

48. Based on the sample data, the mean of the concentration was calculated at 0.7 ppm. The range was 0 ppm to 1.4 ppm. One hundred air samples were taken daily. The lower limit of the sampling device for the contaminant is 1.4 ppm. What is the *best* conclusion you can make from this information?

A. There is a ±1 standard deviation chance that the contaminant is 0.7 in the work area.
B. There is a ±2 standard deviation chance that the contaminant is at or above 1.4 in the work area.
C. There is a presence of the contaminant at or below 1.4 ppm in the work area.
D. There is not enough information to make a valid conclusion.

49. Two methods of sampling are compared. A correction to the random sampling error that contributes to the coefficient of variation for method "B" allowed the CV_T to be lowered to 0.05. If the mean of a single sample is 180, what is the standard deviation? Assume a standard distribution of data.

A. 11
B. 9
C. 3600
D. 99

50. You have been asked to inspect a metal manufacturing facility. Steel billet forging, casting, and other related operations are conducted in a high bay. There is a small office (low bay) attached to the building. What classification would you assign for the hazard of contents?

A. Low hazard
B. Ordinary hazard
C. High hazard
D. Extra high hazard

51. Fuel and oxygen cylinders in storage locations must be separated by a minimum distance, or a firewall must be provided. If a firewall is provided, the fire resistance rating of the wall must be at least:

A. ½ hour.
B. 1 hour.
C. 2 hours.
D. 3 hours.

52. Which of the following conditions would cause a safety professional the *most concern*?

A. Working in a 13 psia atmosphere
B. Working in a 120°F atmosphere
C. Heat load of 3500 BTU per hour
D. Airflow resulting in one air change every 5 minutes

53. Padding installed inside a sound booth is used to reduce which of the following kinds of noise?

A. Reflected
B. Low frequency
C. High frequency
D. Direct

54. Flash point is defined as the _____temperature that will produce a vapor concentration high enough to propagate a flame when a source of ignition is present.

A. lowest
B. highest
C. normal
D. absolute

55. A brake system on an experimental motorcycle has three components: the *master cylinder*, *brake cylinder*, and the *brake line*. The failure probability on the master cylinder is 1×10^{-3}, the probability of failure on the brake cylinder is 1×10^{-2}, and the probability of failure on the line is 1×10^{-4}. What is the overall *reliability* of the brake system?

$$\text{Reliability} = 1 - P_{\text{Failure}}$$

A. 99.9%
B. 50%
C. 88.9%
D. 98.9%

56. A computer parts distributor purchases parts from overseas locations and markets these parts in the United States. The distributor receives 25% of its parts from country "A," who has a 10% reject rate; 25% from country "B" who has a 15% reject rate; 12.5% from country "C" with a 10% reject rate; and 37.5% from country "D" with a 2% reject rate. If you purchase a defective part, what is the probability it came from country "C"?

A. 10%
B. 15%
C. 20%
D. 25%

57. Chromium is used in many occupations, such as welding, plating, and chemicals and dyestuff manufacturing. If proper ventilation is not provided, workers can be exposed to chromic acid fumes. What is the health hazard from this exposure?

A. Severe corrosive action on skin
B. Inflammation and perforation of nasal septum
C. Cyanosis (bluish discoloration)
D. Brittleness of nails

58. Acetylene reacts violently with which of the following?

A. Bromine
B. Radon
C. Halon
D. Fluorine

59. The term "express warranty" implies or states that a product will do all of the following *except*?

A. Remain safe for the life of the product
B. Will perform in a specific manner
C. Contains specific safety provisions
D. Is suitable for a specific use

60. What is a graphic display used in project management of schedule-related information called?

A. Gantt chart
B. Line chart
C. Pie chart
D. PERT chart

61. The process that involves cooling a vapor by refrigeration to capture contaminants is known as:

A. adsorption.
B. absorption.
C. combustion.
D. condensation.

62. *Dose* is defined as the amount of energy or substance absorbed in a unit volume or an organ or individual. The term "dose" does *not* involve which of the following factors?

A. Health of the individual
B. Time of exposure
C. Amount of exposure
D. Toxicity of materials

63. While monitoring plant workers, you discover that the TLV-STEL is being exceeded for more than one hour, each work shift. Which of the following courses of action is appropriate?

A. Continue monitoring and compute a new TWA.
B. Recommend that the operation be curtailed immediately.
C. Send the instrumentation for calibration.
D. Continue as long as you do not exceed TLV-C values.

64. Which of the following diseases is associated with animal products?

A. Anthracosis
B. Anthrax
C. Pneumoconiosis
D. Presbycusis

65. What is the desired air velocity (fpm) for an activity that produces high heat loads for workers?

A. 50 fpm
B. 100 fpm
C. 500 fpm
D. 4000 fpm

66. Which of the following equations describes the deterioration of radioactive nuclei?

A. $N_t = N_0 e^{-kt}$
B. $N_t = \ln x^{-6CE}$
C. $k = \ln x_{L-Max}$
D. B = CE6

67. In product safety, the term "safety factor" is defined as:

A. the extra margin of safety over intended use.
B. a scale from 1 to 10.
C. the product's cost factor.
D. maximum strength over breaking strength.

68. Which of the following sampling strategies is appropriate for determining if an exposure is above the ceiling concentration?

A. Grab sampling
B. Dosimeters
C. 15-minute personal monitoring
D. 8-hour personal monitoring

69. Which one of the following parts of the eye is *most likely* to suffer acute damage through exposure to infrared radiation?

A. Fovea centralis
B. Pupil
C. Retina
D. Sclera

70. What is the pneumoconiosis that is caused by inhalation of iron oxide called?

A. Anthracosis
B. Siderosis
C. Silicosis
D. Silicosiderosis

71. Colorimetric tubes, sometimes referred to as Dräger-Tubes®, are often used in routine measurements. Which of the following explanations *best* describes the wide use of these tubes?

A. One tube can be used for a large number of samples.
B. One tube can be used for a large number of contaminates.
C. Tubes are cheap and easy to read.
D. Tubes are expensive but provide very precise results.

72. Which of the following is a quick screening test for a chemical's potential to be a carcinogen?

A. Ames assay
B. Soot bio-assay
C. Pyrolysis
D. Precipitation

73. The maximum angle for a ramp is __ degrees.

A. 15
B. 20
C. 30
D. No maximum angle.

74. The company management has established a safety performance goal of reducing one of the company's annual incidence rates to 0.50 recordable injuries. The company has defined a recordable injury as any injury that requires treatment of first aid or higher. The index this company uses in calculating annual incidence rates is 100 employees working 40 hours per week for 50 weeks. What are this company's annual recordable injury incidence rates for Year 1, Year 2, Year 3, and Year 4, respectively?

A. 0.18, 0.15, 0.18, 0.21
B. 0.44, 0.46, 0.28, 0.36
C. 0.82, 0.79, 0.47, 0.45
D. 1.27, 1.23, 0.93, 0.99

Year	Number of Recordable Injuries	Number of Total Hours Worked by All Employees
1	18	4,400,000
2	15	3,600,000
3	13	5,800,000
4	17	7,200,000

75. This business metric is *best* described as what kind of safety performance benchmark?

Year	Number of Recordable Injuries	Number of Total Hours Worked by All Employees
1	18	4,400,000
2	15	3,600,000
3	13	5,800,000
4	17	7,200,000

A. Leading indicator
B. Lagging (trailing) indicator
C. General indicator
D. Strategic indicator

76. OSHA, in the Process Safety Management of Highly Hazardous Materials, requires employers to establish an incident investigation capability. The intent is to respond and investigate incidents, which did or could have resulted in catastrophic releases of covered chemicals. This would, of course, include near misses. Which of the following is *not* true concerning this incident investigation?

A. Should investigate no later than 72 hours after
B. Should render a written report
C. Should include at least one knowledgeable person
D. Should be tasked to investigate and analyze

77. If you are going to select a software program to track and monitor your accidents and rates, the *best* option would be a:

A. database.
B. spread sheet.
C. word processing.
D. financial management.

78. Which of the following is *not* required under Total Quality Management (TQM)?

A. Commitment by top management to quality in all areas of organization
B. Continuous improvement programs implemented throughout organization
C. A procedural process control for document improvements
D. Measure systems used to identify areas where improvements can be used

79. Which of the following is the strongest acid?

A. Hydrofluoric
B. Sulfuric
C. Perchloric
D. Hydrocyanic

80. A container displays a vacuum pressure of –6 psig at sea level and STP. The pressure expressed in psia is:

A. 7.7 psia.
B. 14.7 psia.
C. 20.7 psia.
D. 8.7 psia.

81. If a tank contains 60% normal air and 40% hydrocarbons, what is the oxygen content of the vessel?

A. 21%
B. 12.6%
C. 16.6%
D. 20.8%

82. Which of the following principles forms the theoretical basis for diffusive sampling?

A. Fick's Law
B. Charles' Law
C. Raoult's Law
D. Henry's Law

$$Q = \frac{(DA)\, t\, (C_e - C_o)}{L}$$

83. The maximum concentration of a solute, which can be carried in water under equilibrium conditions, is called:

A. dissolvability.
B. water solubility.
C. dissolution.
D. water insolubility.

84. If the disintegration constant (k) of radium is $1.36 \times 10^{-11} sec^{-1}$, what is the half-life of radium?

A. 1600 years
B. 600 years
C. 3200 years
D. 9 months

$$T = \frac{-\ln \frac{1}{2}}{k}$$

85. A facility manufactures electronic components. These components are moved throughout the facility using two types of four-wheel hand trucks: type "A," which weigh 55 pounds; and type "B," which weigh 115 pounds. The coefficient of friction for both carts is 0.12. What is the maximum weight that can be carried in the "A" cart with a 20-pound pushing force?

A. 95 lbs
B. 167 lbs
C. 112 lbs
D. 222 lbs

$$F = \mu N$$

86. Safety regulations require a use zone of 6 feet to surround stationary playground equipment for general public safety. What are the minimum measurements for the placement of children's monkey bars that are 7 feet tall and have an 8 foot × 6 foot footprint?

A. 8 feet × 6 feet
B. 18 feet × 14 feet
C. 19 feet × 18 feet
D. 20 feet × 18 feet

87. If a second set of monkey bars was placed with the 8-foot sides facing each other, the minimum area needed would be _____.

A. 10 feet × 18 feet
B. 28 feet × 21 feet
C. 20 feet × 33 feet
D. 21 feet × 35 feet

For the following three questions, refer to the following information.

Two tank farms are on located plant property. Tank farm number one contains one fuel storage tank 132 feet in diameter and 42 feet high. This tank farm has no diking. Tank farm number two is completely diked and contains

four fuel storage tanks. Tank number one is 100 feet in diameter and 35 feet high. Tanks two and three are 50 feet in diameter and 15 feet high. Tank number four is 40 feet in diameter and 15 feet high. The area enclosed by diking is 220 feet by 330 feet.

88. Calculate the storage capacity of the fuel tank located in tank farm number one.

A. 4,300,000 gallons
B. 2,500,000 gallons
C. 6,800,000 gallons
D. 555,456 gallons

89. The proposed new dike for tank farm number one is 425 feet on each side and 3 feet high. Assuming that this dike meets all other distance requirements, is it acceptable?

A. No, it is short on capacity by 250,000 gallons.
B. Yes, it is more than sufficient.
C. No, it is short on capacity by 25,000 gallons.
D. Yes, it is acceptable by a safety factor of 2.

90. The required height for a dike enclosing tank farm number two, assuming no slope on dike walls, is:

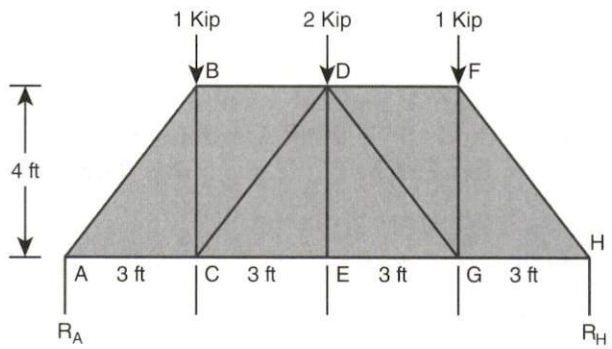
A. 3.8 feet.
B. 4.0 feet.
C. 4.1 feet.
D. 5.6 feet.

91. A CSP is asked for suggestions in designing a training room. The projection screen on the front wall is to be 5 feet by 5 feet. The recommended seating locations for this size screen is ±25 degrees of the screen center line and six screen widths (6W) at the back of the room. What is maximum length of the room to maintain these parameters?

A. 20 ft
B. 32 ft
C. 38 ft
D. 54 ft

$$\sin A = \frac{a}{c} \quad \cos A = \frac{b}{c} \quad \tan A = \frac{a}{b}$$

92. Which of the following truss members could be replaced with a cable and a turnbuckle tensioning device?



A. Members AB and FH
B. Members BD and DF
C. Members BC, DE, and FG
D. Members DG, CD, and GH

93. Assuming the data follows a normal distribution with a mean of 1800 hours and a standard deviation of 250 hours, what is the probability of the component failing if operated until 1400 hours?

AREAS UNDER THE STANDARD NORMAL CURVE FROM 0 TO Z										
z	0	1	2	3	4	5	6	7	8	9
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633

A. About 11.66%
B. About 8.33%
C. About 7.5%
D. About 5.5%

$$z = \frac{X - \mu}{\sigma}$$

94. Which of the following represents a similar method to Pearson product-moment of coefficient correlation?

A. Poisson distribution
B. Chi-square
C. T-distribution
D. Spearman rank

95. Incident frequency distributions that are represented as graphs are called:

A. histograms.
B. confidence intervals.
C. pictograms.
D. bar graphs.

96. The goal of sound experimental design in safety research is the elimination of:

A. dependent variables.
B. independent variables.
C. confounding variables.
D. controlled variables.

97. Two sets of sampling data are compared: the coefficient of variation for method "A" is 0.09; the coefficient of variation for method "B" is 0.08. Assuming that the mean for each method is approximately equal, what inferences can be made given this data?

A. The data from method A has a smaller chance of error.
B. Method A was developed from a larger database than B.
C. The standard deviation is larger for A than B.
D. The data for method A is clustered closer to the mean than for method B.

98. If $1,000 is invested in an investment account paying 8% interest, how much will be accumulated in the account at the end of 10 years?

A. $2535
B. $3125
C. $2159
D. $2076

$$F = P(1 + i)^n \qquad P = F(1 + i)^{-n}$$

99. A safety manager proposes to replace an old piece of equipment with a newer model due to a high accident rate on the old equipment. The useful life of new equipment is 10 years with an annual accident cost averaging $1000 per year. Considering only the cost of accidents and the annual rate for monies is 8%, what is the maximum investment above the new equipment cost that would justify the purchase?

A. $6652
B. $7265
C. $6710
D. $6842

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right) \qquad P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

100. What is the lump sum of money required now to avoid an annual end-of-year expense of $2000 for 7 years with interest at 11.25%?

A. $8741
B. $9456
C. $9122
D. $9349

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right) \qquad P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

Self-Assessment 2 Answers

1. Answer: **C**. OSHA Standard 1904.4 requires a supplementary record of all occupational injuries or illnesses. The supplementary record must be available for inspection within 6 working days after the employer receives information that an occupational injury or illness has occurred. The standard does not specify any individual type of record and in the past OSHA has accepted workers' compensation first report of injury forms, insurance forms, local company forms, etc. Additionally, the OSHA Form 301 is designed to be used for this purpose.

2. Answer: **B**. The American Society of Mechanical Engineers (ASME) is the primary agency providing oversight of pressure vessels in the United States.

3. Answer: **B**. The EPA and OSHA would be most concerned with this firm's operations. The other agencies listed are not considered *regulatory!*

4. Answer: **B**. Labeling of chemicals within industrial plants are controlled by OSHA.

5. Answer: **B**. According to *Fundamentals of Management*, this question can be answered in management terms of team building. The management team has functions similar to a production team.
   - The team must have a real reason for existing.
   - Team members must depend on each another.
   - Team members must have a similar status.
   - Communication must be open and trusting.
   - The team members must understand their particular jobs and how they interrelate to the other functions.

6. Answer: **D**. The concept of *dangerous instrumentality* dictates that an individual who keeps, maintains, transports, or stores a dangerous creature, device, or substance is liable for injury or damage, regardless of fault, even when they exercise due care.

7. Answer: **B**. The most common coverage parts available to commercial enterprises are:
   - CGL = Comprehensive general liability
   - OL&T = Owners, landlords, and tenants
   - M&C = Manufacturers and contractors
   - OCP = Owners and contractors protection
   - SL = Storekeepers liability
   - GL = Garage liability

   APCL is not a valid coverage.

8. Answer: **B**. OSHA 1910.134(d) states that compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiration must "meet at least the requirements of the specification for Grade D breathing air as described in Compressed Gas Association Commodity Specification G-7.1-1996." The requirement further states that compressed oxygen shall not be introduced into supplied-air respirators or in open circuit self-contained breathing apparatus that have previously used compressed air. Also, oxygen shall never be used with airline respirators.

9. Answer: **A**. The straight process line allows the hazardous processes to be isolated from the rest of the production or assembly process thus ensuring better protection of the facility and personnel. Product layout lines tend to group assembly or manufacturing together based on factors such as distance and homogeneous assignment rather than safety.

10. Answer: **D**. Man is more flexible than machines, which allows him to perform complex problems involving intangible variables.

11. Answer: **D**. Safety and the responsibility for achieving it rest with management—primarily with the organization's chief executive officer but, in a shared manner, with all other managers.

    There has always been disagreement in management circles about just how to accomplish safety, but there has always been agreement that management of safety, like all other functions has to start at the top and be supported by subordinate executives and managers. Supervisors, foremen, and workers develop their attitude about the importance of safety and health from both formal and informal clues. A divided position by senior executives sends a clue that management is really not all that interested in safety, and it is just another one of those things they are required to say.

    Management of the safety and health effort is both an art and a science, and the director of Safety & Health is merely the steward of the function. When safety is effective, the entire management team deserves the credit; likewise when it fails, the entire team deserves the blame. The recommended way to ensure that line supervisors are held accountable for safety performance is to build written management safety policies and enforcement principles into line supervisor accountability.

    In the situation described, it appears that failure of the accident prevention program is symptomatic of a larger problem—that of failed management. Therefore, training on accident prevention elements will not prove effective without first establishing a firm foundation based on sound management principles. Safety is not a separate program; rather, it is simply a part of overall management.

12. Answer: **D**. Reference 49 CFR 392.9b:

    A driver whose hearing meets the minimum requirements only when he wears a hearing aid shall wear a hearing aid and have it in operation at all times while he is driving. The driver must also have in his possession a spare power source for use in the hearing aid. There are no other restrictions on these drivers.

    United States, Federal Motor Carrier Safety Regulations, The Bureau, 1975.

13. Answer: **C**. Should you choose to use "before and after testing" as an indicator of training effectiveness, the tests should cover the same areas but be phrased differently. This allows a determination to be made concerning comprehension levels rather than "read and remember" skills.

14. Answer: **C**.

    Some safety engineering professionals question the lack of design and engineering influence on the accident causation model advanced by management theorists (based on behavioral aspects). These professionals do not believe that the majority of safety practice should deal with behavior or administrative controls, and that strict compliance with codes, standards, regulations, and good engineering designs will prevent the vast majority of accidental losses.

15. Answer: **C**. A builder's risk form of insurance covers the building and structure, which includes the structure (i.e., roof, foundation, additions, attachments, fixtures, supplies, building equipment, etc.). Additionally, it generally covers the builder's machinery and equipment while on the premises or within 100 feet of it. Sometimes additional coverage including the property of others is included that is in the care, custody, and

control of the contractor. This type of policy is also frequently used to insure ship construction from the time the keel is laid until the finished vessel passes acceptance tests. Additionally, the marine version of builder's risk coverage provides a form of guarantee of the materials used in the construction of the vessel, thereby providing protection for the replacement of defective parts.

16. Answer: **C**. The manufacturers and contractors (M&C) coverage is designed to provide liability protection to individuals and commercial enterprises whose exposure is largely away from the premises—for example, consulting engineers, remediation specialists, fire fighters, various sales, and service organizations, etc. The basic M&C coverage most often provides:

    - Premises coverage
    - Contractual liability for "incidental contracts"
    - Liability for operations performed by the insured away from the premises
    - Liability for operations performed by the insured or by independent contractors involving maintenance and repairs at premises owned or rented to the insured, and structural alterations at the owned or rented premises

    The M&C policy does not include products liability and completed operations insurance.

17. Answer: **C**. The accounting function is responsible for analyzing financial reports where it is management who interprets the information in light of the various market indicators.

18. Answer: **B**. In the legal and insurance vocabulary "completed operations liability" refers to the liability of the contractor that remains after all of the work has been completed and abandoned by the contractor. These exposures arise from services performed by a firm or organization, after the performance of such service has been completed. For example, the contractor who constructed and installed a faulty patio cover is liable for the injuries to a guest of the owner who contracted for the work.

19. Answer: **C**. NIOSH is the only agency listed that does not have some power in issuing a recall of consumer products in the United States.

20. Answer: **B**. Workers only have the right to contest the abatement date of OSHA citations they have no say in the working of the compliance officer's citation and cannot negotiate the corrective actions. Complaints can be made if the corrective actions do not correct the violation.

21. Answer: **C**. The classical approach to management, which included the bureaucratic organization, surfaced at the turn of the century and consisted of three branches: (1) scientific management, (2) administrative principles, and (3) bureaucratic organization. The bureaucratic organization was characterized by a highly structured organizational structure, containing a rigid authority hierarchy, formal description of duties and responsibilities, firm rules and procedures, stern requirements for personnel selection, and a professional manager to govern the organization. Following the demise of the classical approach came the behavioral approaches, the quantitative approaches, and the modern approaches to management.

22. Answer: **D**. The Management Oversight and Risk Tree (MORT) is a specific, detailed analytical method of evaluation of developing a safety program. It can also be used as an investigation tool to determine what is wrong with the accident prevention effort. MORT according to the developers Bill Johnson and Bob Nertney, focuses on three main concerns:

    - Specific oversights and omissions
    - Assumed risks
    - Management system weaknesses

    The system uses as a model an extensive MORT "tree." In practice the users of the system frequently use two sides of the tree: (1) Management Weaknesses (management factors) and (2) Oversights and Omissions (specific control factors).

23. Answer: **D**. A safety professional's first action is to always identify and quantify the problem before recommending solutions.

24. Answer: **C**. The following is the recommended areas for team building. The management team has functions similar to a production team.

    - The team must have a real reason for existing.
    - Team members must depend on each other.
    - Team members must have a similar status.
    - Communications must be open and trusting.
    - The team members must understand their particular jobs and how they interrelate to the other functions.

25. Answer: **A**. This is the definition of a risk matrix.

26. Answer: **C**. Although it is possible for an auditor to perform a valid audit within the department which they have responsibilities, it is best to be audited by an outside auditor so that the final report will be perceived to be free of bias.

    When possible, it is best for auditors to verify in person that management processes are being implemented as documented. Otherwise, auditors have to rely on in-house certifications that the processes are being conducted properly.

27. Answer: **B**. In accordance with ISO 14000 and OHSAS 18001, a member of the management team must certify that such reviews were conducted. The certification must include the dates of the reviews and a list of the findings or that the company is in compliance. This type of written proof is common in the auditing process, because auditors are not able to verify firsthand that all management processes were conducted.

28. Answer: **C**. In accordance with NFPA, to find the minimum ventilation requirement in ft^3 of air per liter of a chemical that is needed to dilute vapors to a point at or below 25% of the LFL, you use the following formula (not provided on the BCSP formula sheet).

$$\frac{4 \times (100 - \text{LFL}) \times \text{SV}}{\text{LFL}} = \frac{m^3}{\text{ltr}}$$

$$\text{LFL} = 2.1\% \qquad \text{SV} = 0.212$$

$$\frac{4 \times (100 - 2.1) \times 0.212}{2.1} = 39.533 \frac{m^3}{\text{ltr}}$$

29. Answer: **A**. ISO 14001 is applicable to any organization that wishes to establish, implement, maintain, and improve an environmental management system to assure itself of conformity with its stated environmental policy and to demonstrate conformity with ISO 14001 by either:

    - making a self-determination and self-declaration;
    - seeking confirmation of its conformance by parties having an interest in the organization, such as customers;
    - seeking confirmation of its self-declaration by a party external to the organization; or
    - seeking certification/registration of its environmental management system by an external organization.

    All the requirements in ISO 14001 are intended to be incorporated into any environmental management system. The extent of the application will depend on factors such as the environmental policy of the organization, the nature of its activities, products and services, and the location where and the conditions in which it functions.

    Reproduced from ISO 14001:2004. *Environmental Management Systems — Requirements with guidance for use.*

30. Answer: **B**. OSHA requires employers to certify that they have evaluated compliance with process safety requirements at least every three years. Prompt response to audit findings and documentation that deficiencies are corrected is required. Employers must retain the two most recent audit reports.

    Additionally, 1910.119 requires each employer to have written operating procedures to perform a process hazard analysis and to conduct training.

31. Answer: **C**. OSHA in Guidance for Hazard Determination, for Compliance with the OSHA Hazard Communication Standard (29 CFR 1910.1200) states, "Chemical manufacturers, importers and employers evaluating chemicals shall treat the following sources as establishing that a chemical is a carcinogen or potential carcinogen for hazard communication purposes:

    - National Toxicology Program (NTP), "Annual Report on Carcinogens" (latest edition)
    - International Agency for Research on Cancer (IARC) "Monographs" (latest edition)
    - 29 CFR part 1910, subpart Z, Toxic and Hazardous Substances"

    Note: The "Registry of Toxic Effects of Chemical Substances" published by the National Institute for Occupational Safety and Health (NIOSH) indicates whether a chemical has been found by NTP or IARC to be a potential carcinogen.

    The IARC provides a summary classification of a chemical's carcinogenic risk according to the following table:

    Group 1 The agent is carcinogenic to humans

    Group 2A The agent is probably carcinogenic to humans

    Group 2B The agent is possibly carcinogenic to humans

    Group 3 The agent is not classifiable as to its carcinogenicity to humans

    Group 4 The agent is probably not carcinogenic to humans

    All IARC listed chemicals in Groups 1 and 2A must include appropriate entries on both the MSDSs and on the label. Group 2B chemicals need be noted only on the MSDSs.

    The use of in vitro (short-term) testing (such as the Ames assay) has not been specifically addressed in the Hazard Communication Standard. However, it is the consensus within OSHA that the results of an "in vitro" test alone, do not represent significant enough information to establish a health hazard for purposes of the hazard communication standard.

32. Answer: **A**. According to the *Fundamental of Industrial Hygiene*, an **industrial toxicologist** is one who studies the harmful, or toxic, properties of substances and determine dose thresholds. An **industrial hygienist** is one devoted to the art and science of anticipation, recognition, evaluation, and control of those environmental factors in the workplace that may cause sickness, impaired health, and well-being. A **health physicist** studies the field of science concerned with radiation physics and radiation biology with the goal of providing technical information and proper techniques regarding the safe use of ionizing radiation. **Pathologists** are physicians who diagnose and characterize disease in living patients by examining biopsies or bodily fluid. Pathologists may also conduct autopsies to investigate causes of death.

33. Answer: **D**. OSHA at 1920.95(g)(10)(i) states "a standard threshold shift is a change in hearing threshold relative to the baseline audiogram of an average of 10 dB or more at 2000, 3000, and 4000 Hz in either ear."

34. Answer: **C**. According to ANSI B11.TR3, the correct sequence of steps in a Task-Based Machine Risk Assessment and Reduction is:

    1—Determine the limits of the machine.

    2—Determine the tasks to be performed over the life cycle of the machine.

    3—Identify the hazards associated with these tasks and rate their severity.

    4—For each hazard, establish the probability of a hazardous event.

    5—Determine the level of risk. If it is not tolerable, continue.

    6—Eliminate the hazard or reduce its severity (lessen energy or toxicity).

    7—Determine the appropriate type and minimum required level of performance of protective (safeguarding) measures to provide the desired degree of risk reduction, using the Safety Hierarchy as a guide.

35. Answer: **B**. The GHS Working Group identified about 35 different types of information that are currently required on labels by different systems. To harmonize, key information elements needed to be identified. Additional harmonization may occur on other elements in time, in particular for precautionary statements. The elements identified below are ***standardized:**

    - Product identifier
    - Supplier identifier
    - Chemical identity
    - Hazard pictograms*
    - Signal words*
    - Hazard statements*
    - Precautionary information

36. Answer: **A**. The GHS symbols have been incorporated into pictograms for use on the GHS label. Pictograms include the harmonized hazard symbols plus other graphic elements, such as borders, background patterns, or colors, which are intended to convey specific information (**Figure 29**). For transport, pictograms will have the background, symbol, and colors currently used in the UN Recommendations on the Transport of Dangerous Goods, Model Regulations. For other sectors, pictograms will have a black symbol on a white background with a red diamond frame. A black frame may be used for shipments within one country. Where a transport pictogram appears, the GHS pictogram for the same hazard should not appear.

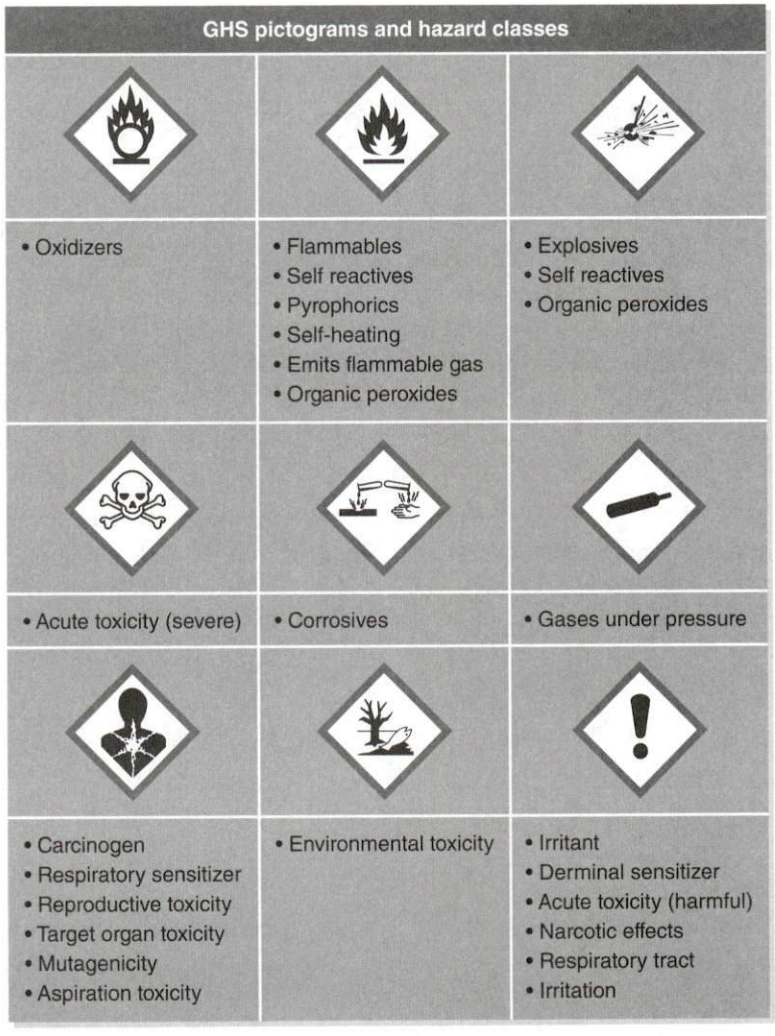


Figure 29 GHS Pictograms and Hazard Classes

OSHA, Hazard Communication Standard Pictogram, U.S. Department of Labor.

37. Answer: **C**. According to NFPA 241, the owner is responsible for loss prevention. He or she should make one person responsible for the fire prevention program. NFPA believes this person (Fire Prevention Program manager) should ensure that a mishap prevention program is carried out until completion of the project. The Fire Prevention Program manager should implement a safety awareness program to include the maintenance of clear access lanes for firefighting equipment, establishment of cutting and welding permit programs, proper use and storage of flammable liquids, fire extinguisher training, training on roofing operations, etc.

38. Answer: **A**. All of the processes listed are used in air cleaning of gases and vapors. However, the method cited is that of *adsorption*. Adsorption involves an action that takes place at the surface of the adsorbent material where gas and solid make contact. The most widely used adsorbent for cleaning air is activated carbon, which most often is placed in canisters, perforated cans, or trays. Activated carbon has the ability to adsorb gases and vapors up to about 60% of its own weight. If the carbon is then heated the captured material can then be reclaimed, making it an attractive and cost-effective process. *Condensation* is the process of lowering the temperature of the incoming air to change the vapor to a liquid state. The process uses various chillers, condensers, or refrigeration units to lower the temperature of the vapor. *Combustion* is a process used for removal of gas or vapor if it can be oxidized to a harmless or odor free state. Many times, this takes the form of a direct-flame afterburner. Catalysts are also used to great effect in paint disposal, animal fats, plastics etc. *Absorption* is the process of using a liquid, which dissolves or chemically reacts with the gas or vapor that is to be removed.

39. Answer: **A**. Future savings are extremely hard to calculate because they are in large part comprised of the indirect underlying cost of accidents.

40. Answer: **A**. System safety is a rigorous concept that involves a planned systematic before-the-fact search for accident producing factors and provides evaluations of these factors to management. A system safety program plan usually has a narrative analysis of schedule times and resources. The first phase to support the definition of mission element needs by identifying safety deficiencies in an existing system and by identifying opportunities for system safety to improve the mission capability is called the *system safety program plan.*

41. Answer: **A**. Tables are constructed as time-saving devices and always show exact answers, although they may use conventional rounding techniques to allow standardization.

42. Answer: **C**. The designation "dry powder" has been especially chosen to indicate an agent's suitability for use on Class D (combustible metal) fires. The term "dry chemical" is reserved for agents effective on A:B:C or B:C fires.

43. Answer: **D**. In accordance with OSHA 1910.147 (c)(4)(ii) individual energy control procedures are required for machines or equipment that have more than one energy source, that is, they must be locked out at different locations to ensure safety. These individual procedures must contain provisions for outlining the techniques to be used for each machine. They must include:

    - specific steps for shutting down the machine;
    - specific steps for the placement, removal, and transfer of lockout or tagout devices; and
    - specific steps to test the machine or equipment to ensure the isolation of energy

44. Answer: **D**. When evaluating boolean logic and applications, the sign + is read "or" (i.e., A + B becomes A or B. The sign "·" is read "and"; thus, A · B is stated A and B. The "A-bar" symbol is read "not-A."

    The expression $(A + \overline{A}) \bullet (A + B) = A + B$ is read:

    A or not-A and A or B equals A or B

    The expression $A \times (B + C) = (A \times B) + (A \times C)$ is also described as a union of one subset with two others can also be expressed as the union of their intersections.

45. Answer: **C**. The *Accident Prevention Manual for Business and Industry: Engineering and Technology,* 12th edition, National Safety Council explains that electric arc welding produces ozone (O_3), a hazardous gas.

46. Answer: **B**. Reference 49 CFR 392.71 Radar detectors; use and/or possession.

(a) No driver shall use a radar detector in a commercial motor vehicle, or operate a commercial motor vehicle that is equipped with or contains any radar detector.

(b) No motor carrier shall require or permit a driver to violate paragraph (a) of this section.

Federal Motor Carrier Safety Administration, DOT § 395.3 Maximum driving and on-duty time.

(a) Except as provided in 395.1(b)(1), 395.1(f), and 395.1(i), no motor carrier shall permit or require any driver used by it to drive nor shall any such driver drive:

(1) More than 10 hours following 8 consecutive hours off duty; or (2) for any period after having been on duty 15 hours following 8 consecutive hours off duty.

(b) No motor carrier shall permit or require a driver of a commercial motor vehicle, regardless of the number of motor carriers using the driver's services, to drive for any period after:

(1) Having been on duty 60 hours in any 7 consecutive days if the employing motor carrier does not operate every day in the week; or (2) Having been on duty 70 hours in any period of 8 consecutive days if the employing motor carrier operates motor vehicles every day of the week

Federal Motor Carrier Safety Administration, DOT § 395.13 Drivers declared out of service

(a) Authority to declare drivers out of service. Every special agent of the Federal Highway Administration (as defined in appendix B to this subchapter) is authorized to declare a driver out of service and to notify the motor carrier of that declaration, upon finding at the time and place of examination that the driver has violated the out of service criteria as set forth in paragraph (b) of this section.

(b) Out of service criteria. (1) No driver shall drive after being on duty in excess of the maximum periods permitted by this part.

(2) No driver required to maintain a record of duty status under 395.8 or 395.15 of this part shall fail to have a record of duty status current on the day of examination and for the prior seven consecutive days.

(3) Exception. A driver failing only to have possession of a record of duty status current on the day of examination and the prior day, but has completed records of duty status up to that time (previous 6 days), will be given the opportunity to make the duty status record current.

47. Answer: **B**. Ischemia is defined as the obstruction or pooling of blood in some part of the body. In the study of human factors and ergonomics tool designs are often developed to avoid this affliction. For example, a common pliers requires considerable force to be applied in the use of the tool. This force obstructs blood flow (ischemia) through the ulnar artery and results in numbness and tingling of the fingers. Progressive tool design provides for large contact areas that distribute forces thereby eliminating the problem.

48. Answer: **C**. The sampling instrument is at or near its capabilities and its measurements are suspect at best. The device has detected some level of the contaminant, however using this information to perform any valid statistical analysis is not possible. The only real conclusion is that there is a presence of the contaminant and that it is at or below the detection limits of the device.

49. Answer: **B**.

$$CV = \frac{\sigma}{\bar{x}}$$

$$= \bar{x} \times CV$$

$$= 180 \times 0.05$$

$$= 9$$

50. Answer: **B**. Definitions for Hazard of Contents classifications can be found in NFPA 101 (Section 4-2.2). A *low-hazard* area has such low combustibility that no self-propagating fire can occur. An *ordinary hazard* area has contents that are likely to burn with moderate rapidity or emit considerable amounts and volumes of smoke while burning. A *high-hazard* area's contents are likely to burn with extreme rapidity or are likely to have explosions.

51. Answer: **A**. Per the OSHA code, firewalls separating fuel and oxygen cylinders must have at least a 30-minute rating and be at least 5 feet high. This is discussed in OSHA 1910.252.

52. Answer: **C**. Total heat load is a combination of the heat produced by the body and the environmental heat the body is exposed to. Working in a *120-degree environment* is certainly a situation that would cause concern but is overshadowed by the heat load of *3500 BTU/hr (1000 kcal/hr)*. Extremely heavy work is about 2000 BTU/hr; a load of 3500 BTU/hr is an obvious, severe hazard. An atmosphere of *13 psia* could be encountered within a wide range of occupations and is not a major concern. *Airflow of one air change every five minutes* could be acceptable with no other information given. However, it should be noted that the number of air changes is a poor basis for ventilation when environmental control of hazards is required. Airflow measured in "changes per minute" is a concept easily understood, but this rapid understanding coupled with ease of application often allows the real problems (contamination control) to go unabated.

53. Answer: **A**. Padding installed inside booths or enclosures is to prevent reflected noise from adding to the overall noise level.

54. Answer: **A**. The flash point of a liquid corresponds roughly to the lowest temperature at which the vapor pressure of the liquid is just sufficient to produce a flammable mixture at the lower limit of flammability (National Fire Protection Association, 2017).

55. Answer: **D**.

Step 1: Solve for P_F $(1 \times 10^{-3}) + (1 \times 10^{-2}) + (1 \times 10^{-4}) = 1.11 \times 10^{-2}$

Step 2: Solve for Reliability $1 - 1.11 \times 10^{-2} = 98.89\%$

*Note: When dealing with probability of failure:

- Parallel construction indicates an "and" gate = multiply failure rates
- Series construction indicates an "or" gate = add failure rates
- Reliability = $1 - P_{Failure}$

56. Answer: **B**.

$$A = 25 \times 10 = 250$$
$$B = 25 \times 15 = 375$$
$$C = 12.5 \times 10 = 125$$
$$D = 37.5 \times 2 = 75$$
$$825$$

$$P_A = \frac{250}{825} = 0.303$$

$$P_B = \frac{375}{825} = 0.454$$

$$P_C = \frac{125}{825} = 0.1515$$

$$P_D = \frac{75}{825} = 0.09$$

57. Answer: **B**. According to NSC's Fundamentals of Industrial Hygiene, chromic acid is both an irritant (reaction contact) and a sensitizer (reaction appears after repeated or extended exposure). It causes ulcers (chrome holes) on the skin and inflammation and perforation of the nasal septum. The other three answers are skin disorders caused by exposure to oxalic acid commonly used in tanneries and blueprint paper manufacturing. Since chromium is used in all stainless-steel alloys, welding stainless steel can cause fumes of chromium to be released. These fumes may be in trivalent of hexavalent form. Additionally, electric arc welding produces ozone (O_3), which is a hazardous gas.

58. Answer: **D**. Acetylene is a nonpoisonous and mildly anesthetic gas. It is very flammable and forms explosive mixtures with air or oxygen. It will react extremely violently (explosively) with *chlorine and fluorine.*

59. Answer: **A**. An express warranty is a written or oral statement by a manufacture or dealer that a product will perform in a specific manner; a specific way; is suitable for a specific purpose; or contains specific safeguards.

60. Answer: **A**. This is the definition of a Gantt chart or bar chart. In the typical Gantt chart, schedule activities or work breakdown structure components are listed down the left side of the chart, dates are shown across the top, and activity durations are shown as date-placed horizontal bars. See **Figure 30**.

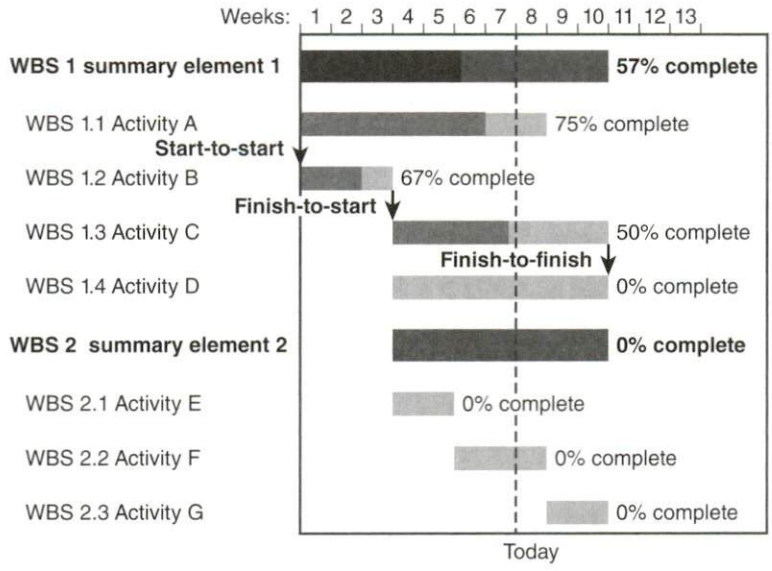


Figure 30 Gantt Chart Example

61. Answer: **D**. All of the processes listed are used in air cleaning of gases and vapors. However, the method cited is that of *condensation*. Condensation is the process of lowering the temperature of the incoming air to change the vapor to a liquid state. The process uses various chillers, condensers, or refrigeration units to lower the temperature of the vapor. *Adsorption* involves an action that takes place at the surface of the adsorbent material where gas and solid make contact. The most widely used adsorbent for cleaning air is activated carbon, which most often is placed in canisters, perforated cans, or trays. Activated carbon has the ability to adsorb gases and vapors up to about 60% of its own weight. If the carbon is then heated, the captured material can then be reclaimed, making it an attractive and cost-effective process. *Combustion* is a process used for removal of gas or vapor if it can be oxidized to a harmless or odor free state. Many times, this takes the form of a direct-flame afterburner. Catalysts are also used to great effect in paint disposal, animal fats, plastics etc. *Absorption* is the process of using a liquid, which dissolves or chemically reacts with the gas or vapor that is to be removed.

62. Answer: **A**. The term "dose" attempts to express exposure over time and does not take into account the health of the individual exposed.

63. Answer: **B**. TLV–STEL (*Threshold Limit Value–Short-Term Exposure Limit)* is the concentration to which workers can be exposed continuously for a short period of time without suffering from:

- Irritation
- Chronic or irreversible tissue damage
- Narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency

The STEL is defined as a 15-minute TWA exposure, which should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV–TWA. Exposures above the TLV–TWA up to the STEL should be no longer than 15 minutes for no more than four times per shift with at least 1 hour between excursions.

64. Answer: **B**.

    Anthrax is a highly virulent bacterial infection contracted from animals and animal products. Pneumoconiosis is dusty lung. Presbycusis is hearing loss due to age. Anthracosis is a disease of the lungs caused by prolonged inhalation of dust that contain particles of carbon and coal.

65. Answer: **D**. The amount of air motion acceptable to a worker performing heavy work would be in the vicinity of 3000 to 4000 fpm. Moderate loads would require about 2000 to 3000 fpm and light loads about 1000 to 2000. Lower velocities are acceptable only in air-conditioned spaces or in fixed workstations where very light heat loads are encountered.

66. Answer: **A**.

    The correct equation for radioactive nuclei decay is $N_t = N_0 e^{-kt}$.

    N_0 = Number of radioactive atoms at start point

    N_t = Number of radioactive atoms left after a specific amount of time

    k = Disintegration constant

    t = Time

67. Answer: **A**. The safety factor is that extra margin of safety designed into the product over and above its intended use.

68. Answer: **C**. In industrial hygiene practice if instantaneous monitoring is not feasible, then the TLV-C can be assessed by sampling over a 15-minute period except for those substances that may cause immediate irritation when exposures are short.

69. Answer: **C**. Infrared (IR) radiation passes easily through the cornea and the energy is absorbed by the lens and retina.

70. Answer: **B**. Anthracosis is a pneumoconiosis caused by the exposure to coal dust (black lung). Silicosis is a pneumoconiosis caused by inhalation of the dust of stone, sand, or flint containing silica. **Siderosis** is a lung disease caused by inhalation of iron oxide or other metallic particles. Silicosiderosis is a pneumoconiosis in which the inhaled dust is that of silica and iron.

71. Answer: **C**. Colorimetric tubes are relatively cheap, have a fairly long shelf life, and are easy to read. Colorimetric or Dräger-Tubes® are the most often used measuring device when taking industrial hygiene measurements.

72. Answer: **A**. The Ames test is a very popular quick screening test in use today. The Ames test or Ames assay is named after its chief developer, Dr. Bruce Ames, a biochemist at the University of California at Berkeley. The test uses various strains of Salmonella bacteria to screen suspect chemicals. The test does not measure carcinogenicity directly. It does however measure mutagenicity of a chemical. It is a widely accepted fact that almost all known mutagens are eventually found to be carcinogens. Remember, the test does not measure carcinogenicity directly but rather the potential for carcinogenicity.

73. Answer: **C**. The suggested maximum angle for a ramp is 30 degrees (**Figure 31**).

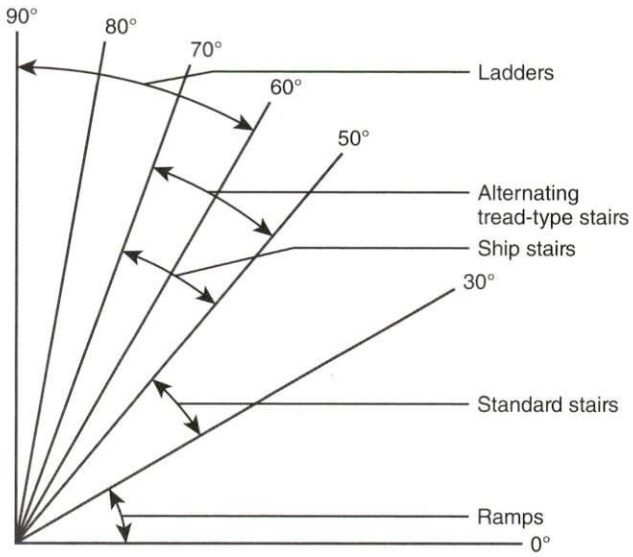


Figure 31 Angles for Stairs, Ramps, and Ladders

Occupational Safety and Health Administration. *1910.25 Walking-Working Surfaces: Stairways.* https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.25

74. Answer: **C**. This is described in the National Safety Council's *Accident Prevention Manual for Business and Industry: Administration and Programs*. The problem requires developing an incidence rate formula based on an annual index of 100 employees working 50 weeks for 40 hours per week. The annual incidence rate formula based on this specification will look like this.

IR = Number of annual cases × Index standard hours/Number of actual annual hours worked

The index will permit multiple facilities to be compared against a common indexing standard.

Step 1: Calculate the annual index standard hours worked.

100 employees × 40 hours per week × 50 weeks/year = 200,000 employee hours/year

Step 2: Calculate the recordable injury incidence rates for the four years using the above formula (**Table 33**).

Table 33

Year	# of Recordable Injuries	Hours Worked	Incident Rate
1	18	4,400,000	0.818
2	15	3,800,000	0.789
3	13	5,800,000	0.448
4	17	7,200,000	0.472

75. Answer: **B**. According to Dan Peterson in *Measurement of Safety Performance*, incidence rates are lagging indicators of safety performance. Overall safety performance cannot be judged by historical data such as this as incidence rates typically are poor performance indicators.

76. Answer: **A**. OSHA 1910.119 PSM standard requires employers to investigate as soon as possible, but no later than 48 hours after the incident which did result or could reasonably have resulted in catastrophic releases of covered chemicals. The standard calls for an investigation team, including at least one person knowledgeable in the process involved, a contract employee when the incident involved contract work, and others with knowledge and experience to investigate and analyze the incident and to develop a written report on the incident. Reports must be retained for five years.

77. Answer: **B**. A spreadsheet is a computer program that enables you to develop and perform all sorts of calculations between the text and values stored in the document. Most spreadsheets include charting and limited database capabilities.

78. Answer: **C**. According to the National Safety Council's definition of Total Quality Management (TQM), TQM requires the following:

    A. Commitment by top management to quality in all areas of organizational life, particularly health and safety
    B. Training and education in safety matters at all levels of the organization
    C. Continuous improvement programs implemented throughout the organization
    D. Measurement systems to identify areas where improvements can be made
    E. Communication fostered between management and employees, encouraging employee involvement and participation in quality improvement

79. Answer: **C**. *Strong* and *weak acids* or *bases* are classified by how completely they ionize in solution. For example, perchloric, nitric, hydrochloric, hydrobromic, hydriodic, and sulfuric acids are classified as strong acids. Examples of weak acids include boric, hydrocyanic, carbonic, and acetic acids (**Figure 32**). Aqueous hydrofluoric (HF(aq)) is not classified as a strong acid because it does not dissociate completely in water. However, it is a very dangerous acid if it contacts human tissues. HF burns are slow to heal, and the fluoride ion causes severe pain in any joint it reaches (e.g., the elbow from a hand burn). Common strong bases include lithium hydroxide (LiOH), sodium hydroxide (NaOH), potassium hydroxide (KOH), and quaternary amine hydroxides (R_4NOH). Common weak bases include ammonium hydroxide (NH_4OH), sodium carbonate (Na_2CO_3), certain organic amines, and more.

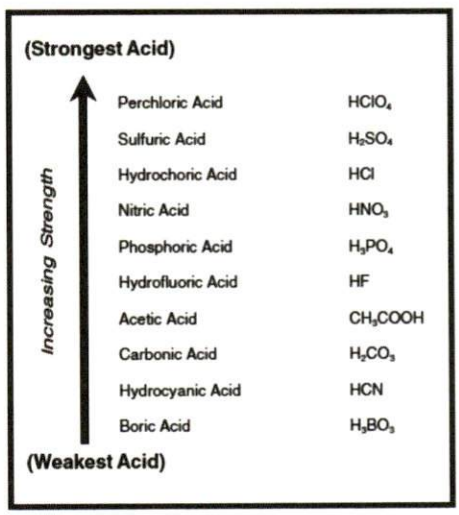


Figure 32 Relative Strengths of Acids in Water

80. Answer: **D**. Add 14.7 to psig to obtain psia.

    1 atm pressure

$$-6 + 14.7 = 8.7 \text{ psia}$$
$$= 14.7 \text{ psi}$$
$$= 760 \text{ mm Hg}$$
$$= 29.92 \text{ in Hg}$$
$$= 33.90 \text{ ft } H_2O$$
$$= 760 \text{ torr}$$
$$= 101.3 \text{ kilopascal}$$

81. Answer: **B**. Normal air contains 21% oxygen by volume. The vessel only contains 60% normal air. Therefore: $0.6 \times 0.21 = 0.126$ or 12.6%.

82. Answer: **A**. Considerable industrial hygiene sampling has been conducted using passive sampling techniques. Passive sampling uses a device capable of taking samples of gas or vapor pollutants from the atmosphere at a rate controlled by a physical process, such as diffusion, through a static air layer or permeation through a membrane. It does not involve active movement of air through the sampler. The theoretical basis for passive sampling for both diffusion and permeation can be described as derivations of Fick's first law of diffusion.

    Charles's Law states, "The volume of a gas varies directly with the absolute temperature if the pressure is kept constant." Raoult's Law applies to the solvent in many liquid systems and states, "The vapor pressure of a volatile solvent in a dilute solution is proportional to its mole fraction." Henry's Law applies to a solute in a dilute solution and states, "The gas phase concentration of the material is proportional to its mole fraction in the solution." The effectiveness of diffusion as a deposition mechanism is indirectly related to the square of the particle diameter and directly to the velocity of the aerosol.

83. Answer: **B**. Water solubility can be defined as the maximum concentration of a solute that can be carried in water under equilibrium conditions and is generally given as ppm (parts per million) or mg/l (milligrams per liter).

84. Answer: **A**.

$$T = \frac{-\ln\frac{1}{2}}{k}$$

$$T = \frac{0.69314718}{1.36 \times 10^{-11}}$$

$$T = 5.09667044\ 1 \times 10^{10} \text{ sec}$$

    Convert to years:

$$T = \frac{5.09667044\ 1 \times 10^{10} \text{ sec}}{1} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ hour}}{60 \text{ min}} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ yr}}{365.25 \text{ days}}$$

$$T = 1615 \text{ years}$$

85. Answer: **C**.

Force to move the cart = the force of friction times the weight of the cart plus the load.

$$F = \mu N$$

$$20 = 0.12 \times N$$

$$\frac{20}{0.12} = N$$

$$N = 167$$

$$N = 167 - 55 \text{ (cart)} = 112 \text{ lbs}$$

86. Answer: **D**. The 6-foot "use zone" is a requirement from the American Society for Testing and Materials (ASTM) standard F1487, *Playground Equipment for Public Use*. A portion of this standard is reprinted below:

9.2 *Stationary Play Equipment*—Stationary play equipment may be freestanding structures, may be in combination with other play equipment, or may be part(s) of a composite play structure.

9.2.1 The use zone for stationary play equipment shall extend no less than 72 in. (1830 mm) from all sides of the play structure.

9.2.2 The use zones for two or more stationary play structures that are not physically attached but are play functionally linked shall be determined as if the separate equipment were parts of a composite play structure.

9.2.3 The use zones of two stationary pieces of equipment that are positioned adjacent to one another may overlap if the adjacent designated play surfaces of each structure are no more than 30 in. (760 mm) above the protective surface (that is, they may be located a minimum distance of 72 in. (1830 mm) apart). If adjacent designated play surfaces on either structure exceed a height of 30 in. (760 mm), the minimum distance between the structures should be 108 in. (2740 mm).

As can be seen in **Figure 33**, if the monkey bars are surrounded by a 6-foot safety zone, it would add 12 feet to each footprint dimension.

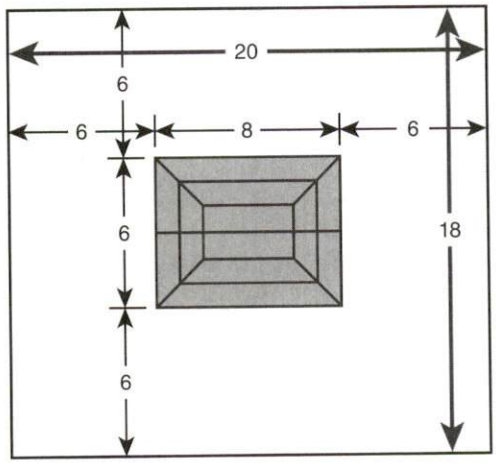


Figure 33 Stationary Play Equipment and Structures Example 1

87. Answer: **C**.

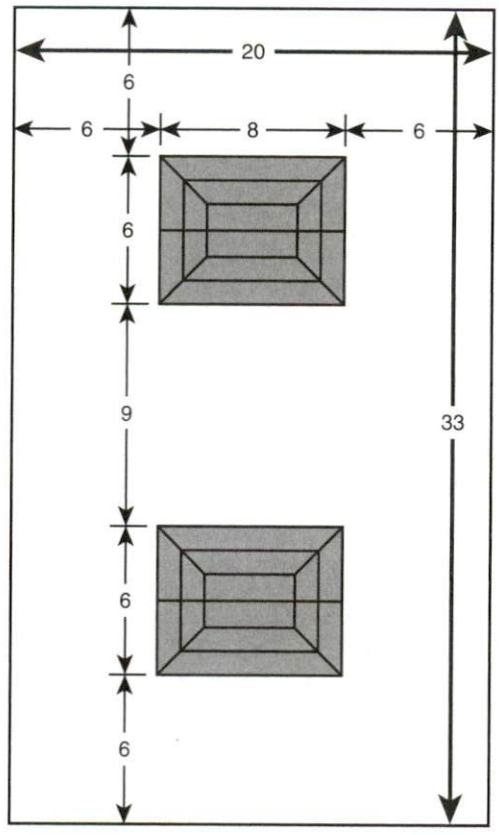


Figure 34 Stationary Play Equipment and Structures Example 2

From ASTM F1487, 9.2.3, two play structures exceeding 30 inches in height must be separated by a use zone of 9 feet (108 in.). As can be seen in **Figure 34**, if the structures are separated by 9 feet and surrounded by a 6-foot safety zone, it would add 12 feet to the length and 21 feet to the width (20' × 33').

88. Answer: **A**.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{3.14 \times (132)^2 \times 42}{4}$$

$V = 574{,}760$ cu ft

574,760 × 7.48 gal per cu ft = 4,299,200 gallons

89. Answer: **A**.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{3.14 \times (132)^2 \times 42}{4}$$

$V = 574{,}760$ cu ft

425 ft × 425 ft = 180,625 × 3 ft = 541,875 cu ft

The proposed dike is too small to hold all material that could be stored in the tank by about 33,000 cubic feet or 250,000 gallons.

90. Answer: **C**.

Step 1: Determine total footage of diked area.

$$220 \times 330 = 72{,}600 \text{ sq ft}$$

Step 2: Determine the footage occupied by tank 2, 3, and 4.

Tank # 2 and 3

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{3.14 \times (50)^2}{4}$$

$$A = 1963 \text{ sq ft each}$$

Tank # 4

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{3.14 \times (40)^2}{4}$$

$$A = 1257 \text{ sq ft}$$

$$\text{TOTAL} = 5183 \text{ sq ft}$$

Step 3: Determine total area not occupied by smaller tanks.

$$\text{Total area} - \text{Tank area} = \text{Area available}$$

$$72{,}600 - 5183 = 67{,}400$$

Step 4: Determine volume in the largest tank.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{3.14 \times (100)^2 \times 35}{4}$$

$$V = 274{,}889 \text{ cu ft}$$

Step 5: Divide volume in largest tank (cu ft) by total area available (sq ft) to determine required height of diking.

$$\frac{274{,}889}{67{,}417} = 4.07 \text{ feet required}$$

*Note: The difference between answer B and C is about **35,000** gallons of product that would not be contained.

91. Answer: **B**.

$$\text{Tan A} = \frac{a}{b} \qquad b = \frac{a}{\text{Tan A}}$$

$$b = \frac{15}{\text{Tan } 25} = 32.17 \text{ feet}$$

The general rule of thumb is a 6:1 ratio. Add 6 feet distance for every 1 foot of screen width. So, for a 5-ft wide screen, the furthest participant should be 30 feet from the screen (**Figure 35**).

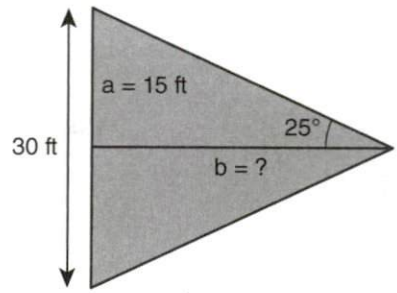


Figure 35 Designing a Training Room with Specific Parameters

92. Answer: **C**. This question leaves a lot to be desired because it does not provide nearly enough information on truss usage. However, assuming the question is really asking which members are in tension, use this illustration of forces in a *stable* structure that is symmetrically loaded. Caution: External forces such as wind can change the loading.

Again, **Figure 36** depicts a perfectly stable structure that is symmetrically loaded and shows forces involved. The analysis of a statically determinate frame is more appropriately accomplished by drawing a free-body diagram of each member and then applying the equilibrium equations for each diagram.

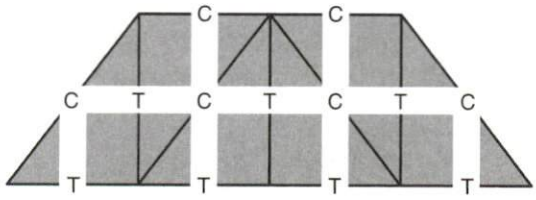


Figure 36 Truss Diagram Example 2

93. Answer: **D**.
Calculate a "z" value using formula.

$$Z = \frac{X - \mu}{}$$

$$Z = \frac{1400 - 1800}{250}$$

$$Z = \frac{-400}{250} = -1.6$$

Area under the curve $-1.6 = 0.4452$ (**Table 34**).

$$P_f = 0.5 - 0.4452 = 5.5\%$$

Table 34 Standard Normal Distribution

Z	0	1	2	3	4	5	6	7	8	9
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545

*Note:

Tables for the normal distribution will be provided on the examination.

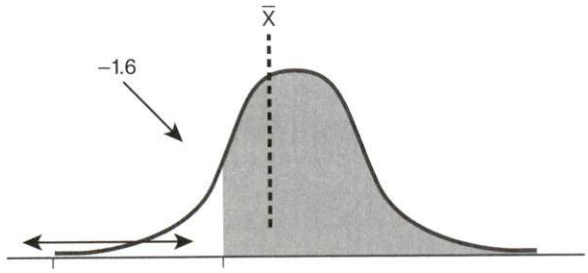


Figure 37 Area Covered from Z to the Mean

This time we are looking for the area under the curve from the beginning of the curve on the extreme left side to −1.6 standard deviations this side of the mean. Again, Z = standard deviation and X-bar = mean (**Figure 37**).

Step 1: From Table 34, determine the area under the curve from the X-bar to a Z of 1.60. There is no negative Z or −1.6 on the table because it would occupy the same area. However, it would lie to the left of the X-bar. Negative left; positive right.

Step 2: Subtract the area occupied from that half of the curve (**Figure 38**).

$$0.5 - 0.4452 = 0.0548$$

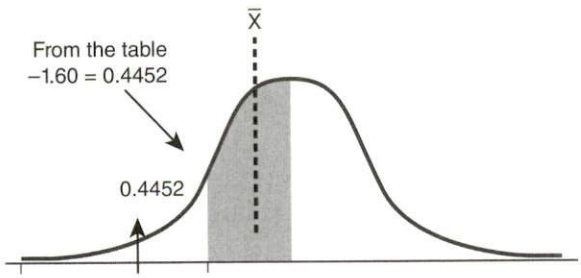


Figure 38 Area Covered by Half the Curve

94. Answer: **D**. The **Spearman correlation** between two variables is equal to the Pearson correlation between the rank values of those two variables; while Pearson's correlation assesses linear relationships, Spearman's correlation assesses monotonic relationships (whether linear or not). If there are no repeated data values, a perfect Spearman correlation of +1 or −1 occurs when each of the variables is a perfect monotone function of the other. There are several other numerical measures that quantify the extent of statistical dependence between pairs of observations. The most common of these is the Pearson product-moment correlation coefficient, which is a similar correlation method to Spearman's rank that measures the "linear" relationships between the raw numbers rather than between their ranks.

95. Answer: **A**. A graphical display where the data is grouped into ranges (such as "40 to 49," "50 to 59," etc.), and then plotted as bars. Similar to a bar graph (bar chart), but in a histogram each bar is for a range of data. Bar graphs are good when your data is in **categories** (such as "body part," "department," etc.). But when you have continuous data (such as incident rates) then use a histogram.

Histogram: a diagram consisting of rectangles whose area is proportional to the frequency of a variable and whose width is equal to the class interval.

Bar Graph: a diagram in which the numerical values of variables are represented by the height or length of lines or rectangles of equal width.

Pictogram (pictograph or icon) is an ideogram that conveys its meaning through its pictorial resemblance to a physical object.

Confidence interval: a range around a measurement that conveys how precise the measurement is. A confidence interval gives an estimated range of values which is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data. If independent samples are taken repeatedly from the same population, and a confidence interval calculated for each sample, then a certain percentage (confidence level) of the intervals will include the unknown population parameter. Confidence intervals are usually calculated so that this percentage is 95%, but we can produce 90%, 99%, 99.9% (or whatever) confidence intervals for the unknown parameter.

96. Answer: **C**. In the case of risk assessments evaluating the magnitude and nature of risk to human health, it is important to control for confounding to isolate the effect of a particular hazard such as a food additive, pesticide, or new drug. For prospective studies, it is difficult to recruit and screen for volunteers with the same background (age, diet, education, geography, etc.), and in historical studies, there can be similar variability. Due to the inability to control for variability of volunteers and human studies, confounding is a particular challenge. For these reasons, experiments offer a way to avoid most forms of confounding.

Confounding: A situation in which the effect or association between an exposure and outcome is distorted by the presence of another variable. *Positive* confounding (when the observed association is biased away from the null) and *negative* confounding (when the observed association is biased toward the null) both occur. Confounding variables may also be categorized according to their source. The choice of measurement instrument (operational confound), situational characteristics (procedural confound), or interindividual differences (person confound).

- An **operational confounding** can occur in both experimental and nonexperimental research designs. This type of confounding occurs when a measure designed to assess a particular construct inadvertently measures something else as well.
- A **procedural confounding** can occur in a laboratory experiment or a quasi-experiment. This type of confound occurs when the researcher mistakenly allows another variable to change along with the manipulated independent variable.
- A **person confounding** occurs when two or more groups of units are analyzed together (e.g., workers from different occupations), despite varying according to one or more other (observed or unobserved) characteristics (e.g., gender).

When examining the relationship between an explanatory factor and an outcome, we are interested in identifying factors that may modify the factor's effect on the outcome (effect modifiers). We must also be aware of potential bias or confounding in a study because these can cause a reported association (or lack thereof) to be misleading. Bias and confounding are related to the measurement and study design.

- **Bias** is a systematic error in the design, recruitment, data collection or analysis that results in a mistaken estimation of the true effect of the exposure and the outcome.
- **Effect modification** is a variable that differentially (positively and negatively) modifies the observed effect of a risk factor on disease status. Different groups have different risk estimates when effect modification is present—smoking and asbestos exposure for example.
- **Independent variable** is the variable you have control over that you can choose and manipulate. It is usually what you think will affect the dependent variable. In some cases, you may not be able to manipulate the independent variable. It may be something that is already there and is fixed or something you would like to evaluate with respect to how it affects a dependent variable like color, kind, time.
- **Dependent variable** is what you measure in the experiment and what is affected during the experiment. The dependent variable responds to the independent variable. It is called dependent because it "depends" on the independent variable. In a scientific experiment, you cannot have a dependent variable without an independent variable.
- **Controlled variable** is the element or feature that cannot be changed during the course of an experiment. The controlled variable is kept constant so the changes in other variables can be observed more easily.

Example: You are interested in how stress affects heart rate in humans. Your independent variable would be the stress and the dependent variable would be the heart rate. You can directly manipulate stress levels in your human subjects and measure how those stress levels change heart rate. The temperature and lighting of the room are examples of controlled variables.

97. Answer: **C**. The coefficient of variation (CV) is a dimensionless number obtained by dividing the standard deviation by the mean. The CV allows comparisons to be made between different distributions.

$$CV = \frac{\sigma}{\bar{x}}$$

Given σ = Standard Deviation

$\bar{x}$ = Mean

98. Answer: **C**. If $1000 is invested in an investment account paying 8% interest how much will be accumulated in the account at the end of 10 years?

$$i = 0.08 \quad n = 10 \quad P = \$1000 \quad F = ?$$

$$F = P(1 + i)^n$$

$$F = 1000\ (1 + 0.08)^{10}$$

$$F = \$2159$$

Keystrokes for the TI-30X IIS calculator: 1000 × 1.08^10 = 2159
Keystrokes for the HP10BII:

1. 1000 (PV KEY)
2. 8 (I/YR KEY)
3. 10 (N KEY)
4. (FV KEY) for the answer

99. Answer: **C**.

$$i = 0.08 \quad n = 10 \quad A = \$1000 \quad P = ?$$

$$P = A\left(\frac{(1 + i)^n - 1}{i(1 + i)^n}\right)$$

$$P = 1000 \times \left(\frac{(1 + .08)^{10} - 1}{.08 \times (1 + .08)^{10}}\right) = \$6710$$

Keystrokes for the TI-30X IIS:

$$1000 \times (1.08\text{^}10\text{–}1)/(.08 \times 1.08\ \text{^}10) = 6710$$

Keystrokes for the HP10BII:

1. 1000 (PMT KEY)
2. 8 (I/YR KEY)
3. 10 (N KEY)
4. (PV KEY) for the answer

100. Answer: **D**.

$$i = .1125 \quad n = 7 \quad A = \$2000 \quad P = ?$$

$$P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

$$P = 2000 \times \left(\frac{(1.1125)^7 - 1}{.1125 \times (1.1125)^7}\right) = \$9349$$

Key Strokes for the TI-30X IIS:

$$2000 \times (1.1125\text{^}7-1)/(.1125 \times 1.1125\text{^}7) = 9349$$

Keystrokes for the HP10BII:

1. 2000 (PMT KEY)
2. 11.25 (I/YR KEY)
3. 7 (N KEY)
4. (PV KEY) for the answer

Self-Assessment 3 Questions

1. Which of the following is correct concerning the use of structural reinforcing steel in concrete structures?

A. Steel is used to prevent cracking.
B. Steel should not be used in floor slabs.
C. Plastic is commonly used as a reinforcing medium.
D. Steel reinforcement is often placed on chairs to prevent displacement.

2. An elevated water tank produces a ground level pressure of 95 psi. How high is the tank?

A. 255 feet
B. 65 feet
C. 40 feet
D. 220 feet

3. You have just finished inspecting a degreasing operation involving an open tank equipped with a canopy hood. The tank is 2 ft × 3 ft and the canopy is 3 feet above the tank. The minimum capture velocity for this type of operation is 100 fpm. What rate of airflow is required in the canopy hood?

$$Q = 1.4 \times 2(L + W)HV$$

Where Q = rate of airflow (cfm)

L = tank length (ft)
W = tank width (ft)
H = height of canopy above tank (ft)
V = desired control velocity (fpm)

A. 2200 cfm
B. 3200 cfm
C. 4200 cfm
D. 6500 cfm

4. When determining the electromagnetic propagation of thermal energy (radiation heat transfer), the transfer is accomplished by the motion of thermal waves traveling at the speed of light. These waves can be absorbed, transmitted, or reflected by other bodies. The ratio of heat transfer by radiation from a fire to anybody maintained at a temperature above absolute zero can be determined from the equation shown below. If a fire temperature increases from 600°F to 1200°F, that is, the temperature doubles, radiation will increase by a factor of ____.

*Note: Assume the same area and emissivity for the affected surface.

$$Q_2 : Q_1 = (T_2 + 460)^4 : (T_1 + 460)^4$$

A. 8
B. 6
C. 12
D. 16

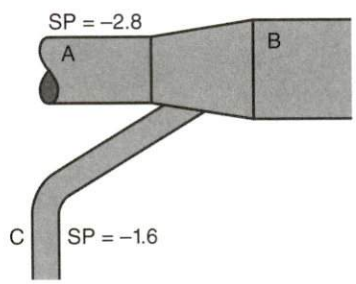
5. Using the table of distances, determine the distance an aboveground fuel tank can be located from your plant property line. The tank is upright, above ground, and with a diameter of 32 feet 9 inches. It is 10 feet tall and will be filled to capacity.

Tank Capacity in Gallons	Minimum Distance in Feet from Property Line	Minimum Distance in Feet from Nearest Public Way or Nearest Important Building
0 to 275	10	5
751 to 12,000	15	5
12,001 to 30,000	20	5
30,001 to 50,000	30	10
50,001 to 100,000	50	15
100,001 to 500,000	80	25
500,001 to 1,000,000	100	30

A. 20 feet
B. 30 feet
C. 50 feet
D. 80 feet

$$V = \frac{\pi d^2 \times h}{4}$$

6. During design, two ducts meet at a junction (illustrated to the right). Which of the following options is the *most appropriate*?



A. Install blast gate in B.
B. Resize ducts.
C. Ignore difference in SP.
D. Use enlargement regain calculation.

7. If the pressure in a closed gas cylinder is doubled, and the original temperature was 25 degrees Celsius, what is the new temperature?

A. 596°K
B. 273°K
C. 596°C
D. 273°R

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

8. If a light source produces a surface illumination of 70 foot-candles at 10 feet, at what distance will the illumination be 250 foot-candles:

A. 7.7 feet
B. 5.3 feet
C. 3.4 feet
D. 4.4 feet

$$I_2 = I_1 \times \frac{(d_1)^2}{(d_2)^2}$$

9. Which of the following agents could be used to clean up a spill of mercury from a thermometer that has collected in the cracks of a wooden floor?

A. Calcium polysulfide
B. Nitric acid
C. Phenylmercury urea
D. Hydrogen phosphate

10. When electroplating, the object to be plated is suspended in a chemical bath as the _____ in an electrical circuit and the material to be applied to the surface acts as the _____.

A. anode, cathode
B. cathode, anode
C. plate, filament
D. filament, plate

11. Which of the following equipment selections would you expect to be used in asbestos fiber counting by Phase Contrast Microscopy (PCM)?

A. Pumps, cassette filters, and PVC filters
B. Coconut shell charcoal tube
C. Walton-Beckett Graticule
D. Gilian circon-2 air sampling system

12. What is the present worth of a lump sum payment of $250,000 in 5 years, using a 13% interest rate?

A. $140,000
B. $135,000
C. $135,700
D. $136,700

$$P = F(1 + i)^{-n}$$

13. An exhaust ventilation system in an industrial shop is removing about 3500 cfm from a 10- × 30-foot room with 10-foot ceilings. The shop has no other source of ventilation. What is the air change in this shop?

A. 22 room changes/min
B. 33 room changes/min
C. 1.16 room changes/min
D. 3.36 room changes/min

14. The ASME code requires that the minimum pressure for a standard hydrostatic test be 150% of which of the following pressures?

A. Burst pressure
B. Normal operation pressure
C. The required pressure relief valve setting
D. Maximum operation pressure

15. Which of the following is the *best* demonstration for auditor impartiality during an audit?

A. Being expertly prepared to conduct the audit
B. Holding an accredited third-party professional certification
C. Signing a statement confirming impartiality and will report objectively all on the audit
D. Being free from any line or operational responsibility for the activity being audited

16. Which of the following equations is balanced?

A. $N_2H_4 + 2H_2O_2 \rightarrow 4H_2O + N_2$
B. $N_2H_4 + 2H_2O_2 \rightarrow 6H_2O + N_2$
C. $N_2H_4 + 2H_2O_2 \rightarrow 4H_2O + 2N_2$
D. $N_2H_4 + 2H_2O_2 \rightarrow 4H_2O + 4N_2$

17. During the course of an inspection, you observe the following conditions: an exposure to methylene chloride of 10 ppm (TLV = 50), methyl chloroform of 100 ppm (TLV = 350), and an exposure to methyl alcohol of 50 (TLV = 200). Assuming the effects of these exposures are additive, what is the percentage of TLV for this concentration?

A. 92%
B. 100%
C. 80%
D. 74%

18. An enclosed parts cleaning operation using a spray gun is being conducted that results in two pints of methyl alcohol (MW = 32.04 and SG = 0.792) being released each hour. You measure concentrations of 300 ppm, which is above the TLV of 200 ppm. How much dilution ventilation is required to lower the concentration to the TLV? You may assume a K factor of 6.

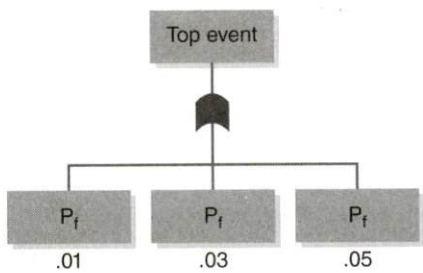
A. 11,400 cfm
B. 39,400 cfm
C. 3400 cfm
D. 9950 cfm

$$Q = \frac{403 \times 10^6 \times SG \times ER \times K}{MW \times C}$$

19. Your company is considering purchasing a company based in Germany. You need to find the relevant fire standards for that company. What is the *best* first step?

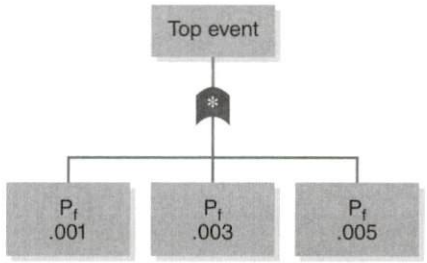
A. Perform a key word search on the NFPA website.
B. Perform a key word search using a general search engine.
C. Perform a key word search on the OSHA website.
D. Perform a key word search on the ISO website.

20. Using the logic illustrated in this fault tree, calculate the top event probability of failure.



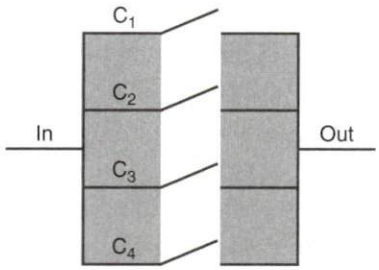
A. 1×15^{-8}
B. 1.5%
C. 8.998%
D. 0.00001

21. Using the logic illustrated in this fault tree, calculate the top event probability of failure.



A. 1.5×10^{-8}
B. 1.5%
C. .9%
D. 0.00001

22. The diagram shown below illustrates a parallel component arrangement where the failure of one, two, or three components would not result in output failure (all four components must fail to produce output failure). Assuming the failure rate is the same for all components, which of the following formulas would you use to compute the probability of failure for this system?



A. $C^2 - F^4$
B. $C_1 + C_2 + C_3 + C_4$
C. $F(e^{-t/m})$
D. $F_1 \times F_2 \times F_3 \times F_4$

23. A process uses chemical A and will be transferred from a storage tank into the process equipment. During the transfer, employees may be exposed to chemical A concentrations of 1.7 ppm for two hours each day. Will this exposure exceed the exposure limit for chemical A?

TWA = 0.5 pp,
LFL = 10%
VP = 11.6 kPa @ 20°C
BP = 53°C @ 1 atm
UFL = 75%

A. No—the TWA is greater than 1.0.
B. No—the TWA is less than 1.0.
C. Yes—the TWA is greater than 1.0.
D. Yes—the TWA is less than 1.0.

24. A company establishes an exposure limit for gas B at 100 mg/m^3. If you have a constant concentration of 400 mg/m^3, how many hours a day can an employee be exposed to this concentration of gas B?

A. 0.5
B. 2.0
C. 4.0
D. 8.0

25. One of the commercial drivers working at your plant had a vehicle accident with a company truck that resulted in a citation for a moving traffic violation. Must your company procedures require a drug test for this driver?

A. No, unless fatality is involved
B. Yes, within 8 hours
C. Yes, within 32 hours
D. No, solely driver's responsibility

26. According to OHSAS 18001, a successful management system should be based on all the following *except:*

A. a generic occupational health and safety policy.
B. identification of occupational health and safety risks and legal requirements.
C. objectives, targets, and programs that ensure continual improvements.
D. management activities that control the occupational health and safety risks.

27. The *primary* way to protect potable water from a nonpotable supply is the use of _____.

A. a shutoff valve
B. an air gap
C. a check valve
D. a one-way flow valve

28. Which audit technique is *best* to verify that an organization is implementing an energy isolation program as written?

A. Observing the energy isolation program practices and condition of the tools and equipment
B. Interviewing authorized employees
C. Reviewing employee training records and verifying supervisory effectiveness by conducting perception surveys
D. Verifying that the organization has documented inspections of equipment, has a preventive maintenance program for energized equipment, and a process to ensure that any deficiencies found are corrected in a timely manner

29. For hazards, the Global Harmonized System (GHS) requires all of the following classification criteria *except:*

A. physical hazards.
B. health and environmental hazards.
C. protective equipment requirements.
D. mixtures.

30. GHS-compliant labels on chemical containers must display which of the following elements?

A. A pictogram
B. The word "danger"
C. Flammable liquid
D. The word "warning"

31. Which of the following *best* describes the primary purpose of classifying potential chemical hazards?

A. Ensuring proper hazard class and labeling on chemical containers
B. Communicating information concerning hazards and protective measures
C. Standardizing the Safety Data Sheet format
D. Implementing visual icons and pictograms to communicate hazards

32. Information on the nature of the physical or health hazard is *best* described by the term:

A. classification.
B. hazard class.
C. hazard category.
D. hazard statement.

33. Placing a chemical into a "hazard class" and where necessary, a "hazard category," is the concept of classification based on determining the hazard and:

A. the severity of the effect.
B. identification of the chemical container.
C. the layout of the SDS requirements.
D. nature of the hazard.

34. Which of the following is a hazard as defined by GHS?

A. Pyrophoric gas
B. Simple asphyxiants
C. Pyrophoric liquids
D. Combustible dust

35. Which of the following is considered to be the *most important* source of fire standards in industry today?

A. Factory Mutual
B. Underwriters Laboratory
C. National Fire Protection Association
D. Uniform Fire Code

36. The scope of the ISO 19011 standard is to provide guidance on the principles of:

A. managing and conducting an occupational health and safety system audit.
B. managing and implementing an environmental management system.
C. managing and implementing an occupational health and safety management system.
D. managing and conducting quality and environmental management system audits.

37. Which of the following is true concerning the use of the signal word "CAUTION" on product warning labels? "Caution" is used where there is a hazard or unsafe practice which if encountered could usually result in:

A. severe personal injury or extensive property damage.
B. minor personal injury or property damage.
C. death, extensive property damage, extensive product damage, and severe personal injury.
D. minor personal injury, product damage, or property damage.

38. Of the many fire standards in the United States, which of the following is considered to be the *most influential* source?

A. ANSI
B. NFPA
C. OSHA
D. UL

39. Which of the following classes of product is covered by the Consumer Product Safety Commission rules?

A. Swimming pools
B. Tobacco
C. Hair spray
D. Breakfast cereal

40. When developing an emergency management plan, what is the principle against which the strategies and tactics must be compared?

A. Command responsibilities
B. Communications responsibilities
C. Protection of life, property, and the environment
D. Business continuity

41. To identify hazardous conditions, assess their risk and establish effective risk control measures is the primary function of a:

A. risk control system.
B. risk management system.
C. loss control system.
D. loss management system.

42. When both parties involved in a disagreement agree to accept the determination of a third party, the process is known as:

A. negotiation.
B. concession.
C. obfuscation.
D. arbitration.

43. Which of the following is considered the biggest problem in the computation of cost-benefit analysis?

A. Obtaining computer time
B. Determining the indirect costs of mishaps
C. Obtaining cost estimates for damage
D. Determining lost time costs

44. Which of the following classes of product is covered by the Consumer Product Safety Commission rules?

A. Firearms
B. Pesticides
C. Motor vehicles
D. Bicycles

45. A science that deals with the incidence, distribution, and control of disease in a population, including the sum of factors controlling the presence or absence of a disease or pathogen is called?

A. Epidemiology
B. Toxicology
C. Biology
D. Environmental

46. Which of the following is generally considered to be a disadvantage of a safety committee?

A. Serves as a channel to workers
B. Deals with trivial issues, thus freeing others' time
C. Fosters understanding and cooperation among workers
D. Allows multi-craft solution to problems

47. Which of the following *best* describes the main objective of the Consumer Product Safety Commission?

A. Enforce the Product Recall Law
B. Administer the Consumer Product Safety Act
C. Determine fine for violators of the CPSA
D. Protect consumers from unreasonable risk

48. A safety professional is reviewing the recommendations from a root cause analysis report. A recommendation for corrective action suggests that employees in the affected process area be retrained in certain safety procedures to reduce the frequency of the event reoccurring. What should the safety professional ensure was considered before *retraining the employees* is submitted as a recommendation for corrective action?

A. Employees completed written checklist has been considered.
B. Employees' use of personal protective equipment has been considered.
C. One or more effective engineering controls has been considered.
D. One or more effective administrative controls has been considered.

49. The primary reason safety professionals perform accident investigation is to determine causal conditions. Who is responsibility for correcting the accident causes?

A. Supervisor
B. Safety administrator
C. Senior safety engineer
D. Plant manager

50. Which of the following tests is associated with the Otis–Lennon Mental Ability Test?

A. Personnel classification tests
B. Personality inventory tests
C. Multiple aptitude tests
D. IQ tests

51. All of the following are examples of *staff* functions *except:*

A. supporting.
B. planning.
C. commanding.
D. assisting.

52. All the following are valid reasons for accident (mishap) investigation *except:*

A. prevent reoccurrence of similar events.
B. establish casual factors.
C. provide vehicle for discipline.
D. provide data for trend analysis.

53. Which of the following is generally *not* considered to be an indirect cost of accidents?

A. Wages paid to fellow workers for loss of productivity
B. Cost of accident investigation team
C. Cost to train new worker
D. Cost of physical therapy

54. An employer cited by OSHA has a period of _____ to contest the citation. The notice to contest is sent directly to the _____.

A. 15 working days, OSHA area director
B. 10 working days, Occupation Safety & Health Review Commission
C. 15 working days, Occupation Safety & Health Review Commission
D. 15 working days, OSHA regional administrator

55. Which of the following statements is in agreement with the Domino Theory of Accident Causation?

A. All accidents have multiple causes.
B. Improper training causes most accidents.
C. An accident is symptomatic of a management error.
D. An unsafe act or condition initiates the accident sequence.

56. The Occupational Safety and Health Review Commission (OSHRC) was established to hear and decide contested OSHA citations. All of the following statements concerning the commission are true *except:*

A. the OSHRC is an independent agency of the federal government.
B. the OSHRC has three appointed members.
C. any OSHRC member can overrule an administrative law judge.
D. there are two levels to the OSHRC, administrative law judges, and OSHRC members.

57. Arrange the following hazard control steps in the proper sequence: (1) guard the hazard; (2) engineer the hazard out, if possible; (3) educate personnel.

A. 2,1,3
B. 3,1,2
C. 1,2,3
D. 3,2,1

58. Which is a method of reducing losses?

A. Equipping and training a fire brigade
B. Replacing physical guards on saws
C. Installing ground fault circuit interrupters
D. Performing hazard communication training

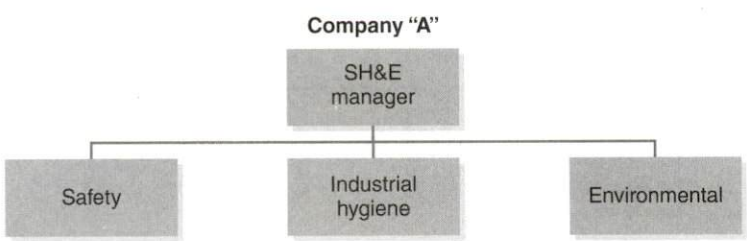
59. The process of determining safety goals, allowing supervisors a chance to perform, providing assistance along the way, and rewarding them according to their progress is known as:

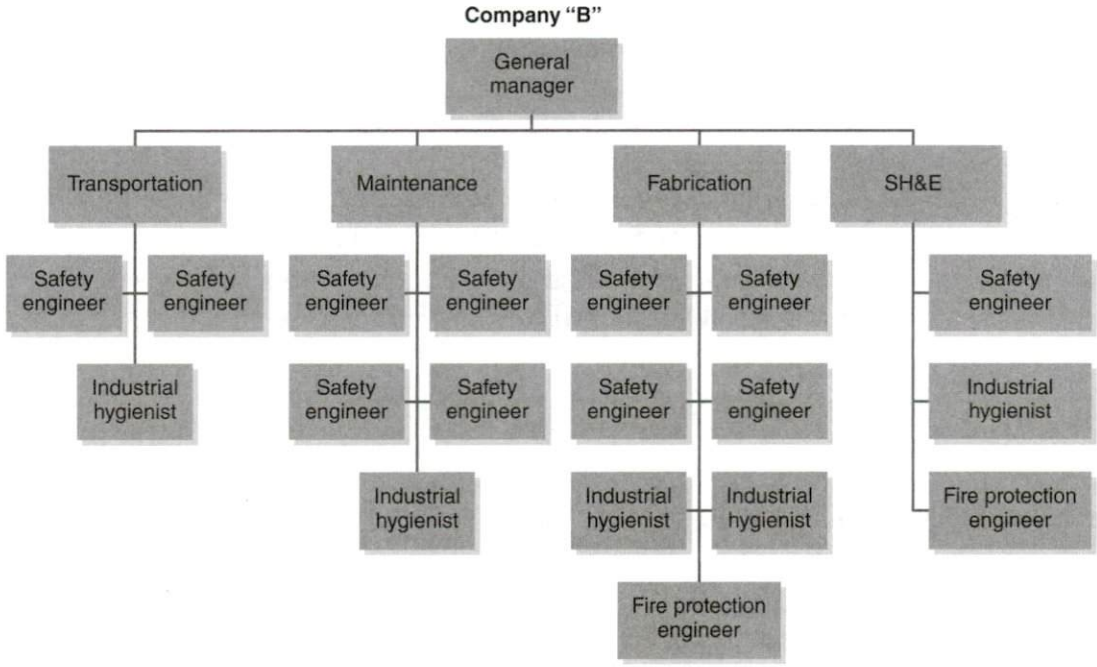
A. management by exception.
B. safety by objectives.
C. OSHA Star Program.
D. motivation-hygiene theory.

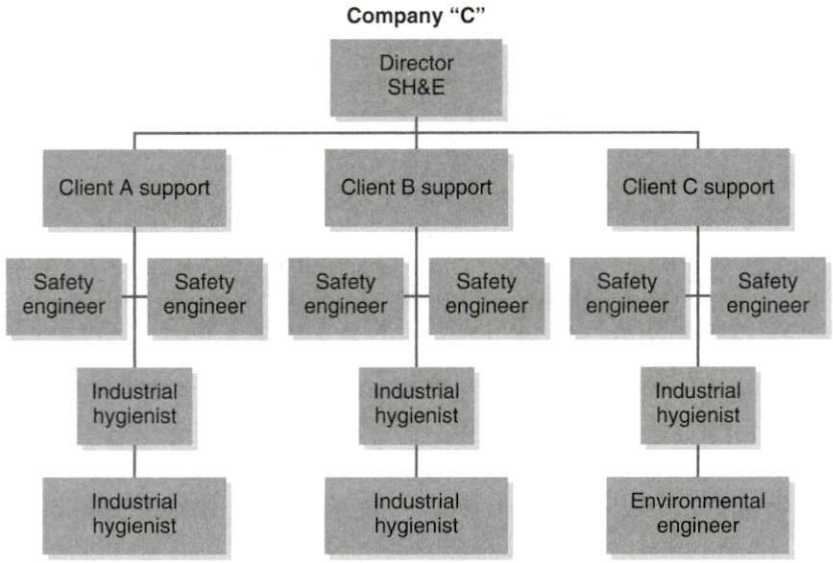
60. Your company's chief executive officer and general manager feels he has too many personnel reporting directly to him, including you (safety director). He has asked your opinion about where in the organizational structure to best place the safety function. The company has three senior executives: personnel, support, and operations. Where would you suggest placement of the safety function?

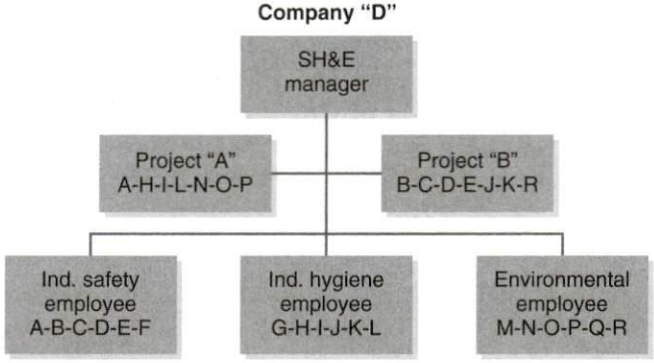
A. Personnel
B. Support
C. Operations
D. Remain staff of general manager

61. Several organizational charts are shown on the next two pages. These organizational charts depict different types of management concepts including traditional management, functional management, goal-oriented management, and matrix management. Which of the following organizational charts is the *best* example of a matrix management organization?









A. Company "A" is an example of matrix management.
B. Company "B" is an example of matrix management.
C. Company "C" is an example of matrix management.
D. Company "D" is an example of matrix management.

62. Which of the following *best* describes the method of establishing workers' compensation rates by the "prospective rating plan" method?

A. Client receives credit for improvements to safety conditions according to a set schedule of accident prevention activities.
B. Premiums are based on similar employer experience.
C. Client pays according to the rate schedule per $100 of payroll.
D. Premiums relate to company experience averaged over a period of time.

63. Which of the following are used to adjust workers' compensation insurance rates?

A. Experience modification rate
B. Incident rate
C. Workers' compensation mod rate
D. Accident rate

64. Which of the following would be included by the insurance term "natural wear and tear perils"?

A. Paint that has orange peeled
B. Cracked and broken weather stripping
C. Rust
D. Roller-bearing wear and cracking

65. A company manufactures plastic products. Raw plastic is purchased in pellet form and is molded into various products. Heat is applied to the plastic pellets (causing visible fumes in the molding processes), and mechanical sawing and grinding are done on some of the finished plastic products. In evaluating occupational health controls, what should a safety professional first advise management to do?

A. Install exhaust ventilation on all operations producing visible dust or fumes
B. Provide employees with eye and respiratory protection and advise them to avoid visible fumes
C. Monitor employees' exposure to vinyl chloride
D. Determine the nature of any health risks and monitor employee exposures where appropriate

66. The "bathtub" curve is frequently used in the study of reliability. The curve is a stress-related depiction that describes the relationship between component failure and exposure. Failures occurring during early stages of use occur in the "debugging" period. This period or range on the bathtub curve is also often called the _____ period.

A. wear-out
B. experimental
C. burn-in
D. wear-in

67. What principle is employed to identify the "vital few," whether customers, customer needs, product features, or inputs, to help assure that resources and attention are concentrated where they will do the *most good*?

A. Hystograph principle
B. Juran principle
C. Pareto principle
D. Smith principle

68. As a CSP, which of the following methods could you suggest to control dust hazards?

A. Product substitution and ventilation controls
B. Preventative maintenance and procedural controls
C. Infrared thermographic imaging and inspection controls
D. Layers of physical and operational controls

69. After a training program is conducted, what is essential?

A. Obtaining student feedback for continuous improvement.
B. Administering a quiz to ensure the student met the learning objectives.
C. Concluding the training program with a member of management to emphasize the importance of the training program.
D. Identifying the regulatory and compliance-related drivers from which the training program was derived.

70. What are the two phases of effectively communicating risk to the public?

A. Informing the public of the presence of the risk and involving the public in performing risk assessments
B. Identifying/locating the various loss scenarios for the public and educating the public on how the risk level was determined
C. Alerting/explaining a risk to the public and reassuring the public that the risk is being managed properly by describing what is being done to manage the risk
D. Disclosing the presence of a risk to the public and explaining to the public that the risk to the public is low

71. The U.S. Voluntary Protection Programs (VPP), as administered by Occupational Safety and Health Administration, is an optional safety-related management system. The four components associated with participating in the VPP include: a management commitment, one or more work site analyses, hazard prevention and control, and establishing:

A. program goals and objectives.
B. a joint labor-management committee.
C. safety and health training.
D. a written safety policy.

72. When establishing an organization's goals, each specific goal should be: realistic, measurable, and:

A. transferable.
B. scheduled.
C. innovative.
D. tactical.

73. Based on OHSA's 18001 guideline that the management system be suitable, adequate, and effective, which item should trigger a thorough management evaluation?

A. The financial performance of the company was 30% lower than predicted.
B. The environmental health and safety manager position experienced a high turnover rate in the past year.
C. The safety performance has deteriorated by 40%.
D. A lawsuit related to the company's environmental performance was filed in the last year.

74. A paper shredder is labeled with the UL mark. What does this mark indicate?

A. A specific piece of equipment and model number has been tested and certified that it meets Underwriters Laboratories published standards for product safety
B. The product manufacturer has determined that this line of products is safe for intended use
C. Represents that the product is listed in the Universal Library for Patents
D. A statement that the product is certified to operate for a minimum number of hours before failure

75. UN 1A1/is the code for a steel, closed-head drum. What does the UN designation or symbol signify?

A. The drum contents are hazardous and must be listed on the shipping paper.
B. The packaging conforms to the performance requirements for shipment.
C. The drum can be shipped internationally.
D. The packaging was produced by the United Nations.



From UN packing symbol of United Nations General Assembly, United Nations. Reprinted with the permission of the United Nations.

76. A single harmonized hazard statement is required for each hazard category within each hazard class. Which of the following represents the greatest hazard?

A. Category 1
B. Category 2
C. Category 3
D. Category 4

77. An analysis that is a thorough study of an organization or specific job/task to determine how training can help the organization to improve its safety, effectiveness, or efficiency or if the specific job/task can be enhanced is called a(n):

A. organizational analysis.
B. training analysis.
C. needs analysis.
D. task analysis.

78. Which of the following techniques is *not* normally used in the development or implementation of a system safety program?

A. MORT
B. PERT
C. THERP
D. Fault tree analysis

79. Which of the following reflects the management theorist Peter F. Drucker's definition of productivity?

A. The sum of all profit producing resources
B. The total of all applied concepts to the formation of minimum personnel for maximum profit
C. The balance between all factors of production that will give the greatest output for the smallest effort
D. The art of maximum producing goods or services through the use of minimum human resources

80. Which of the following would have the lowest value?

A. Lower Explosive Limit (LEL)
B. Upper Explosive Limit (UEL)
C. Threshold Limit Value (TLV)
D. Immediately Dangerous to Life and Health (IDLH)

81. Halogenated fire extinguishing agents are hydrocarbons, which have one or more atoms of hydrogen replaced by one or more halon atoms. Halogenated compounds stop combustion by interfering with the progress and development of combustion-intermediate free radicals. When Halon 1301 is exposed to a high temperature (over 900°F), hydrogen-based fire, which of the following gases are formed?

A. Hydrogen fluoride
B. Hydrogen carbonate
C. Hydrogen chloride
D. Phosgene

82. The U.S. Centers for Disease Control and Prevention (CDC) uses categories A, B, and C to describe bioterrorism diseases and agents. Which of the following *best* describes a category A disease/agent?

A. They can be easily disseminated or transmitted from person to person.
B. They result in moderate morbidity rates and low mortality rates.
C. Water safety threats
D. Emerging infectious diseases, such as hantavirus

83. As the safety director, you are asked to determine whether a proposed corrective action is justified. The risk score for an oven explosion event is calculated to be 25. The proposed corrective action of a barricade outside of the building with a 75% effectiveness for protecting a passerby in the event of an oven explosion has a cost of $5000. The critical justification rating has been arbitrarily set at 10. For a score less than 10, the cost of the corrective action is not justified. Given the following chart, calculate critical justification rating score and determine if the corrective action can be justified.

Cost Factor	Rating	Degree of Correction	Rating
Over $50,000	10	Hazard eliminated 100%	1
$25,000 to $50,000	6	Hazard reduced by 75%	2
$10,000 to $25,000	4	Hazard reduced by 50%–74%	3
$1000 to $10,000	3	Hazard reduced by 25%–49%	4
$100 to $1000	2	Slight effect on hazard less than 25%	6
$0 to $100	1		

A. 18.75; yes, it is justified
B. 0.55; no, it is not justified
C. 28; yes, it is justified
D. 4.20; no, it is not justified

84. While monitoring plant workers, you discover that the TLV-C is being exceeded for more than 15 minutes each work shift. Which of the following courses of action is appropriate?

A. Continue monitoring and compute a new TWA.
B. Recommend that the operation be curtailed immediately.
C. Send the instrumentation for calibration.
D. Continue as long as you do not exceed LD-50 values.

85. What type of respiratory protection would you recommend for employees working in the cloth cutting area of a fiberglass manufacturing facility?

A. Mechanical filter
B. Supplied air
C. Chemical cartridge
D. Self-contained breathing air

86. Which of the following statements is *most correct* concerning electrical ground fault circuit interrupters (GFCI)?

A. GFCIs will trip at about 5 milliamps line-to-line fault current.
B. GFCIs will trip at about 5 milliamps line-to-ground fault current.
C. GFCIs will protect against line to ground and line to line faults and trip at about 15 amperes.
D. GFCIs are required on all construction sites.

87. In an office environment with a mixed workforce (male and female), which of the following conditions would cause a safety professional the *most concern*?

A. Working in a 14 psia atmosphere
B. Working in an 80°F atmosphere
C. Work area noise of 76 dBA
D. Airflow resulting in one air change every five minutes

88. Which of the following would be considered a vasodilator?

A. Glycol
B. Ether
C. Aliphatic hydrocarbons
D. Aromatic hydrocarbons

89. What do the intercostal canals of the body sense?

A. Vibration
B. Wind movement
C. Changes in pressure
D. Changes in temperature

90. According to most adult training experts, adults have four basic training needs. Which of the following is *not* included in those needs?

A. Controlling their learning
B. Knowing why they are learning a topic
C. Changing the material to fit their understanding of the requirement
D. Wanting to learn things that will make them more effective and successful

91. Which of the following is the common language of client/server database management?

A. SQL
B. URL
C. HTML
D. HTTP

92. When you develop the tests and evaluations for your training program, you should use all of the following guidelines *except:*

A. test items must be reliable.
B. evaluations are norm-referenced.
C. each test item must have criterion-related validity.
D. the evaluation tool should be developed before the training begins.

93. One technique often used in safety and health training in the industrial environment is the conference method. Which of the following is the *most correct* concerning this important training tool?

A. Individual knowledge is not particularly important during a conference session.
B. The conference technique is not particularly suited to problem solving.
C. The success of the conference technique depends on the ability of the main presenter.
D. The success of the conference depends almost entirely on the ability of the facilitator.

94. Which statement *best* defines "anthropometry"?

A. Data gathering to identify the average size or shape of human limbs
B. The measuring of various response times of muscle contraction
C. The study of human size and shape data to aid in workspace design and the arrangement of tools and equipment
D. Measuring male and female hand, arm, and leg lengths to better design sitting workstations

95. Given the following numbers: 10, 10, 15, 25, 35, compute the (sample) standard deviation.

A. 9.5
B. 15
C. 10.8
D. 18

$$s = \sqrt{\frac{\sum(x^2)}{N-1}} \quad (x = X - \bar{X}) \quad \sigma = \sqrt{\frac{\sum(x^2)}{N}}$$

96. Assuming the data follows a normal distribution, with a mean of 1800 and a standard deviation of 250, what is the overall probability of the component failing between 1600 and 2000 hours?

Z	0	1	2	3	4	5	6	7	8	9
0.7	0.2580	0.2612	0.2652	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2996	0.3023	0.3051	0.3078	0.3106	0.3133

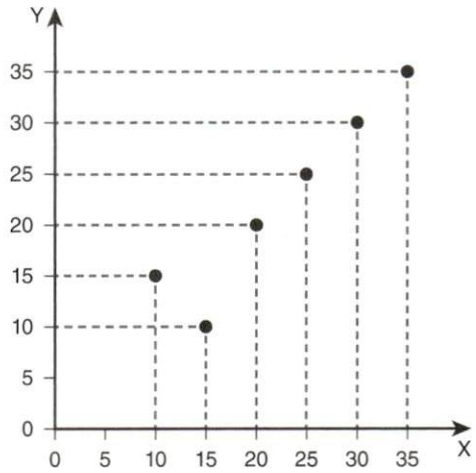
A. 33.3%
B. 57.8%
C. 61.6%
D. 45.5%

$$Z = \frac{X - \mu}{\sigma}$$

97. Compute the product moment coefficient of correlation for the scatter diagram shown below.

A. 0.955
B. 0.943
C. 0.886
D. 0.998

$$r = \frac{N\sum(XY) - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{\left[N\sum(X^2) - \left(\sum X\right)^2\right]\left[N\sum(Y^2) - \left(\sum Y\right)^2\right]}}$$



98. As a consultant, you have been given the task of investigating the safety of a dangerous intersection. Police reports indicate that there is an average of 5 accidents per month. Your employer tells you to develop an action report to change the intersection if the probability of more than 3 accidents is 0.65 or greater. What is the probability that there will be more than three accidents at the intersection this month?

A. 0.26502—Develop report.
B. 0.26502—Take action.
C. 0.73498—Develop report.
D. 0.73498—Take no action.

$$p(r) = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$$

99. You have a machine in your shop that has gone out of service unexpectedly 12 times in the last 2 years. What is the probability that the machine will operate the next 2 months without a break down?

A. 37%
B. 47%
C. 50%
D. 25%

$$p(r) = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$$

100. Which of the following is used when the occurrences of an event are small, but the number of cases is large enough to assure a few occurrences?

A. Poisson distribution
B. Chi-square
C. Pearson product moment of coefficient
D. Spearman rank correlation

Self-Assessment 3 Answers

1. Answer: **D**. Concrete structures must resist two kinds of forces: *compression and tension*. Design of concrete slabs, beams, and girders involves the computation of how much steel is required for strength in *tension* and how much concrete is required for strength in *compression*. The placement of reinforcement is a critical function if the structure is to resist the forces placed on it. All metal reinforcement should be accurately placed and supported at the proper height by concrete or *metal chairs* to prevent movement during pouring. The actual placement in the slab, or beam, is dependent on the forces the slab will see. When a beam is supported at two or more points, it will tend to break by pulling apart at the bottom—to add strength we place steel near the bottom surface where it is needed most. When a beam is supported at one point it is likely to fail by pulling apart at its upper surface first—so we need to place reinforcing as high as possible (but not generally closer to the surface than 1 inch). The weakness of concrete in tension is illustrated in the failure of a cantilevered slab, which fails at the top of the slab, thus requiring the steel to be placed toward the top of the slab.

2. Answer: **D**.

$$\text{psi} = k \times H \qquad H = \text{Height} \qquad k = 0.433 \text{ psi per ft}$$

$$H = \frac{\text{psi}}{k}$$

$$H = \frac{95}{0.433} = 219.4$$

3. Answer: **C**.

$$Q = 1.4 \times 2(L + W)HV$$

$$Q = 1.4 \times 2(3 \text{ ft} + 2 \text{ ft}) \times 3 \text{ ft} \times 100 \text{ fpm}$$

$$Q = 2.8 \times 5 \times 300$$

$$Q = 4200 \text{ cfm}$$

4. Answer: **B**.

$$Q_2 : Q_1 = (T_1 + 460)^4 : (T_2 + 460)^4$$

$$Q_2 : Q_1 = (1200 + 460)^4 : (600 + 460)^4$$

$$Q_2 : Q_1 = (7.5 \times 10^{12}) : (1.26 \times 10^{12})$$

$$Q_2 : Q_1 \approx 6$$

5. Answer: **C**.

$$V = \frac{\pi d^2 \times h}{4}$$

$$V = \frac{3.14 \times (32.75)^2 \times 10}{4}$$

$$V = 8424 \text{ cu ft}$$

$$8424 \text{ cu ft} \times 7.48 \text{ gal per cu ft} = 63{,}000 \text{ gallons}$$

According to the table, 50 feet of distance is required.

6. Answer: **B**. Balancing with dampers or blast gates is possible; however, the damper would be installed in duct "C" rather than "B" (**Figure 39**). The recommended balancing method is to calculate the static pressure for each run from the exhaust hood up to the junction and calculate the percent differential (in this case it's 2.8 ÷ 1.6 = 1.75 or 75%). Then a decision is made based on the following:
   - If SP is less than 5% different use greatest static pressure.

$$CFM_{actual} = CFM_{calcuated}\sqrt{\frac{SP\ higher}{SP\ lower}}$$

   - If the SP difference is 5 to 20%, calculate the increase in cfm in the duct with the lower static pressure.
   - If the SP is greater than 20%, resize the duct with the lowest SP (smaller duct will increase resistance and SP).

   *Note: Enlargement regain calculations are not used for branch entry enlargements.

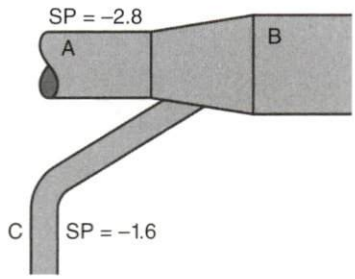


Figure 39 Two Ducts Schematic

7. Answer: **A**.

T = Temperature in Kelvin

P = Pressure

V = Volume

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

$$\frac{P_1}{T_1} = \frac{2(P_2)}{T_2}$$

$$T_2 = 2(T_1)$$

$$T_2 = 2(298) = 596°K$$

8. Answer: **B**.

$$I_2 = I_1 \times \frac{(d_1)^2}{(d_2)^2} \text{ becomes } d_2 = \sqrt{\frac{I_1 \times d_1^2}{I_2}}$$

$$d_2 = \sqrt{\frac{70 \times 10^2}{250}}$$

$$d_2 = 5.3 \text{ ft}$$

9. Answer: **A**. Small spills of mercury can be cleaned up using calcium polysulfide with excess sulfur by sprinkling the powder into cracks or inaccessible sites. The power will combine with the mercury and can then be removed by vacuum or other methods.

10. Answer: **B**. When electroplating, the object to be plated is suspended in a chemical bath as the cathode in an electrical circuit and the material to be applied to the surface acts as the anode. When current is applied in this process, material enters the conductive chemical solution at the anode as ions and reverts back to atoms at the surface of the cathode; much like with cathodic protection for corrosion when a sacrificial anode is consumed. The terms "plate" and "filament" refer to electron flow theory, such as in vacuum amplification tubes.

11. Answer: **C**. The only possible selection would be the Walton-Beckett Graticule, which is an eyepiece graticule specifically designed for asbestos fiber counting. It consists of a circle with a projected diameter of 100 plus or minus 2 µm with a crosshair having tic marks at 3-µm intervals in one direction and 5-µm in the orthogonal direction. There are marks around the periphery of the circle to demonstrate the proper sizes and shapes of fibers. The disk is placed in one of the microscope eyepieces so that the design is superimposed on the field of view. This allows counting of the fibers by field. Selection "A" is incorrect due to the PVC rather than MCEF filters that **are** used for asbestos sampling.

12. Answer: **C**.

$$i = .13 \quad n = 5 \quad F = \$250{,}000 \quad P = ?$$

$$P = F(1 + i)^{-n}$$

$$P = 250{,}000 \times (1 + .13)^{-5}$$

$$P = \$135{,}690$$

13. Answer: **C**.

$$\text{Room size} = 10 \times 10 \times 30 = 3000 \text{ cfm}$$

$$\frac{3500 \text{ cfm}}{3000 \text{ cfm}} = 1.16 \text{ room changes/min}$$

14. Answer: **D**. The ASME Code calls for 150% of the *maximum operating pressure.*

15. Answer: **D**. According to the book *Health and Safety, Environmental and Quality Audits: A Risk-Based Approach*, though it is possible for an auditor to perform a good job within the organization with which he or she has line or staff responsibilities, it is best for an auditor to be free from all such responsibilities so that the final audit report will be perceived by all readers to be free from any real or perceived biases.

16. Answer: **A**. Only the first equation is balanced and represents the mixture of two substances, which explode on contact. The hypergolic reaction shown is that of hydrazine and hydrogen peroxide.

17. Answer: **D**.

$$\frac{10}{50} = .2$$

$$\frac{100}{350} = .29$$

$$\frac{50}{200} = .25$$

$$74\%$$

18. Answer: **D**.

$$Q = \frac{403 \times 10^6 \times SG \times ER \times K}{MW \times C}$$

$$Q = \frac{403 \times 1{,}000{,}000 \times 0.792 \times 0.0333 \times 6}{32.04 \times 200}$$

$$Q = \frac{63{,}771{,}365}{6480}$$

$$Q = 9841 \text{ cfm}$$

*Note: Remember the solvent is being applied at an hourly rate and must be reduced to minutes to get cfm. The "K" factors are safety factors and run between 3 to 10 and depend on:

1. The toxicity of the material (lower TLV = higher "K")
2. The evolution rate of the contaminant (usually nonuniform)
3. The effectiveness of ventilation (location in airflow)

19. Answer: **B**. Given the selections of word searches, the general Internet search engine will provide the most valuable information. The other options will not provide international information.

20. Answer: **C**. The symbol shown in the fault tree is that of the "OR" logic gate. This means that failure of any of the components in the tree will cause the overall system to fail; that is, component 1 can fail, or component 2 can fail, or component 3 can fail, etc. This arrangement is often called series construction. The + shown in the gate represents the engineering symbol for the "OR" function. The rare event approximation cannot be used in this problem (see next question).

$$P_{Total} = P_1 + P_2 + P_3 - (P_1 \times P_2 \times P_3)$$

$$P_{Total} = .01 + .03 + .05 - (.01 \times .03 \times .05) = .08998 \text{ or } 8.998\%$$

21. Answer: **A**. The symbol shown in the fault tree is that of the "AND" logic gate. The * shown in the gate represents the engineering symbol for the "AND" function. This means that failure of all the devices in the system must occur before the entire system will fail. This arrangement is often called parallel construction. To determine the total probability of failure for this representation the bottom event probabilities would be multiplied.

$$P_{Total} = P_1 \times P_2 \times P_3$$

$$P_{Total} = .001 + .003 + .005 = .000000015 \text{ or } 1.5 \times 10^{-8}$$

*Note that if any of the minimal cut set event probabilities were higher than about 1×10^{-2}, using the rare event approximation would be inappropriate (see preceding question).

22. Answer: **D**. Since the components are in parallel, the configuration indicates an "AND" gate situation, that is C_1 and C_2 and C_3 and C_4 must fail before the output fails. The symbol for an "AND" gate is "*," which indicates multiplication; this leads us to the correct answer. Multiply the failure rates of each component. $F_1 \times F_2 \times F_3 \times F_4$, or since the failure rates are all the same, F^4 (**Figure 40**).

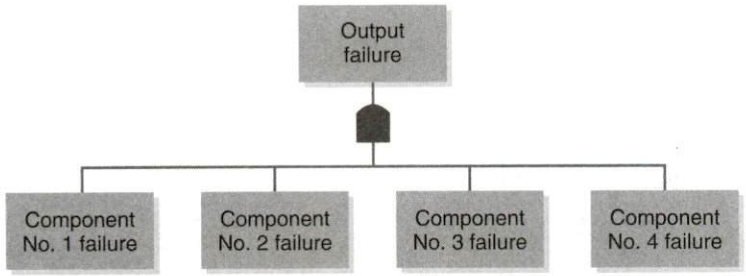


Figure 40 Fault Tree Analysis

*Note: When dealing in probability of failure the general rules are:

- parallel construction indicates "AND" = multiply
- series construction indicates "OR" = addition

23. Answer: **B**. Find the exposure of chemical A over an 8-hour period.

$$\text{8-hr exposure} = \frac{(C_1T_1) + (C_2T_2) + \ldots + (C_nT_n)}{8 \text{ hrs}}$$

$$\text{8-hr exposure} = \frac{(1.7 \text{ ppm} \times 2 \text{ hrs}) + (0 \text{ ppm} \times 6 \text{ hrs})}{8 \text{ hrs}} = 0.425 \text{ ppm}$$

The exposure is less than the TWA.

24. Answer: **B**. Find the allowable exposure time of gas B.

$$\text{8-hr exposure} = \frac{(C_1T_1) + (C_2T_2) + \ldots + (C_nT_n)}{8 \text{ hrs}}$$

$$100 \text{ ppm} = \frac{(400 \text{ ppm} \times T_1)}{8 \text{ hrs}}$$

$$T_1 = \frac{100 \text{ ppm} \times 8 \text{ hrs}}{400 \text{ ppm}} = 2 \text{ hrs}$$

25. Answer: **C**. The DOT defines a motor vehicle accident as one in which either someone is transported to the hospital, or a vehicle is towed. The requirement for post-accident-controlled substances testing can be found in 49 CFR 382.303:

(a) A driver shall provide a urine sample to be tested for the use of controlled substances as soon as possible, but not later than 32 hours, after an accident, as defined in 390.5 of this subchapter, if the driver of the commercial motor vehicle receives a moving traffic violation citation arising from the accident.

(b) A driver who is seriously injured and cannot provide a specimen at the time of the accident shall provide the necessary authorization for obtaining hospital reports and other documents that would indicate whether there were any controlled substances in his/her system.

(c) A motor carrier shall provide drivers with necessary information and procedures so that the driver will be able to meet the requirement of paragraph (a) of this section.

26. Answer: **A**. OHSAs 18001 is an *Occupation Health and Safety Assessment Series* for health and safety management systems. It is intended to help an organization to control occupational health and safety risks.

It was developed in response to widespread demand for a recognized standard against which to be certified and assessed. OHSAS 18001 will measure your managements system with regards to several dimensions. The extent of application will depend on such factors as the occupational health and safety policy of the organization, the nature of its activities, and conditions under which it operates. A successful management system should be based on:

- An occupational health and safety policy appropriate for the company.
- Identification of occupational health and safety risks and legal requirements.
- Objectives, targets, and programs that ensure continual improvements.
- Management activities that control the occupational health and safety risks.
- Monitoring of the occupational health and safety system performance.
- Continual reviews, evaluation, and improvement of the system.

27. Answer: **B**. An air gap is a physical separation between a potable water supply and a nonpotable water system that prevents the contamination of drinking water by back-siphonage or back flow. An air gap is often required by code.

28. Answer: **A**. In the book *Health and Safety, Environmental and Quality Audits: A Risk-Based Approach*, when possible, it is best for auditors to verify firsthand that management processes are being implemented as documented. Otherwise. auditors have to rely on management certifications that the processes are being conducted appropriately.

29. Answer: **C**. The GHS hazard definitions are criteria-based and address three main classification criteria: health and environmental hazards; physical hazards; and mixtures. Classification is the starting point for hazard communication. It involves the identification of the hazard(s) of a chemical or mixture by assigning a category of hazard/danger using defined criteria. The GHS is designed to be consistent and transparent. It draws a clear distinction between classes and categories in order to allow for **"self-classification."** For many hazards, a decision tree approach (e.g., eye irritation) is provided in the GHS document. For several hazards, the GHS criteria are semi-quantitative or qualitative. Expert judgment may be required to interpret these data. It is recommended that the person responsible for GHS implementation consult the GHS document or "Purple Book" for more complete information.

30. Answer: **A**. Chemical manufacturers and importers have until June 1, 2015, to develop new GHS-compliant labels and put them on chemical containers. Chemical distributors have until December 1, 2015, to make sure the new labels are affixed to all containers that are shipped. However, some manufacturers and distributors are ahead of schedule and you may already have started to see the new GHS labels on your shipments of chemicals.

    The new labels shipped with the container have to display all of the following elements:

    - A pictogram with one of eight new hazard symbols inside a diamond-shaped box with a red border
    - A signal word, either "Danger" or "Warning"
    - Hazard statements, such as "Highly flammable liquid and vapor."
    - Precautionary statements, such as "Keep container tightly closed."
    - The product identifier, such as product name and/or code
    - Supplier identification, including manufacture name, address, and phone
    - The label may also contain supplemental information, such as "Directions for use."

31. Answer: **B**. 1910.1200(a)(2) This occupational safety and health standard is intended to address comprehensively the issue of classifying the potential hazards of chemicals and communicating information concerning hazards and appropriate protective measures to employees.

32. Answer: **B**. The GHS new terms are defined as:

- **Classification**—identification and evaluation of relevant data regarding chemical hazards and comparison to GHS criteria
- **Hazard class**—the nature of the physical or health hazard
- **Hazard category**—division of criteria within each hazard class
- **Hazard statement**—statement assigned to a hazard class and category that describes the nature and degree of hazard
- **Pictogram**—symbol plus other graphic elements intended to convey specific information about the hazards
- **Precautionary statement**—phrase that describes measures that should be taken to minimize or prevent adverse effects
- **Safety data sheet (SDS)**—Material Safety Data Sheet (MSDS)
- **Signal word**—indicates the relative level of severity of hazard. Danger is more severe. Warning is less severe.

(OSHA, *A Guide to the Globally Harmonized System of Classification and Labeling of Chemicals [GHS]*)

33. Answer: **A**.

Each physical or health hazard is a "hazard class" (e.g., carcinogenicity is a hazard class). A "hazard class" may be subdivided in the criteria into several "hazard categories" based on the degree of severity of the hazard.

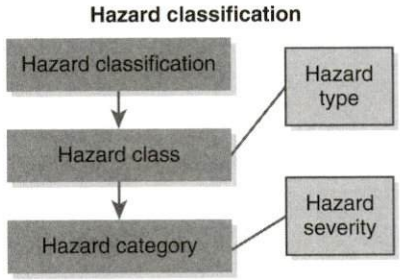


Figure 41 Classifying Hazards

Placing a chemical into a "hazard class," and where necessary, a "hazard category," is the concept of classification based on **determining not only the hazard but also the severity of the effect (Figure 41).**

34. Answer: **C**. The 2012 OSHA HazCom's addition of pyrophoric gas, simple asphyxiants, and combustible dust to the physical and health hazards is very significant as these are not hazards as defined by GHS.

"**Simple asphyxiant**" means a substance or mixture that displaces oxygen in the ambient atmosphere and can thus cause oxygen deprivation in those who are exposed, leading to unconsciousness and death. Label: ***Warning. May displace oxygen and cause rapid suffocation.***

"**Pyrophoric gas**" means a chemical in a gaseous state that will ignite spontaneously in air at a temperature of 130°F (54.4°C) or below.

Label: **Danger. Catches fire spontaneously if exposed to air.**

"**Combustible dust**" is covered separately from HNOC, but is not specifically defined.

Guidance for defining combustible dust is to be taken from existing documents, including the directive for the National Emphasis Program; the NFPA standards also provide useful information.

Combustible dust must be addressed on labels where appropriate:

Warning. May form combustible dust concentrations in air.

Paragraph (f)(4) may apply to materials shipped in solid form that create combustible dust when processed.

35. Answer: **C**. All of these codes are used in industry in the fire protection and prevention business. However, the National Fire Protection Association (NFPA) is considered the most important source of standards.

36. Answer: **D**. This standard guides how to manage and conduct quality and environmental systems audits.

37. Answer: **D**. There are three traditional levels of warnings:

    - Danger is used where there is an immediate hazard, which, if encountered, will result in severe personal injury or death.
    - Warning is the signal word for hazards or unsafe practices, which could result in severe personal injury or death.
    - Caution is for hazards or unsafe practices, which could usually result in minor personal injury, product damage, or property damage.

38. Answer: **B**. The National Fire Protection Association is the main source of fire standards in the United States. Some other sources would include the Uniform Fire Code, BOCA Basic Fire Prevention Code, Standard Fire Prevention Code.

39. Answer: **A**. Several classes of products are covered by other agencies and therefore exempted from CPSC rules (CPSC rules, Consumer Products EXCLUDED from CPSC Jurisdiction), these are:

    - Motor vehicles and equipment
    - Food
    - Medical devices
    - Aircraft
    - Tobacco
    - Ammunition
    - Drugs
    - Cosmetics
    - Poisons
    - Boats
    - Firearms
    - Pesticides

    The CPSC has issued several guidelines for specific products. Some of the more well-known are:

    - Bicycles
    - Swimming pool slides
    - Matchbook covers
    - Stovetops

40. Answer: **C**. When developing emergency management plans, sometimes the fundamental purpose is lost, that is, to protect life, property, and the environment. Though command and communication responsibilities are important (and must be part of the plan), the fundamental strategies have to be developed to protect people. property, and the environment, and then the tactics can be applied.

41. Answer: **C**. This is the definition of a loss control system.

42. Answer: **D**. The definition of arbitration is "the settlement of a dispute by a person or persons chosen to hear both sides and come to a decision."

43. Answer: **B**. It is extremely hard to determine the indirect underlying cost of accidents, damage to equipment, total costs etc.

    Benefit-cost analysis is the systematic approach to assess, calculate and analyze the costs and benefits of competing alternatives. A simple analysis can be defined as a benefit divided by its cost. If the benefit is of measurable value, the benefit-cost ratio represents the benefit derived per unit of cost.

    The reciprocal of this is the cost/benefit and can be used to understand how good a "bargain" a particular alternative poses or the cost of one unit of benefit.

44. Answer: **D**. Several classes of products are covered by other agencies and therefore exempted from CPSC rules (CPSC rules, Consumer Products EXCLUDED from CPSC Jurisdiction). These are:

    - Motor vehicles and equipment
    - Food
    - Medical devices
    - Aircraft
    - Tobacco
    - Ammunition
    - Drugs
    - Cosmetics
    - Poisons
    - Boats
    - Firearms
    - Pesticides

The CPSC has issued several guidelines for specific products. Some of the more famous are:

- Bicycles
- Swimming pool slides
- Matchbook covers
- Stovetops

45. Answer: **A**. This is the definition of epidemiology.

46. Answer: **B**. According to the NSC, a safety and health committee is a group that aids and advises both management and employees on matters of safety and health pertaining to plant or company operations. In addition, it performs essential monitoring, educational, investigative, and evaluation tasks. The committee should evaluate its performance against its established goals.

    No other facet of safety program management is as controversial as the "safety committee." Depending on the support afforded the committee, it can become a do-nothing, gossip club, or it can be can be an extremely valuable and effective medium for communication and problem solving. The committee is ideally suited for gaining widespread support for special projects or for "getting the word out." A committee is not especially suited to providing quick decisions; however, they do provide an excellent coordination vehicle. One disadvantage is that these committees can become a "dumping ground" for trivial issues.

47. Answer: **D**. The main objective of the Consumer Product Safety Commission is to prevent the consumer from being presented with a *substantial risk* of death, injury, or serious frequent illness. The first chairman of the CPSC, Richard Simpson, said the goal of the commission "is not to remove all risk, but all unnecessary risk."

48. Answer: **C**. In Roger Brauer's *Safety and Health for Engineers*, before forwarding a recommendation for corrective action to train (or retrain) employees, a safety professional should check to see if one or more effective engineering controls would cost effectively reduce the risk to an acceptable level.

49. Answer: **A**. The cause factors discovered during accident investigations are normally corrected by the level of supervision that exercises control over the operation.

50. Answer: **D**. The Otis–Lennon mental ability tests, often referred to as the Otis test, is used extensively in IQ testing. There is and has been huge controversy within the educational community concerning the use of this type of testing. The controversy is multifaceted and involves the test content, methods used in administering the test, methods used in scoring the test, etc. The generally accepted premise in industrial safety work is that the cognitive ability tests, such as the Otis test, are not reliable indicators of the ability to do well in industrial or safety training efforts.

51. Answer: **C**. Actions that are typically considered staff include planning, supporting, facilitating, training, assisting etc. Commanding implies actual production and is a *line* function.

52. Answer: **C**. Accident investigation has as its primary purpose the prevention of similar occurrences and the discovery of hazards. The intent is not to place blame or administer discipline but rather to determine how responsibilities may be defined or clarified and to reduce error-producing situations. Accident investigation should improve the safety of operations. If accident investigation is used for punitive measures, the tool has the reverse effect.

53. Answer: **D**. There are no universally agreed upon indirect costs of accidents within the health and safety community. Consequently, the term "uninsured costs" have grown in popularity because it has some standardization. However, it is generally agreed that the indirect costs of accident include, but are not limited to:

    - Cost of overtime for workers not injured
    - Cost of training new worker to replace injured
    - Cost of wages paid to accident investigators
    - Cost of wages paid to unproductive workers due to accident
    - Cost of damage to material and equipment
    - Cost of medical not covered by insurance

54. Answer: **A**. When OSHA provides a penalty for a citation, they do it by certified mail. From the time you receive the letter you have 15 working days to contest the citation or the proposed assessment of penalty or both. You must notify the OSHA area director within this 15-day period, or both the citation and penalty become final. The OSHA area director then forwards your notice to the Occupational Safety and Health Review Commission.

55. Answer: **D**. H. W. Heinrich in 1931 developed a theory of accident prevention, which was based on five axioms. One of which was the domino theory of accident causation. This theory modeled the accident sequence with five dominoes standing on end. As shown here, the dominoes represent the factors of ancestry or social environment, fault of the person, the unsafe act or condition, the accident and lastly, the injury. Once any one domino starts to fall, there is nothing you can do to stop the sequence; however, if you break the chain of dominoes by removing the center domino (unsafe act/condition), the accident sequence is aborted, and an injury will not occur. Heinrich stated it this way: "The occurrence of an injury invariably results from a completed sequence of factors the last one of these being the injury itself. The accident which caused the injury is in turn invariably caused or permitted directly by the unsafe act of a person and/or a mechanical or physical hazard." *Industrial Accident Prevention*, 4th ed., McGraw-Hill Book Company, New York.

    This accident causation model has largely been replaced by the more modern concept of multiple causes that envisions many factors combining to set the stage for accidental loss.

56. Answer: **C**. The Occupational Safety and Health Review Commission (OSHRC) has two levels of adjudication. The first level is the Administrative Law Judge (ALJ) who hears all cases not resolved on informal proceedings. The second level of review is the three-member commission. The commission can change a judge's decision on a case with votes from two or more members. A single member can bring the case up for review before the commission but acting alone cannot change the decision of the ALJ. One recent case involved a contractor who used a mobile crane to lift a backhoe (with operator) equipped with hydraulic hammer 70 feet above grade to demolish the top of a bridge pier. The contractor was cited under 1926.550 (g); however, the ALJ ruled in favor of the contractor. As would be expected, the ruling was overturned by the OSHRC who ruled that a backhoe does not fall within the definition of a personnel platform. Additionally, the commission said that the worker was "riding the load," and the company could also be cited for that violation.

57. Answer: **A**. Engineering is always the first and most successful method of dealing with a problem, second choice would be to guard the hazard, and last to educate the human element. Before making any recommendations, such as wearing PPE or training/retraining employees, for a corrective action to a problem area, a safety professional should check to see if installing engineering controls would be the cost-effective way to reduce the risk.

58. Answer: **A**. According to *Safety and Health for Engineers*, a fire brigade is equipped, trained, maintained, and called on to reduce the effects of a loss that has already occurred. The other answer selections are loss prevention method.

59. Answer: **B**. According to Dan Peterson in his book *Safety by Objectives*, there are five steps involved in SBO:

    - Obtain management supervision agreement on objectives
    - Give the supervisors an opportunity to perform
    - Let them know how they are doing
    - Help, guide, and train them
    - Reward them according to their progress

    Safety by objective works best in an organizational climate that has upward and downward communications.

60. Answer: **D**. This is a very difficult question! Like many management questions, there could be several different answers. However, the general feeling is that the safety effort should report to a function with power and the control to correct problems. Root causes of mishaps can exist in any of the elements in a company as can the interrelated causes of accidents. We feel the best place for the safety expertise is in a staff function reporting to the senior executive.

61. Answer: **D**.

COMPANY "A" = Traditional (**Figure 42**)

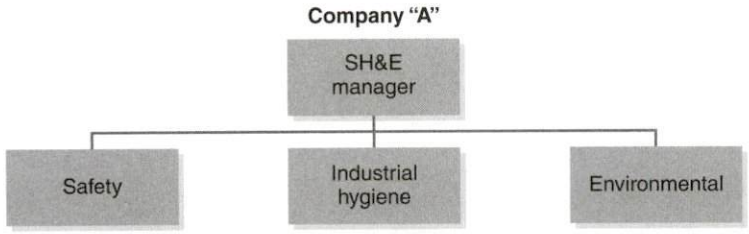


Figure 42 Organizational Chart of Traditional Management

COMPANY "B" = Functional (**Figure 43**)

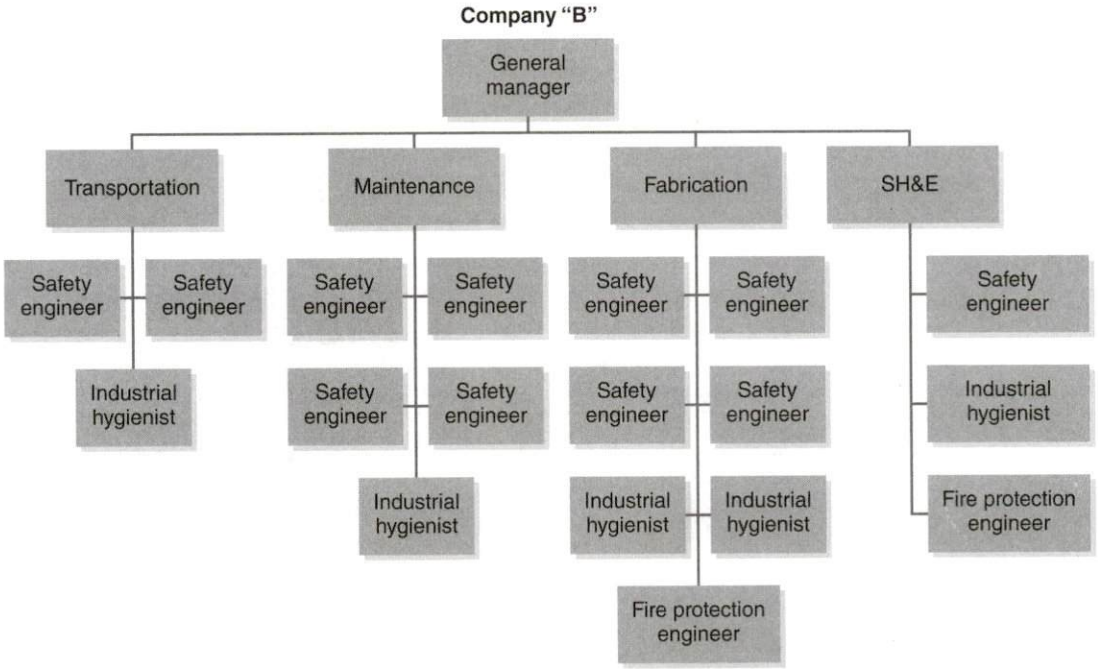


Figure 43 Organizational Chart of Functional Managment

COMPANY "C" = Goal Oriented (**Figure 44**)

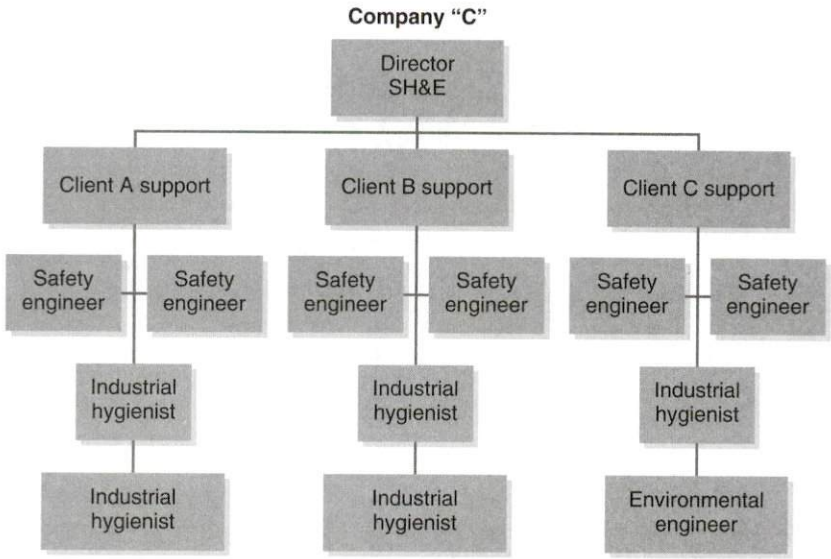


Figure 44 Organizational Chart of Goal Oriented Management

COMPANY "D" = Matrix (**Figure 45**)

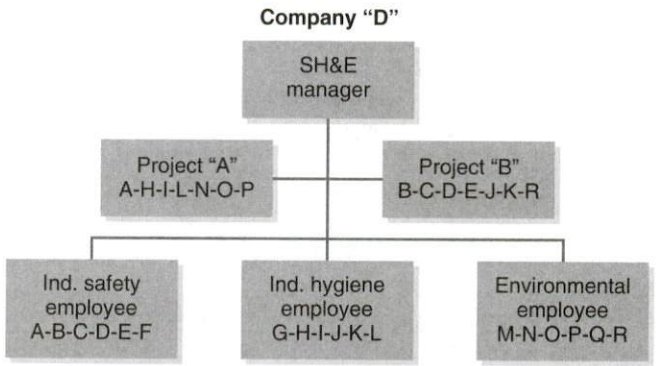


Figure 45 Organizational Chart of Matrix Management

The safety function must give attention to outside influences such as the external environment, community interest, and general concerns. The management style that reacts to these performance forces is known as the contingency style. In choosing an organizational model that is most appropriate, the manager should remember that there is a range of workable solutions. The task is to find one that will give results with minimum difficulty in the situation in which the organization operates.

62. Answer: **D**. Answer A "Client receives credit for improvements to safety conditions according to a set schedule of accident prevention activities" sounds like a "schedule rate." The schedule rate method involves penalizing or regarding a client for engaging in proven accident prevention activities, which are prescribed by the insuring agency. An audit of the "schedule" of activities is performed and the rate computed.

    Answer B "Premiums are based on like employer experience" is the definition of a manual rating method. The premium is based on the classification of the industry and the amount of payroll.

    Answer C "Client pays according to the rate schedule per $100 of payroll" is again a manual rating method.

Answer D "Premiums relate to company experience averaged over a period of time" is one description of the experience or prospective rating method. It combines some of the characteristics of the manual rating method with an experience adjustment. Premiums are based on estimates of the expected losses for the average company in a similar industry classification. Adjustments are made for loss experience (generally over the past three years). Premiums can be more or less than the manual rate. Another popular method is the "retrospective rating." Under this system, premiums are directly related to past experience; however, the company pays an expected premium at the beginning of a period (usually) one year and then adjustments are made at the end of the period that reflect accident experience.

63. Answer: **A**. The insurance industry uses EMR for workers' compensation insurance as a means of determining equitable premiums. These rating systems consider the average incident losses for a given firm's type of work and the amount of payroll and predict the dollar amount of expected losses due to work-related injuries and illnesses. The experience rating plan is an actuarial formula used by the workers' compensation insurance industry to allow the insured to benefit from successful loss control.

64. Answer: **C**. Natural wear and tear perils include items such as fading, rust, pollution, settling of foundations, walls, pavements, etc. Wear and tear perils are not accidental; these things are certain to happen given a long enough timeframe. There would be no benefit in insuring these items; the risk would not be transferred.

65. Answer: **D**. According to the NSC *Fundamentals of Industrial Hygiene*, to evaluate this problem, it is best to consult the material safety data sheets and the suppliers of the materials. With more details, one can determine what to monitor and the best method of controls.

66. Answer: **C**.

When the failure rates of many common components are plotted against time, a "bathtub" curve develops (**Figure 46**). These curves or plots are generally divided into three distinct areas or periods. Period "I" is known as the early failure or infant mortality period. This period is also often called the debugging or **burn-in** period. Failures occur during this period due to substandard material, construction, or use of the component. As can be seen from the chart the failure rate is high during this period and gradually levels off as we approach period "II." Period "II" is known as the constant failure or the useful life period. Failures during this period occur as random or chance failures usually as a result of complex failures. Many times, these failures involve two or more subcomponents. This is the period where the largest percentage of accidental failures occur. Period "III" is the old age or wear-out period. The product or components are past the useful life and failures are due to embrittled metal, excess wearing of parts, breakage, excessive consumption, etc.

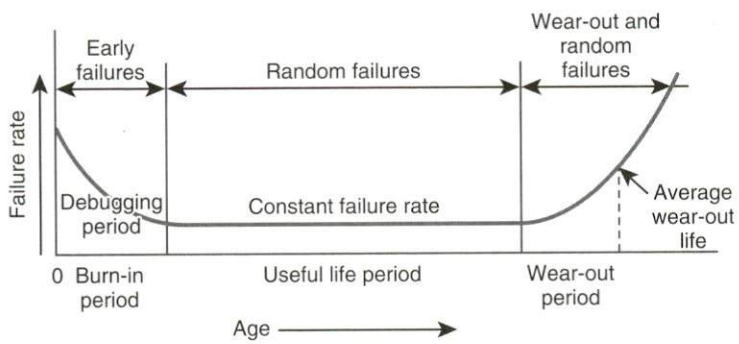


Figure 46 Bathtub Curve Depicting Relationship Between Component Failure and Exposure

67. Answer: **C**. This is the definition of the Pareto Principle, sometimes referred to as the 80-20 rule that indicates that 80% of the problems come from 20% of the operations. It is also true that 20% of the corrective actions and risk reduction actions can mitigate 80% of the risk, when the risks are understood.

68. Answer: **D**. Some authorities claim that installation of dust removal equipment is the first real step—the idea of prevention through design. Others believe substitution of materials is the first step. According to NFPA 654 (Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids), both substitution and engineering controls are viable options, and the process must be studied to determine the best solution. When substitution of materials or processes is not a viable option, then engineering options are needed. The overall goal is to control dust concentrations, emissions, accumulations, and ignition sources. A collaborative effort may be made with management, process engineers, facility maintenance engineers, SH&E professionals, operators, and others providing input. Failure mode and effects analysis, fault tree analysis, or another methodology may be implemented to optimize the design. Physical controls, such as detection and suppression systems with shutdown interlocks, should be integrated into the design. Operating procedures for start-up, normal operations, emergency situations, and shutdown should be developed in conjunction with the process unit's design to ensure compatibility. Training for all personnel involved with the operation and maintenance of the unit must be provided and updated as needed. For existing processes, the hazard analysis should be reviewed regularly and when the process or equipment is changed. Suggestions for improvement from operators and maintenance personnel should be incorporated into the system when possible. New advances in technology should be evaluated for inclusion into the design, if possible. Ongoing equipment maintenance is critical. Systems should be inspected regularly. Predictive maintenance using infrared thermographic imaging will identify hot spots in the process and in electrical systems and motors. Vibration analysis and acoustic and sound monitoring are also important tools to use in determining and repairing potential maintenance problems.

69. Answer: **A**. According to *Developing Safety Training Programs,* obtaining student feedback is essential. All modern management systems require formal processes for obtaining feedback for continuous improvement of the management systems. The training subsystem is no different.

70. Answer: **C**. Risk that affects the public must be explained to the public in a careful, planned way. First, the public must be alerted to the identity and magnitude of the risk in a straightforward, easy to understand way. Next, the public must be reassured that the risk is being managed and the steps that are being taken to manage the risk (in a straightforward, easy to understand way).

71. Answer: **C**. The four major elements of the U.S. OSHA Voluntary Protection Programs are (1) management commitment and employee involvement, (2) work site analysis, (3) hazard prevention and control, and (4) safety and health training.

72. Answer: **B**. In the book *Safety and Health Management*, an organization's achievable goals must include schedule-based success parameter where each goal should have a time frame for success.

73. Answer: **C**. In the book *Health and Safety, Environmental and Quality Audits: A Risk-Based Approach*, the real purpose of adopting the OHSAS 18001 health and safety management system is to promote continuous improvement. If the management system detects a significant deterioration of the company's safety performance, then it should trigger a comprehensive management review of the issues that are contributors to the deterioration. The other items are ancillary, and possibly not even related to the occupational health and safety management system.

74. Answer: **A**. The Underwriters Laboratory (UL) Mark on a product means that UL has tested and evaluated representative samples of that product and determined that they meet UL requirements. There are many types of UL Marks, each with its own specific meaning. The only way to determine if a product has been certified by UL is to look for the UL Mark on the product itself. In a few instances, the UL Mark may be present only on the packaging of a product. The UL Listing Mark is one of the most common UL Marks. If a product carries this mark, it means UL found that representative product samples met UL's safety requirements. These requirements are primarily based on UL's own published standards for safety. This type of mark is seen commonly on appliances and computer equipment, furnaces and heaters, fuses, electrical panel boards, smoke and carbon monoxide alarms, fire extinguishers and sprinkler systems, personal flotation devices, bullet resistant glass, and thousands of other products.

75. Answer: **B**. The Research and Special Program Administration (RSPA) published final rule HM-181. In this rule, RSPA adopted a performance-oriented approach to the construction of nonbulk and intermediate-bulk hazardous materials packaging. These changes were based on the United Nations (UN) Recommendations on the Transport of Dangerous Goods and harmonized U.S. and international standards for the transportation of hazardous materials. Each manufacturer must mark every packaging that meets UN standards with the markings specified in §49 CFR 178.503. The identification codes must be durable and legible. Identification marks will be placed in a location on the packaging to be readily visible. All certified hazardous materials' packaging must bear the UN symbol (From UN packing symbol of United Nations General Assembly, United Nations. Reprinted with the permission of the United Nations). The letters UN may be applied in place of the symbol. Identification codes must be printed or embossed on the packaging in association with the UN symbol. The packaging identification code. This code designates:

- The type of packaging;
- The material of construction; and, when appropriate,
- The category of packaging.

76. Answer: **A**. Category 1 represents the greatest hazard. Opposite numbering system to traditional HMIS and NFPA (**Tables 35** and **36**).

- Flammable liquid
  - Category 1 *"Extremely flammable liquid and vapor"*
  - Category 2 *"Highly flammable liquid and vapor"*
  - Category 3 *"Flammable liquid and vapor"*
  - Category 4 *"Combustible liquid"*
- Oral Acute Toxicity
  - Category 1 *"Fatal if swallowed"*
  - Category 2 *"Fatal if swallowed"*
  - Category 3 *"Toxic if swallowed"*
  - Category 4 *"Harmful if swallowed"*
  - Category 5 *"Maybe harmful if swallowed"*

Table 35 Flammable and (Combustible) Liquid Classification Comparison

Flash Point Closed Cup	<20°F (–7°C)	<20°F (–7°C) – 100°F (38°C)	100°F (38°C) – 140°F (60°C)	140°F (60°C) – 150°F (66°C)	150°F (66°C) – 200°F (93°C)
OSHA	Flammable	Flammable	Combustible	Combustible	Combustible
ANSI	Extremely Flammable	Flammable	Flammable (<141°F/60.5°C)	Combustible	Combustible
RCRA (EPA)	Ignitable	Ignitable	Ignitable		
DOT	Flammable	Flammable	Flammable (<141°F/60.5°C)	Combustible	Combustible
CPSC	Extremely Flammable	Flammable	Combustible	Combustible	
NFPA 30	Class I	Class I	Class II	Class III	Class III

Table 36 GHS Flammable (and Combustible) Liquid Criteria

Criteria	GHS Category	Transport Class I Packing Group
Flash point <73°F (23°C) and initial boiling point ≤ 95°F (35°C)	1	3, I
Flash point <73°F (23°C) and initial boiling point > 95°F (35°C)	2	3, II
Flash point ≥73°F (23°C) and ≤ 140°F (60.5°C)	3	3, III
Flash point >140°F (60.5°C) and ≤ 199.4°F (93°C)	4	Combustible Liquid, PG III [DOT uses <200°F(93°C)]

77. Answer: **C**. This is the definition of a needs analysis and will help you decide between training and nontraining needs. After you define the performance discrepancy, instead of training, maybe a new set of work instructions will solve the problem. An example could be to hang out a PPE required sign to remind personnel that PPE is required when they operate a particular machine.

78. Answer: **B**. **MORT is Management Oversight and Risk Tree** that is a type of fault tree that has both a management side and an operations side. When using MORT, the two areas leading to management oversights and omissions are specific control factors and management factors.

    Program Evaluation Review Technique *PERT* is the presentation of events, tasks, and activities on a network in sequential form with completion time estimates. Although the safety engineer can use this scheduling "model" to uncover bottlenecks and possible hazards that may arise from the order of work, or from changes in the setup or environment that may arise it is not normally considered a system safety methodology. CPM, or Critical Path Method, is another scheduling model.

    THERP is **Technique for Human Error Rate Prediction,** developed by Sandia Laboratories.

79. Answer: **C**. According to the teachings of Peter F. Drucker, productivity is the measure of all the efforts that go into output, including managing social responsibilities. It should be expressed in terms that evaluate the overall result rather than assume that labor is the only productive effort. His concept of productivity includes:

    - Knowledge workers: That is, those workers who possess extraordinary skills and experience. These talented workers (line or staff) are usually high-cost and represent a high social investment. They can add tremendously to the overall productivity "score" or drive the cost of doing business through the roof.
    - Time: The ability to allow all resources to be involved in output activities to the maximum extent possible. Drucker warns that idle time for equipment or personnel is a tremendous waste; however, it can be overshadowed by the loss of the manager's time. Drucker believes that the manager's time can be the most or least productive of any resource; however, it is least evaluated, analyzed, and managed of all the elements of overall productivity.
    - Product mix: The balance between high dollar-profit products and low-profit products is an important element in the overall productivity equation.
    - Process mix: The balance between what the company produces with its own equipment or people and what it chooses to buy from an outside source. How much time is spent doing what the company is really good at?
    - Organizational structure: How well does the organizational structure suit the business? If time is spent fighting the organizational hierarchy, it is wasted to production. Assignment of the wrong kind of people is an example; if top management is all sales folks, then could engineering suffer?

    *Note: Extracted from: *An Introductory View of Management* by Peter F. Drucker (1977).

80. Answer: **C**.

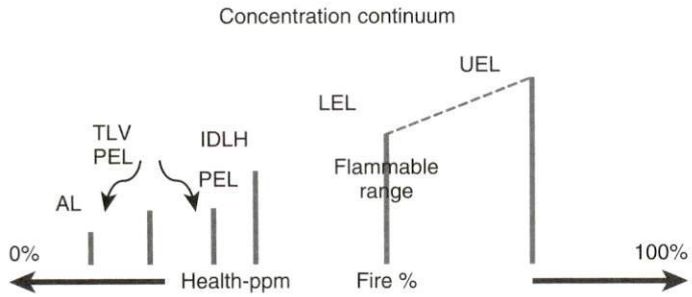


Figure 47 Concentration Continuum

As can be seen in **Figure 47**, health limits are measured in parts per million while flammability is measured in percentage (parts per hundred).

AL = Action Limit

PEL = Permissible Exposure Limit

TLV = Threshold Limit Value

REL = Recommended Exposure Limit

IDLH = Immediately Dangerous to Life and Health

LEL = Lower Explosive Limit

UEL = Upper Explosive Limit

81. Answer: **A**. Halons (Halogenated compounds) are currently widely used as fire extinguishing agents, although environmental concerns have placed some restrictions on their continued use. For example, halon 1301, 1211, and 2402 have been identified as ozone-depletion agents. A complete phase-out of the production of these halons by the year 2000 (with few exceptions) was required by international agreement (the Montreal Protocol). The substitution of an atom of hydrogen by a halogen atom renders the compound nonflammable and adds a flame retardant capability. Most halons are known by a four-digit number which indicates the number of atoms of each type contained in the compound. **Table 37** illustrates the process.

Table 37 Types and Numbers of Atoms in Halogenated Compounds

Name of halogenated agent	C	F	Cl	Br	BP (°F)	SG 70°F
Carbon tetrachloride—CCl_4	1	0	4		170	1.6
Chlorobromomethane—CH_2ClBr	1	0	1	1	151	1.9
Dibromotetrafluoroethane—$C_2F_4Br_2$	2	4	0	2	76	2.3
Dibromodifluoromethane—CF_2Br_2	1	2	0	2	76	2.3
Methyl bromide—CH_3Br	1	0	0	1	40	1.7
Bromochlorodifluoromethane—CF_2ClBr	1	2	1	1	25	1.8
Bromotrifluoromethane—CF_3Br	**1**	**3**	**0**	**1**	-72	1.6

The last entry, Halon 1301, when exposed to a high temperature fire could produce either hydrogen fluoride or hydrogen bromide (or both) gases. Halon 1301 is made from methane by substitution of three atoms of hydrogen with fluorine and one atom of hydrogen with bromine. Halon 1301 = 1 carbon, 3 fluorine, NO chlorine, and 1 bromine.

82. Answer: **A**. NFPA 473 standard uses the CDC categories of diseases and agents. Category A: The U.S. public health system and primary healthcare providers must be prepared to address various biological agents. These high-priority agents include organisms that pose a risk to national security because of the following: ease of dissemination or transmission from person to person; result in high mortality rates and have potential for major public impact; might cause public panic and social disruption; or they require special action for public health preparedness. Category B: The second-highest priority. They are moderately easy to disseminate; result in moderate morbidity rates and low mortality rates; they require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance. Category C: These third-priority agents include emerging pathogens that could be engineered for mass dissemination in the future because they are readily available, easy to produce and disseminate, and have a potential for high morbidity and mortality rates and major health impact.

83. Answer: **D**. As described in Peterson's *Techniques of Safety Management*, the justification formula is:

    Justification = Risk Score/Cost Factor × Degree of Correction or J = 25/6 = 4.20.

    This factor is well below 10 and therefore not justified.

    The Risk Score = Consequences × Exposure × Probability.

84. Answer: **B**. TLV-C *(Threshold Limit Value-Ceiling)* **Is the one limit that should not be exceeded at any time during any part of the working exposure.** In some references you may find recommendations that allow the TLV-C to be assessed by sampling over a 15-minute period for some substances. This does not change the *limit*; it merely suggests a sampling strategy. Don't get confused!

85. Answer: **A**. The cloth cutting area of a fiberglass facility would most likely contain fibers and dust; thus, the logical choice would be a mechanical particulate matter filter.

86. Answer: **B**. The ground-fault circuit interrupter (GFCI) is a fast-acting device, which senses small differences in current flow (about 5 milliamp) between the white and black wire and in a fraction of a second (0.02–0.03 seconds) and shuts off the power to the circuit. The GFCI will not sense a line-to-line fault. Construction sites must guard against ground faults either by installing GFCIs or through an assured equipment grounding conductor program.

87. Answer: **C**. Working in an *80° environment* could be a situation that would cause concern but is overshadowed by an office workplace noise level of 76 dBA. At this noise level, employees would have to shout to communicate at distances of only 4 feet. Although hearing loss might not occur at this level, noise induced irritation could certainly contribute to mishaps. An atmosphere of *14 psia* could be encountered within a wide range of occupations and is not a major concern. *One air change every five minutes* could be acceptable with no other information given.

88. Answer: **D**. Aromatic hydrocarbons can be vasodilators and can cause severe pulmonary and vascular injury when absorbed in large quantities.

89. Answer: **C**. The *intercostal spaces* are hollows between the ribs. *Intercostal nerves* sense the difference between the pressure in the chest cavity and the outside (ambient) pressure. The *intercostal muscles* respond to the pressure differences to keep the intercostal spaces from blowing out or sucking in during respiration.

90. Answer: **C**. According Clay Carr in *Smart Training, The Manager's Guide to Training for Improved Performance*, adults have four basic training needs.

    - Adults need to know why they are learning a particular topic or skill, because the need to apply learning to immediate, real-life challenges.
    - Adults have experience that they apply to all new learning.
    - Adults need to be in control of their learning.
    - Adults want to learn things that will make them more effective and successful.

    To help accomplish these needs, include precise behavioral guidelines and procedures that the trainees are required to follow.

91. Answer: **A**. SQL is the abbreviation for Structured Query Language. It is a standardized application language for relational databases that is used to enter data into a database, modify data, delete date, and retrieve data.

    URL is the abbreviation of Uniform Resource Locator, the global address of documents, and other resources on the World Wide Web.

    HTML stands for Hyper Text Markup Language and is used for web publishing.

    HTTP stands for Hyper Text Transfer Protocol and is a file transfer protocol.

92. Answer: **B**. **Reliability** is a measure of how well a test item discriminates the knowledge level of the participants. Evaluations for training purposes are **NOT norm-referenced**. Norm-referencing means that how well a trainee scores depends on how well or how poorly other trainees perform. Evaluations for training purposes **should always be criterion referenced**. This means performance is measured against a preset standard. The test must measure what it is supposed to measure. The evaluation tool should always be developed before training begins. Pre-test and post-test should cover equivalent subject matter; however, it should not be the same test or test questions.

93. Answer: **D**. One of the most valuable group techniques is the conference method. The strength of the conference method is in the individual knowledge and experience of the participants. The number of members should be kept small to allow maximum exchange of ideas. The establishment of goals and objectives is crucial to the success of this method. But more than anything else, this teaching method hinges on the capability of the facilitator or instructor. The facilitator logs the objectives and keeps the information and opinions flowing during sessions. After the conference, the facilitator distributes recommendations and informs members of actions taken as a result. Shortfalls associated with this method include the facilitator ensuring that the conference does not become a bull session and if management does not follow up on the recommendations, then the group will not support future efforts.

94. Answer: **C**. This is described in terms of population percentages of different body segments. The remaining choices only partially define anthropometry.

95. Answer: **C**. To solve this problem without the use of the stat function on our calculator we must build a table and then apply the formula.

X	$\bar{X}$	$X - \bar{X}$	$(X - \bar{X})^2$
10	19	−9	81
10	19	−9	81
15	19	−4	16
25	19	6	36
35	19	16	256
$\sum X = 95$		$\sum (X - \bar{X})^2 = 470$	

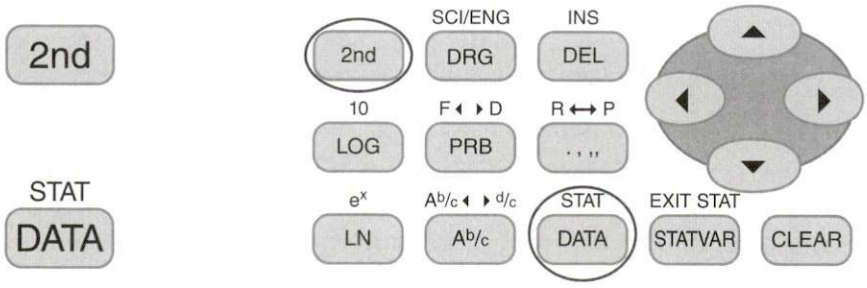
$$s = \sqrt{\frac{\sum (x^2)}{n - 1}} \quad \text{WHERE } (x = X - \bar{X})$$

$$s = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

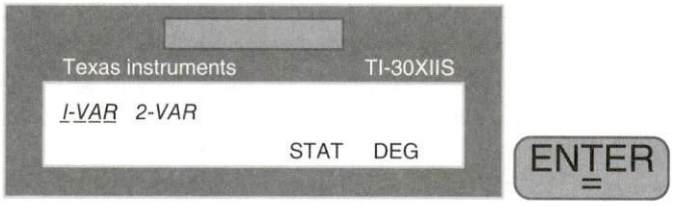
$$s = \sqrt{\frac{470}{5 - 1}} = 10.839$$

On the TI 30X IIS:

1. Set to STAT Mode using the second function of DATA key.



2. Select *1-VAR* and enter.

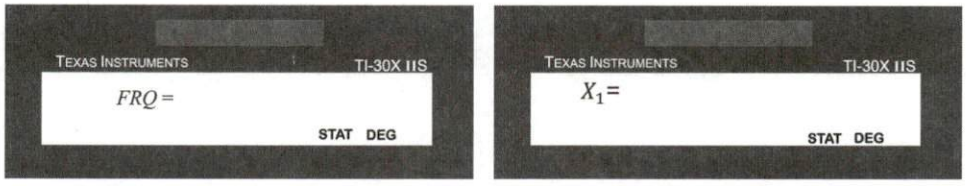


Reproduced from Texas Instruments Incorporated.

3. Press DATA key.



4. Enter $X_1 = 10$ down arrow FRQ = 1; down arrow; $X_2 = 10$ down arrow FRQ = 1 down arrow; $X_3 = 15$ down arrow FRQ = 1 down arrow; $X_4 = 25$ down arrow FRQ = 1 down arrow; $X_5 = 35$ down arrow FRQ = 1 down arrow.

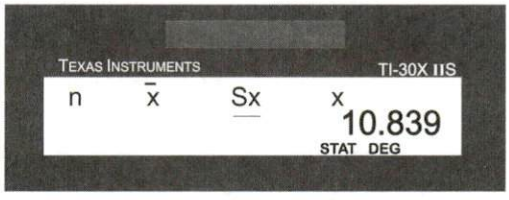


Reproduced from Texas Instruments Incorporated.

5. Press STATVAR.



6. Select Sx = 10.839.



Reproduced from Texas Instruments Incorporated.

96. Answer: **B**.

Step 1: Calculate a "z" value using the formula.

$$z = \frac{X - \mu}{\sigma}$$

$$z = \frac{2000 - 1800}{250}$$

$$z = \frac{200}{250} = 0.8$$

$$\text{Area}; 0.8 = 0.2881$$

$$z = \frac{X - \mu}{\sigma}$$

$$z = \frac{1600 - 1800}{250}$$

$$z = \frac{-200}{250} = -0.8$$

$$\text{Area}; -0.8 = 0.2881$$

$$P_f = 0.2881 + 0.2881 = 0.5762$$

$$P_f = 57.6\%$$

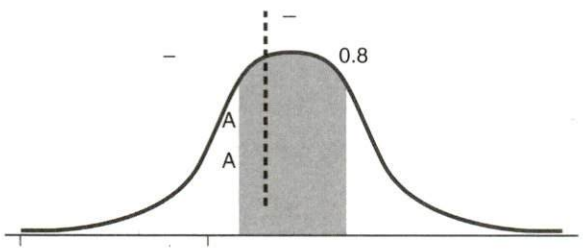
Step 2: Add each individual area to determine the total area under the curve.

This time we are looking for the area under the curve between two points. In this case the distance from the mean is the same, that is ± 0.8 standard deviations from the mean. So, we can determine the area under one deviation and double it to determine the total area. If they were different values, we would simply add them together.

Table of the Normal Distribution Provided on the Exam

Z	0	1	2	3	4	5	6	7	8	9
0.7	0.2580	0.2612	0.2652	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2996	0.3023	0.3051	0.3078	0.3106	0.3133

From the table, determine the area under the curve from the X-bar to a Z of 0.8. There is no negative Z or –0.8 on the table because it occupies the same area. So, to find the total area we simply double the table value.



97. Answer: **B**.

Step 1: Build a table.

X	Y	X^2	Y^2	XY
35	35	1225.00	1225.00	1225.00
30	30	900.00	900.00	900.00
25	25	625.00	625.00	625.00
20	20	400.00	400.00	400.00
15	10	225.00	100.00	150.00
10	15	100.00	225.00	150.00
$\sum X = 135$	$\sum Y = 135$	$\sum X^2 = 3475$	$\sum Y^2 = 3475$	$\sum XY = 3450$

Step 2: Apply the formula.

$$r = \frac{N\sum(XY) - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{N\sum\left(X^2\right) - \left(\sum X\right)^2}\sqrt{N\sum\left(Y^2\right) - \left(\sum Y\right)^2}}$$

$$r = \frac{6(3450) - (135)(135)}{\sqrt{6(3475) - (135)^2}\sqrt{6(3475) - (135)^2}}$$

$$r = \frac{20{,}700 - 18{,}225}{\sqrt{20{,}850 - 18{,}225}\sqrt{20{,}850 - 18{,}225}}$$

$$r = \frac{2475}{\sqrt{2625}\sqrt{2625}} = \frac{2475}{2625} = 0.943$$

Most scientific calculators have a "stat" function, which will allow you to compute coefficient of correlation with a single key stroke after entering the individual data points. Consult your calculator instruction book.

On the TI 30X IIS: Set to STAT Mode then select 2-VAR and enter: Press DATA $X_1 = 35$ down arrow $Y_1 = 35$ down arrow $X_2 = 30$ down arrow $Y_2 = 30$ down arrow $X_3 = 25$ down arrow $Y_3 = 25$ down arrow $X_4 = 20$ down arrow $Y_4 = 20$ down arrow $X_5 = 15$ down arrow $Y_5 = 10$ down arrow, $X_6 = 10$ down arrow $Y_6 = 15$, then press STATVAT, select $r = 0.943$.

98. Answer: **C**. In order to solve this problem, we must calculate the probability of 0, 1, 2, 3 accidents occurring, add these together, and then subtract from 1. The value of "t" in this problem is 1.

$$P_0 = \frac{e^{-5}5^0}{0!} = 0.00674 \qquad P_1 = \frac{e^{-5}5^1}{1!} = 0.03369$$

$$P_2 = \frac{e^{-5}5^2}{2!} = 0.08422 \qquad P_3 = \frac{e^{-5}5^3}{3!} = 0.14037$$

$$P_{(0,1,2,3)} = 0.00674 + 0.03369 + 0.08422 + 0.14037 = 0.265502$$

$$P_{(>3)} = 1 - 0.26502 = 0.73498$$

99. Answer: **A**.

$$P(r) = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$$

Set t = 1 (a 2-month period) λ = expected number of events; so if 12 failures happened in 24 months, then for 2 months we would expect one failure or $\lambda = 1$.

Rate I to solve for is "0."

$$P_{(0)} = \frac{(1)^0 e^{-1}}{0} = 0.37$$

100. Answer: **A**. A Poisson distribution is useful when an occurrence happens more than once (e.g., industrial accident experience over a period of time where a worker may have more than one accident in a year or where the same type of accident may occur over and over).

Self-Assessment 4 Questions

1. Acetylene reacts violently with which of the following?

A. Chlorine
B. Halon 1211
C. Halon 1301
D. Astatine

2. An automobile brake *master* cylinder fails four times out of 1,000,000 operations. What is its success rate?

A. 9.99996×10^{-1}
B. 99.9999×10^{-2}
C. 99.9×10^{-3}
D. 0.99×10^{-1}

3. Which of the following is true concerning placement of underground flammable liquid storage tanks with respect to *existing* building foundations?

A. Must be 1 foot from foundations for Class I liquids
B. Must be 5 feet from foundations for Class II liquids
C. Must be 3 feet from foundations for Class I liquids
D. Must be 4 feet from foundations for Class I liquids

4. Which of the following factors does *not* affect the load capacity of a mobile crane?

A. Boom length
B. Boom angle
C. Extension of outriggers
D. Installation of an anti-two-block device

5. When a loss scenario is identified, what are the four steps to control its risk?

A. Recognition of incident potential, employer participation, implementation, and feedback and control
B. Problem identification, implementation of corrective measures, employee participation, and feedback and control
C. Problem characterization, selection of corrective measures, implementation, and feedback and control
D. Problem identification, selection of corrective measures, management briefing, and feedback and control

6. Your plant has had 50 serious vehicle accidents in the past 10 years, 3 involving fork trucks. What is the probability that the next serious accident will involve a fork truck?

A. 10%
B. No way to tell
C. 9%
D. 6%

7. The National Electrical Code uses a class, division, and group hazard identification system. Class II hazards involve:

A. flammable liquids.
B. dusts.
C. fibers.
D. powders.

8. Which of the following is true concerning placement of structural reinforcing steel in concrete slabs?

A. Steel should be placed high in cantilever floor slabs.
B. Steel should always be placed low in floor slabs.
C. Steel should always be placed high in floor slabs.
D. Steel should always be on chairs in the middle of floor slabs.

9. A school bus is moving at 100 km/hr and is acted on by a decelerating force of 5 meters per second squared. How many meters will it take the bus to stop?

A. 144 meters
B. 77 meters
C. 154 meters
D. 111 meters

$$V^2 = V_0^2 + 2\,a\,s$$

10. An automotive parts distributor purchases parts from overseas locations and markets these parts in the United States. The distributor receives 25% of its parts from country "A," who has a 10% reject rate; 25% from country "B," who has a 5% reject rate; 12.5% from country "C" with a 15% reject rate; and 37.5% from country "D" with a 1% reject rate. If you purchase a defective part, what is the probability it came from country "D"?

A. 10%
B. 12%
C. 6%
D. 8%

11. Which of the following temperature ranges concerning fire sprinkler heads color-coding is correct?

A. 100° Ceiling Temperature—Green
B. 150° Ceiling Temperature—White
C. 225° Ceiling Temperature—Orange
D. 300° Ceiling Temperature—Blue

12. Which of the following items would *not* normally be present on the "accounting form" used to perform a Failure Modes and Effects Analysis (FMEA)?

A. Name of item
B. Failure mode of the item
C. Effect of operation on the system
D. Cost of the item with respect to reliability

13. During a field inspection, you observe an operation involving a mechanical power press that requires guarding. The press is equipped with an electrical main power disconnect switch that has provisions for locking-out in the OFF position. The point of operation enclosure is unguarded, and management decided to use a "point of operation device" that requires the operator to use both hands to operate the controls. What is the safe distance if the total press cycle is 1 second in duration?

A. 3.25 feet
B. 5.25 feet
C. 7.25 feet
D. 9.25 feet

14. How much pressure would be lost to friction for 200 feet of 6-inch Schedule 40 steel pipe, having an inside diameter of 6.065 inches and a C factor of 100 and providing a flow of 1850 gpm?

A. 18 psi
B. 31 psi
C. 22 psi
D. 11 psi

$$P_d = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times D^{4.87}}$$

15. All of the following are examples of *line* functions *except:*

A. ordering.
B. supervising.
C. scheduling.
D. training.

16. Which of the following steps would be taken in the establishment of a Safety by Objective (SBO) program?

A. Establish a fee schedule for safety infractions.
B. Develop goals with supervisors.
C. Schedule site-wide training.
D. Order a new library of safety literature.

17. Which of the following factors were *not* included in the original Hawthorne studies on productivity and morale?

A. Illumination levels
B. Rest periods
C. Length of workday
D. Mix of males and females

18. Which of the following were included in Heinrich's Domino Theory of Accident Causation?

A. Safety, security, belonging, and self-esteem
B. The three Es
C. Social, fault, unsafe act, accident, and injury
D. Man, machine, money, injury, and accident

19. Which of the following methods reflects today's thinking on dealing with a minor rule infraction in the workplace?

A. Reprimand first time, terminate second time
B. Written reprimand
C. Oral reprimand, one-day suspension
D. Oral reprimand

20. It is a generally accepted theory in the accident prevention arena that the attitude of supervisors and managers can affect the actions of junior supervisors and employees. Which of the following best describes that relationship?

A. Supervisors' attitudes have no effect on employees.
B. Supervisors' attitudes have little effect on employees.
C. Supervisors' attitudes have direct influence on employees.
D. Supervisors' attitudes have direct influence, which cannot be changed.

21. The Management Grid® by Robert Blake and Jane Mouton, illustrates management styles by drawing a grid that has on the y-axis Concern for People and the x-axis Concern for Production. Thus, a 1,1 supervisor would exhibit which of the following?

A. High production, high concern
B. High production, low concern
C. Low production, high concern
D. Low production, low concern

22. What are the axes of a conventional risk matrix?

A. Risk vs. Likelihood
B. Number of Loss Scenarios vs. Probability
C. Likelihood vs. Consequence
D. Severity vs. Magnitude

23. Your Environmental Safety and Health plan calls for a expenditure of $300,000 in 3 years from now. How much must be set aside in each of your annual budgets for this expenditure? Money is currently worth 11% and will remain constant for your computations.

A. $90,430
B. $110,560
C. $140,900
D. $89,760

$$A = F\left(\frac{i}{(1+i)^n - 1}\right)$$

24. In some combustible gas meters, an electrical circuit consisting of a series of resistors is used to measure the mixture of combustible gas to air. The resistors are balanced, and one leg of the circuit, called a hot wire, is exposed to the suspect atmosphere. If a combustible mixture is present, a catalytic combustion increases the resistance of the wire and causes an imbalance. The circuit is called a:

A. combustible resistor circuit (CRC).
B. Wheatstone bridge.
C. combustible balancing circuit.
D. hot wire detector (HWD).

25. Which of the following is considered to be the *least effective* safety measure for work that requires entry into a confined space known to have contained toxic chemicals?

A. One man equipped with a rope tied around his waist
B. Entry personnel equipped with SCBA
C. Rescue personnel on standby at the fire station
D. Both workers assigned to task inside the tank

26. All of the following are common redundant design philosophies *except:*

A. series.
B. parallel.
C. standby.
D. derating.

27. What is the study of disease, as it spreads through man and the environment and usually involves large groups of people called?

A. Demography
B. Diseasealogy
C. Epidemiology
D. Cronogology

28. You passed the CSP Core Examination with a score of 192. The cumulative statistics for this examination are as follows: mean 180, standard deviation 32. How many safety professionals taking the exam have scored higher than you?

A. 25%
B. 35%
C. 16%
D. 45%

29. Which is a management tool for helping top management understand and prioritize the corrective actions to reduce the risk of identified loss scenarios?

A. Failure, mode, effect, and criticality analysis.
B. Risk-ranking analysis
C. Event-tree analysis
D. Benefit-cost analysis

30. The Total Quality Management (TQM) philosophy considers accidents to fall into which of the following categories?

A. Cost of doing business
B. Largely preventable but not always cost effective
C. Out-of-control perturbations
D. Process defect or mistake—preventable in every way

31. As the safety director for a large construction company, you discover that several pieces of equipment are not in compliance with federal directives. Additionally, your own survey of the equipment has convinced you that the noncompliance poses a moderate risk of injury. However, your initial request for funding has been turned down and will not be added to the budget until next year. Which of the following is the *best* course of action?

A. Place your budget request for next year early and with ample justification and keep up the good work.
B. Document your feelings in a file and store in a safe place, then report the entire situation to the union steward.
C. Discuss the situation with the previous safety director to determine if he or she has any suggestions.
D. Prepare a report to management, documenting your findings in a clear, concise manner, stressing the risk of injury and the degree of noncompliance.

32. In concert with the concept of *behavioral* management and reinforcement strategy, which of the following situations represents the best opportunity to develop good work habits? During training the instructor/supervisor should:

A. demonstrate, then evaluate the workers' abilities to perform the job, providing coaching assistance.
B. reward incorrect responses with negative reinforcement.
C. reward correct responses with positive reinforcement.
D. read from prepared text, have students do homework, and then administer periodic written tests.

33. Which of the following provides the *best* example of progressive discipline?

A. A behavioral who operated a crane without being qualified was fired.
B. An electrician who worked a 4160-volt circuit was given a letter of reprimand and subsequently fired for not using a proper ladder.
C. A worker was given a verbal warning for not wearing safety glasses and a month later was given 5 days without pay for a second offense.
D. An iron worker was given a verbal warning for not tying off in January 1993 and fired for not tying off in December 1994.

34. The supervisor for an electrical crew is ill and will be off the job for a period in excess of two weeks. A new supervisor has been assigned and has just assumed her duties. On her first walk around of the job site, she observes one of the workers, a senior electrician, without his safety glasses. As she checks her hand-over log from the last supervisor, she spots a note that this same worker has received a verbal warning a week ago for the same offense. The company discipline policy calls for three days off without pay for a second offense of such a violation. Which of the following courses of action would be the *most effective*?

A. Warn the employee that since she is a new supervisor, he will get a verbal warning this time, but future discipline will be by company policy.
B. Follow company policy and give the worker three days off without pay and a firm admonishment against future violations.
C. Act like you do not see the violation, talk to the worker in private, and ask for his help in getting everyone to wear safety gear.
D. Document the violation and if it happens again, take strong disciplinary actions.

35. Which of the following provides the *most correct* statement concerning respiratory protection?

A. All employees are to be issued their own personal respirator.
B. Respirators must be locked up when not in use—an exception is granted for personal respirators, which may be taken home for cleaning during off shift times.
C. Respirators used by more than one worker are to be thoroughly cleaned and disinfected after each use.
D. Fit testing of respirators is required only when performing asbestos insulation more than 30 calendar days out of each year.

36. Which of the following *best* describes the primary purpose for the establishment of a construction safety plan?

A. Identify hazards before OSHA does.
B. Correct hazards to prevent injuries.
C. Establish what will be done and when.
D. Set the stage for VPP application.

37. During epidemiological studies, selection of cases is frequently required at random. Which of the following *best* describes selection of personnel by random?

A. Every tenth name from the phone book
B. Using employment data, personnel are separated into age distribution sectors and then a predetermined number from each stack is selected using alphabetical matrix regression.
C. Personnel are selected using a random number generator.
D. Personnel are stratified and then, using standard double or multiple sampling techniques, selected by salary, hair color, sex, age, foot size, etc.

38. According to contemporary management theory, decisions should be:

A. made at the lowest level that has adequate knowledge.
B. made only after full analysis of all outcomes.
C. made by senior management officials only.
D. made by safety trained supervisors or competent persons.

39. When measuring the performance of the safety program, lagging indicators measure historical results and show the effectiveness of loss prevention measures applied in the past. What are leading indicators?

A. Trends that predict future loss performance.
B. Measures that lead the performance measure analyst to pursue other lagging indicators.
C. Measures that provide the context for the lagging indicators.
D. There is no such thing as a leading indicator.

40. Which of the following *best* describes the theory of "management by exception"?

A. Terminating employees who have contributed to mistakes
B. Accountability for mistakes
C. Only manage deviations from normal.
D. Question all operations by taking exception to normal standards in an attempt to find better, more effective methods.

41. The results of a fault-tree analysis performed for an assembly line system identified five basic initiating events having probabilities of occurrence depicted in the table.

Event	Probability
A	10^{-3}
B	10^{-8}
C	10^{-6}
D	10^{-3}
E	10^{-7}

The minimal cut sets from the fault-tree analysis are shown below.

- AB
- CD
- DE

What is the TOP event probability for this fault tree?

A. 1.0×10^{-9}
B. 1.2×10^{-10}
C. 1.0×10^{-30}
D. 3.3×10^{-30}

42. All of the following are alternate names for the process of Management by Objectives, or MBO, *except:*

A. management by results.
B. management by goals.
C. management by cooperation.
D. work planning and review.

43. The process known as Safety by Objectives (SBO) involves agreement between which of the following groups?

A. Managers and supervisors
B. Supervisors and the CEO
C. Supervisors and employees
D. Department heads and line managers

44. Which of the following is *not* true concerning the data presented by graphs and tables?

A. Graphs are easier to read than tables.
B. Tables are harder to construct than graphs.
C. Tables are approximations; graphs are exact.
D. Graphs are used less frequently than tables.

45. Periodic evaluations of employee performance are most valuable if the ratings of each employee are:

A. based principally on his or her personality traits.
B. stringent, containing criticisms as well as praise.
C. discussed with him or her and directions for improvement indicated.
D. based entirely on factors that can be measured objectively.

46. Which of the following provides the *most effective* example of positive reinforcement?

A. A worker fails to wear safety equipment when the boss is not looking and is administered an immediate reprimand.
B. A worker submits a suggestion that is adopted and receives a cash award 6 months from the date of the suggestion implementation.
C. A worker is complimented by the boss at the morning tailgate for installing proper shoring on a trench job the day before.
D. A driver is presented a safe driving award for 1 million miles of safe trucking.

47. Which of the following manufacturing production "lines" would be the *most conducive* to safe operations?

A. Straight process line
B. Product layout line
C. Just-in-time assembly line
D. Multiple product layout line

48. In a comparison of the capabilities of a computer and humans, all of the following are true *except:*

A. computers are better at voluminous searches of data.
B. humans are better at abstract judgment situations, such as emergency management.
C. computers are better at following random and variable strategy.
D. humans are better at exercising inductive reasoning, making judgments based on experience and reasoning.

49. When performing complicated system safety analysis, how is computer performance affected by a single bit problem?

A. Speed is reduced significantly.
B. Speed is increased.
C. Analysis could be incorrect.
D. Screen will be the wrong color.

50. What is a system safety technique that selects an undesired event whose possibility or probability is to be determined and then reviews system requirements, functions, and designs to determine how the top event could occur called?

A. Fault-tree analysis
B. Boolean algebra
C. Preliminary Hazard Analysis (PHA)
D. Failure Mode and Effect Analysis (FMEA)

51. Which of the following involves an action that takes place at the surface of an adsorbent material where gas and solids make contact?

A. Combustion
B. Condensation
C. Absorption
D. Adsorption

52. Which infection is associated with milk?

A. Bursitis
B. Laryngitis
C. Brucellosis
D. Pleurisy

53. Which of the following is *not* true concerning Threshold Limit Values (TLVs)?

A. TLVs are airborne or chemical skin contact values.
B. TLVs may be based on experimental data.
C. TLVs may be based on freedom from irritation.
D. TLVs offer protection for nearly all workers.

54. The *Ames test* uses which of the following bacteria?

A. Staphylococcus
B. Salmonella
C. Spirochaeta
D. Lactobacillus

55. Lighting, radiation and sound are energy sources that follow the inverse square rule, which states: "The propagation of energy through space is inversely proportional to the square of the distance it must travel." Accordingly, if a lighting source has an illumination reading of 50 foot-candles at 8 feet from the source, what will the illumination be at 1 foot?

A. 4000 foot-candles
B. 4400 foot-candles
C. 2000 foot-candles
D. 3200 foot-candles

$$I_2 = I_1 \frac{(d_1)^2}{(d_2)^2}$$

56. Which of the following groups of hydrocarbons would have the greatest chance of not being flammable?

A. Aliphatic hydrocarbons
B. Aromatic hydrocarbons
C. Halogenated hydrocarbons
D. Ethers

57. If an underground tunnel atmosphere is contaminated with 4% crystalline quartz dust, what is the permissible exposure level for this exposure? The PEL for respirable dust is:

A. 10 mg/m^3.
B. 2.5 mg/m^3.
C. 1.66 mg/m^3.
D. 1.33 mg/m^3.

$$Pel = \frac{10\ mg/m^3}{\%SiO_2 + 2}$$

58. During the course of an inspection, you observe the following conditions: an exposure to methylene chloride of 30 ppm (TLV = 50), methyl chloroform of 200 ppm (TLV = 350), and an exposure to methyl alcohol of 150 (TLV = 200). Assuming the effects of these exposures are additive, what is the percentage of TLV for this concentration?

A. 192%
B. 100%
C. 90%
D. 65%

$$TLV_m = \frac{C_1}{TLV_1} + \frac{C_2}{TLV_2} + \ldots + \frac{C_n}{TLV_n}$$

59. Based on a *qualitative* fit test, what is the protection factor afforded by a half-mask facepiece respirator?

A. 1
B. 10
C. 100
D. 1000

60. In an effective organization, who is responsible and accountable for enforcing occupational safety and health policies?

A. Line management
B. Safety and health staff management
C. Human resource staff management
D. Employees

61. A 1-gallon beaker of Toluene falls to the floor and breaks in a lab room that is 20 feet by 20 feet by 10 feet. The molecular weight of Toluene is 92 and the SG is 0.8. Assuming complete evaporation and no air change, what is the concentration in PPM?

A. 1117 ppm
B. 117 ppm
C. 7120 ppm
D. 710 ppm

$$ppm = \frac{mg/m^3 \times 24.45}{MW}$$

62. In choosing an appropriate organizational model, a manager should understand that:

A. the best arrangement reduces the manager's span of control to the minimum number of supervised persons to ensure that supervision is maintained as closely as possible.
B. a staff unit assists line managers with the burdens of broad supervisory responsibilities.
C. there are multiple arrangements that will produce the best results with minimum difficulty in the situation in which the organization operates.
D. the best arrangement reduces the number of organizational layers as much as possible so that the communication lines between the manager and the subordinates will be short.

63. Which of the following is *least likely* a result of failure to adequately clean up chemical releases?

A. The spill area being considered an unpermitted land disposal unit
B. Extensive soil and ground water contamination
C. Enforcement actions
D. Increased property value

64. Which of the following is the preferred angle for fixed industrial stairs?

A. 30 to 35 degrees
B. 15 degrees
C. 30 to 45 degrees
D. 75 to 90 degrees

65. You have discovered an acetone leak in one of your facilities. The room is closed with no ventilation taking place. It measures 10 m × 10 m × 20 m and your CIH tells you that she has a 6000 ppm reading on her analyzer. How many liters of acetone has leaked from the container?

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

MW = 58.08

SG = 0.79

Temp = 25°C

Barometric Pressure = 1 atm

A. 36 L
B. 58 L
C. 78 L
D. 360 L

66. Which of the following is true concerning the use of the signal word "WARNING" on product warning labels? Warning is used where there is a hazard or unsafe practice, which, if encountered, could result in:

A. death or severe personal injury.
B. death, severe personal injury, or extensive property damage.
C. death, extensive property damage, extensive product damage, and severe personal injury.
D. death, loss of livelihood, and property damage.

67. If a man applies a force in a horizontal direction to slide an 80-lb. crate 10 ft, how much work did he perform? (Assume the coefficient of static friction is 0.40 between the crate and the floor.)

$F = \mu N$

A. 320 ft-lb
B. 610 ft-lb
C. 800 ft-lb
D. 1120 ft-lb

68. Which of the following statements is *true*?

A. The coefficient of static friction for any two surfaces is less than the coefficient of dynamic friction.
B. The coefficient of dynamic friction applies when objects are in motion.
C. A coefficient of friction of 1 indicates a low friction value.
D. Coefficient of friction is a constant value.

69. Which organization is responsible for primary safety standards dealing with boilers?

A. ANSI
B. ASME
C. UL
D. ASSE

70. Which of the following ANSI standards deals with accident reporting?

A. ANSI Z16.1
B. ANSI Z87.1
C. ANSI Z12.1
D. ANSI Z358.1

71. The legal process that establishes the right of the plaintiff to demand and receive all documents in any specific category prior to trial is known as:

A. access.
B. prior right of record.
C. discovery.
D. right of prior review.

72. A building at an explosive processing laboratory contains a number of ovens used for environmental testing of explosive materials. This type of oven has been known to heat excessively due to faulty heat controls and cause detonation. People walk past the outside of the building. Considering that a fatality is the most likely consequence and the hazard event is the failure of the thermostat, which has rarely happened, and redundant thermostat controls and other safety features on each oven make this event failure remotely happens. Using the risk matrix exhibited, what is the calculated risk score?

Risk Score = Consequences × Exposure × Probability

Severity	Rating	Exposure	Rating	Probability	Rating
Catastrophic; Damage over $1,000,000	100	Continuous	10	Most Likely	10
Several fatalities; $500,000 to $1M	50	Frequently	6	Possible	6
Fatality; $100,000–$500,000	25	Occasionally	3	Unusual	3
Extremely serious injury; $1000–$100,000	15	Usually	2	Remotely	1
Disabling injuries, up to $1000	5	Rarely	1	Extremely Remote	0.5
Minor injuries	1	Very Rarely	0.5	Practically Impossible	0.1

A. 25
B. 15
C. 90
D. 30

73. All the following are valid reasons for accident (mishap) investigation *except:*

A. prevent reoccurrence of similar events.
B. establish casual factors.
C. provide vehicle for discipline.
D. provide data for trend analysis.

74. Critical pressure is defined as the point where:

A. temperature is 460°R.
B. temperature is 473°K.
C. no liquid-vapor phase transition occurs.
D. vapor pressure releases.

75. Which of the following *best* describes tenosynovitis?

A. A pain in the shoulder
B. An inflammation of the tendon sheath
C. A type of carpal tunnel syndrome
D. A common toe and ankle injury

76. Which of the following meter settings would be *most appropriate* for measuring impact sound levels when the sound level meter is supplying a signal to an auxiliary instrument for additional analysis?

A. A scale, fast response
B. B scale, slow response
C. A scale, slow response
D. C scale, fast response

77. After searching for a shimshot machine, two options are selected. First, a machine can be leased for 10 years at $1500 per year. Second, the machine can be purchased for $10,000 with a maintenance agreement that costs $500 per year. After 10 years, the machine can be sold as scrap for $5000. Assuming money value will be 15% for the years, is buying or leasing the better option?

A. Buy and save $5000
B. Lease and save $5000
C. Lease and save $3700
D. Buy and save $3700

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right)$$

$$P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

78. First, a machine can be leased for 10 years at $1500 per year. Second, the machine can be purchased for $10,000 with a maintenance agreement that costs $500 per year. After 10 years, the machine can be sold as scrap for $5000. Assume the money value will be 15% for the years. If the $500 per year maintenance agreement was required for leasing, as well as buying the shimshot machine, which would be the better option (buying or leasing) and what would be the percentage saved?

A. Buy and save 13.21%
B. Lease and save 12.31%
C. Buy and save 11.45%
D. Lease and save 10.90%

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right)$$

$$P = A\left(\frac{(1+i)^n - 1}{i(1+i)^n}\right)$$

79. Which of the following techniques are *not* in general considered to be system safety practices?

A. FTA/FMEA
B. PERT/CPM
C. PHA/OHA
D. MORT/FTA

80. A two cable sling is supporting 22,000 pounds. What is the tension on the left sling? Sling angle to load is 55°.

A. 13,428 pounds
B. 9853 pounds
C. 10,567 pounds
D. 12,368 pounds

$$\sin A = \frac{a}{c} \quad \cos A = \frac{b}{c} \quad \tan A = \frac{a}{b}$$

81. The middle ear consists of:

A. hammer, anvil, and Eustachian tube.
B. ear drum, external auditory canal, and pinna.
C. cochlea, cochlear nerve, and semicircular canals.
D. cochlea, Eustachian tube, and ear drum.

82. Which is *best* design for continuous input with precision for operator control?

A. Toggle switch
B. Knob
C. Limit switch
D. Push button

83. Calculate the RWL given the following conditions: Weight to be lifted = 30 lbs (13.6 kg); distance between body and hand grip on the object to be lifted = 18 inches (45 cm); vertical position at the beginning of the lift = 30 inches (75 cm); vertical position at end of lift = 40 inches (100 cm); frequency of lift = once every 5 minutes for 1 hour. *Note: Hand coupling is good, and this activity does not require any twisting movement.

A. 14.0 kg
B. 12.1 kg
C. 13.6 kg
D. 12.8 kg

$$\text{RWL (kg)} = 23\left(\frac{25}{\text{H}}\right)(1 - .003\,|\,\text{V} - 75\,|)\left(.82 + \frac{4.5}{\text{D}}\right)\left(1 - (0.0032 \times \text{A})\right)(\text{FM})(\text{CM})$$

See charts below.

COUPLING MULTIPLIER (CM)

Coupling Type	Coupling Multiplier	
	V < 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

FREQUENCY MULTIPLIER TABLE (FM)

Frequency Lifts/min. (F)**	Work Duration					
	≤ 1 Hour		> 1 but ≤ 2 Hours		> 2 but ≤ 8 Hours	
	V < 30*	V ≥30	V < 30	V ≥30	V <30	V ≥30
≤ 0.2	1.00	1.00	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.80	0.80	0.60	0.60	0.35	0.35
6	0.75	0.75	0.50	0.50	0.27	0.27
7	0.60	0.70	0.42	0.42	0.22	0.22
8	0.52	0.60	0.35	0.35	0.18	0.18
9	0.45	0.52	0.30	0.30	0.00	0.15
10	0.41	0.45	0.26	0.26	0.00	0.13
11	0.37	0.41	0.00	0.23	0.00	0.00
12	0.00	0.37	0.00	0.21	0.00	0.00
13	0.00	0.34	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	0.00	0.00	0.00
15	0.00	0.28	0.00	0.00	0.00	0.00
> 15	0.00	0.00	0.00	0.00	0.00	0.00

84. In a conventional sanitary sewer, employees are continuously monitoring for oxygen content, % of LEL, and the presence of hydrogen sulfide and carbon monoxide using a direct reading multi-gas detector. The detector alarms have a carbon monoxide reading of 1350 ppm (IDLH for carbon monoxide is 1200 ppm), while also displaying a hydrogen sulfide reading of 9 ppm (TLV 8-hour TWA for hydrogen sulfide is 10 ppm). The most likely explanation of this combination of readings in this environment is:

A. the detector's hydrogen sulfide gas-specific sensor is malfunctioning.
B. the hydrogen sulfide reading is correct and the hydrogen sulfide in the atmosphere is interfering with the carbon monoxide gas-specific sensor.
C. the detector's carbon monoxide sensor is malfunctioning.
D. the carbon monoxide reading is correct, and the CO is interfering with the hydrogen sulfide gas-specific sensor.

85. The 5-whys is an iterative question–asking technique used to explore the cause-and-effect relationships underlying a particular problem. This technique is used to identify which of the following?

A. Root causes of incidents
B. Outcomes of incidents
C. Behavior-based safety rules
D. Human behavior errors

86. A company was cited for failure to implement engineering controls to reduce noise levels. The ruling was overturned because OSHA failed to prove economic feasibility. What was this ruling based upon?

A. This is not a violation.
B. No cost-benefit analysis was provided.
C. The company provided hearing protection, with administrative controls, in lieu of engineering controls.
D. Economic feasibility is not defined and cannot be used as a reason for a citation.

87. Which situation is *not* included/covered on a contractor's completed operations liability insurance policy?

A. A toxic epoxy was mistakenly used to seal a pipe resulting in an occupant's illness.
B. A cabinet falls because it was screwed into a plaster wall instead of wooden studs.
C. The homeowner trips over a wrench left behind by a plumber.
D. A person becomes ill as a result of a faulty chimney cap installation.

88. A machining operation was inspected, and OSHA issued citations on several violations. The citations have been received at the central plant. Which is the *most* correct?

A. Pay the fine within 15 working days.
B. Workers must be allowed to see the citation.
C. Correct the cited violations within 30 days.
D. Post the citations for at least 3 days.

89. What size of cast-iron underground pipe should be specified to limit friction loss to a maximum of 0.04 psi per foot when delivering 4000 gpm? You may assume a C factor of 100 for unlined pipe. Inside diameter is 102.4% of indicated size.

A. 8 inch
B. 10 inch
C. 12 inch
D. 14 inch

$$P_d = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times D^{4.87}}$$

90. Determine the required pressure for the first sprinkler (most hydraulically remote) in the system described below. The fire protection sprinkler system is made from Schedule 40 black piping ranging from 3 inch to 1 inch (id = 1.049) at the most remote heads. The pipe has a "C" factor of 120 and 12 feet of equivalent length between each sprinkler. Density is assigned at 0.178 gpm per ft^2 for an ordinary hazard, Group 2 occupancy with each sprinkler protecting 120 ft^2, and a typical "K" factor of 5.8.

A. At least 7 psi
B. 13.6 psi
C. 16.3 psi
D. 8.8 psi

$$P = \left(\frac{Q}{K}\right)^2 \qquad p_v = \frac{Q^2}{891d^4} \qquad P_d = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times D^{4.87}}$$

91. A flow test was conducted on a fire supply water system and a flow of 5700 gpm dropped the pressure from 70 psi to 36 psi. Determine the maximum flow available from this system. *Note: Maximum flow is achieved at 20 psi residual.

A. 5000 gpm
B. 6000 gpm
C. 7000 gpm
D. 8000 gpm

$$Q_2 = Q_1 = \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

92. A sprinkler system was designed to cover Ordinary Hazard, Group I Occupancies. It requires a minimum of 225 gpm for sprinkler operation and an additional _____ gpm to support exterior hose streams.

A. 150
B. 250
C. 550
D. No additional flow is needed.

93. If 4400 cfm of air is drawn through a 6-inch diameter duct, calculate the air's velocity through this duct in feet per minute?

A. 2250 fpm
B. 9990 fpm
C. 250 fpm
D. 22,449 fpm

$$Q = AV$$

94. Given a velocity pressure reading of 0.80 in a circular duct, what is the velocity in feet per minute?

A. 3582 fpm
B. 1500 fpm
C. 2900 fpm
D. 4027 fpm

$$V = 4005\sqrt{VP}$$

95. When hazardous waste is being handled, personnel involved in the operation must have instant access to an internal alarm or emergency communication mechanism. Which of the following system is *not* required for accomplishing emergency communication?

A. Shutting down all operations and systems
B. Notifying all employees by alarm
C. Identifying said system in the evacuation plan
D. Providing for a method of summoning emergency equipment and personnel

96. Cost factors equal the total compensation and medical costs incurred per exposure and are calculated by which of the following?

A. CF = Exposure/Cost incurred
B. CF = Cost × Exposure
C. Cost incurred × 1000/total work hours
D. Total work hours/Cost incurred × 100,000

97. Hazards fall into three broad categories. Which of the following is *not* generally considered one of these categories?

A. Intrinsic properties or characteristics of equipment
B. Failures of materials or individuals
C. Environmental stresses
D. Mechanical stresses

98. Which of the following *best* defines a management system audit under ISO 19011?

A. Systematic, independent, and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled
B. Systematic and independent examination of data, statements, records, operations, and performances (financial or otherwise) of an enterprise for any unstated purpose
C. Examination of financial statements and formulation of an opinion on the effectiveness of a company's internal control over financial reporting
D. A process that enables organizations to develop their environmental performance through a process of continuous improvement

99. Auditing is characterized by reliance on many principles. Adherence to these principles is a prerequisite for providing audit conclusions that are relevant and sufficient and also for enabling auditors, working independently from one another, to reach similar conclusions in similar circumstances. Which of the following are included in these principles?

A. Integrity, confidentiality, due professional care
B. Confidentiality, conformity, liability
C. Fair representation, subjective observation, performance in a partial manner
D. Evidenced-based, interdependence, biased

100. The audit objectives define what is to be accomplished by the individual audit and may include which of the following?

A. Evaluation of the ineffective monitoring of audit program outcomes
B. Determination of the extent of nonconformity of activities, processes, and products with the requirements and procedures of the management system
C. Conformity with audit program procedures
D. Determination of the extent of conformity of the management system to be audited, or parts of it, with audit criteria

Self-Assessment 4 Answers

1. Answer: **A**. Acetylene is a nonpoisonous and mildly anesthetic gas. It is very flammable and forms explosive mixtures with air or oxygen. It will react extremely violently (explosively) with chlorine and fluorine.

2. Answer: **A**.

$$\text{Success Rate} = \frac{\text{Successes}}{\text{Attempts}}$$

$$S_R = \frac{999,996}{1,000,000}$$

$$S_R = 9.99996 \times 10^{-1}$$

3. Answer: **A**. NFPA 30 specifies that underground storage tanks should be placed not less than 1 foot from existing building foundations. The intent here is to ensure that the loads carried by the foundation or supports will not transfer to the tank. The distances are greater for separation from property lines.

4. Answer: **D**. The installation of an anti-two block device, although a very desirable device (required for personnel lifting), does not affect the load weight capacity of a mobile crane.

5. Answer: **C**. According to the *System Safety Analysis Handbook*, to manage risk, one must anticipate what will go wrong and make timely attempts to overcome identified loss scenarios. The risk management process consists of the following steps:
   - Identify the loss scenarios
   - Develop alternatives to control them
   - Implement the best solution
   - Manage and control the risk

6. Answer: **D**. Probability is the number of fork truck accidents divided by the number of total accidents.

$$P = \frac{3}{50}$$

$$P = .06 = 6\%$$

7. Answer: **B**.

The NEC Class II hazard classification includes combustible dusts

Class	Division 1	Division 2
I Gases, Vapors, and Liquids (ART. 501)	Normally explosive and hazardous	Not normally present in an explosive concentration (but may accidentally exist)
II Dusts (ART. 502)	Ignitable quantities of dust normally is or may be in suspension, or conductive dust may be present	Dust not normally suspended in an ignitable concentration (but may accidentally exist). Dust layers are present
III Fibers and Flyings (ART. 503)	Textiles, woodworking, etc. (easily ignitable but not likely to be explosive)	Stored or handled in storage (exclusive of manufacturing)

Modified from NFPA 70 Article 500.

8. Answer: **A**. Concrete structures must resist two kinds of forces: *compression and tension*. Design of concrete slabs, beams, and girders involves the computation of how much steel is required for strength in *tension* and how much concrete is required for strength in *compression*. The placement of reinforcement is a critical function if the structure is to resist the forces placed on it. All metal reinforcement should be accurately placed and supported at the proper height by concrete or metal chairs to prevent movement during pouring. The actual placement in the slab or beam (slab in this question) is dependent on the forces the slab will see. When a slab is supported at two or more points, it will tend to break by pulling apart at the bottom—to add strength we place steel near the bottom surface where it is needed most. When a slab is supported at one point it is likely to fail by pulling apart at its upper surface first—so we need to place reinforcing as high as possible (but not generally closer to the surface than 1 inch). The weakness of concrete in tension is illustrated in the failure of a cantilevered slab, which fails at the top of the slab and requires the steel to be *concentrated at the top* of the slab.

9. Answer: **B**.

Step 1: Convert km/hr to meters per sec.

$$\frac{100 \text{ km}}{1 \text{ hr}} \times \frac{1000 \text{ meters}}{1 \text{ km}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}}$$

$$= \frac{100{,}000}{3600}$$

$$= 27.77 \text{ meters/sec}$$

Step 2: Solve for s when $V^2 = 0$.

$$V^2 = V_0^2 + 2as$$

$$V^2 = 0$$

$$0 = V_0^2 + 2as$$

$$0 = (27.8 \text{ m/sec})^2 + 2(-5 \text{ m/sec}^2)s$$

$$0 = 771.6 + 10 \text{ s}$$

$$10 \text{ s} = 771.6$$

$$s = 77.16 \text{ m}$$

10. Answer: **C**.

$$A = 25 \times 10 = 250$$

$$B = 25 \times 5 = 125$$

$$C = 12.5 \times 15 = 187.5$$

$$\underline{D = 37.5 \times 1 = 37.5}$$

$$600$$

$$P_A = \frac{250}{600} = .416$$

$$P_B = \frac{125}{600} = .208$$

$$P_C = \frac{187.5}{600} = .3125$$

$$P_D = \frac{37.5}{600} = .625$$

11. Answer: **B**. According to **Table 38**, 150° ceiling temperature would require a green fire sprinkler head.

Table 38 Temperature Ranges and Color-Coding

Ceiling Temperature	Temperature Rating	Temperature Classification	Color Code
100°	135 to 170	Ordinary	Uncolored
150°	175 to 225	Intermediate	White
225°	250 to 300	High	Blue
300°	325 to 375	Extra High	Red
375°	400 to 475	Very Extra High	Green
475°	500 to 575	Ultra-High	Orange

12. Answer: **D**. The Failure Modes and Effects Analysis (FMEA) relies heavily on the principle of "cause and effect." A typical form with sample entries is shown in **Table 39**.

Table 39 Failure Modes and Effects Analysis (FMEA)

#	Name	Part #	Fail Mode	Cause	Protection	Effects of Failure	Frequency	Severity	Hazard Class
1	Brake Light	1800	On	Part 1600	None	Loss of Warning	10^{-6}	IV	D
2	Brake Pad	2388	Overheat	Overuse	None	Loss of Brakes	10^{-8}	I	A
3	Brake Unit Bolt	3456	Head breaks off	Poor quality Torque too high	One of three bolts holding unit in place	Possible loose brake unit, failure of brakes with additional bolt failure	10^{-6}	I	A

13. Answer: **B**. Using this method requires that the controls be placed at a safe distance from the point of operation so that the slide completes the downward travel or stops before the operator can reach into the point of operation with his or her hands. OSHA 1910.217 "Mechanical Power Press" requires 63 inches (5.25 feet) per second of stopping time from "point of operation devices" to ensure the safety of the operator.

14. Answer: **B**.

Step 1: Calculate using Hazen–Williams formula.

$$P_d = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times D^{4.87}}$$

$$P_d = \frac{4.52 \times 1850^{1.85}}{100^{1.85} \times 6.065^{4.87}}$$

$$P_d = \frac{5{,}005{,}023631}{32{,}537{,}63787}$$

$$P_d = 0.1538 \text{ psi/ft}$$

Step 2: Multiply loss per foot times total run.

$$\frac{0.1538 \text{ psi}}{\text{ft}} \times \frac{200 \text{ ft}}{1} = 30.8 \text{ psi}$$

15. Answer: **D**. Actions that are typically considered *line* include almost anything that has to do with actual production. Training is a line function in many organizations; however, in this question it is the only possibility that would fall under a *staff* function.

    The management functions can be categorized as planning, organizing, and controlling. Budgeting provides a mechanism for measuring an organization's performance. The activities of scheduling and forecasting are part of the development of the budget.

16. Answer: **B**. According to Dan Peterson in his book *Safety by Objectives* there are five steps involved in SBO:

    - Obtain management-supervision agreement on objectives
    - Give the supervisors an opportunity to perform
    - Let them know how they are doing
    - Help, guide, and train them
    - Reward them according to their progress

17. Answer: **D**. A pioneering study in the subject of investigating motivations was conducted in the 1920s and 1930s at the Hawthorne Works of the Western Electric Company. The experiments were originally designed to determine the effects of illumination, rest periods, length of workday, wage incentives, fatigue, and monotony on the Western Electric employees.

18. Answer: **C**. The correct answer is social, fault, unsafe act, accident, injury.

19. Answer: **D**. The current thinking in today's management circle includes progressive discipline. This means the first offense would be dealt with an oral reprimand; continuing offenses would receive harsher punishment, such as suspensions.

20. Answer: **C**. It is generally believed that the supervisor's attitudes toward safety vs. production has a *major* influence on actions of subordinates. These influences can be changed through the use of various training and education methods. Activity measures are leading or proactive measures a line supervisor should do as part of his or her normal responsibilities as being accountable for the safety of the employees. An example would be to perform safe/unsafe work observations and discuss them with the employee.

21. Answer: **D**. The 1,1 supervisor would be one who believes workers are naturally lazy. He expects no production and receives none.

22. Answer: **C**. According to *Principles of Risk-Based Decision Making*, A risk matrix is merely a graphic, or tabular representation of the components of risk itself (e.g., frequency/likelihood and consequence/severity).

23. Answer: **D**.

$$i = .11 \quad n = 3 \quad F = \$300{,}000 \quad A = ?$$

$$A = F\left(\frac{i}{(1+i)^n - 1}\right)$$

$$P = 300{,}000 \times \left(\frac{.11}{(1+.11)^3 - 1}\right) = \$89{,}764$$

24. Answer: **B**. The question describes a Wheatstone bridge electrical circuit.

25. Answer: **D**. Although none of the precautions are particularly effective the exposure of two men in the tank is certainly the least desirable.

26. Answer: **D**. *Series redundancy* is employed as a redundant design in many systems as blocking devices. Many devices in series, each operated from a different source and involving a different parameter must be activated before an accident can occur. The more items in series the lower the probability of failure. *Parallel redundant* components perform the same function at the same time. This type of redundancy is often applied to equipment that is in continuous operation. *Standby systems* increase system reliability by having an extra operative or idling standby unit that can take over if an operational unit fails; emergency electrical generators fall in this category.

27. Answer: **C**. Epidemiology is the branch of medicine that investigates the causes and control of epidemics. It is defined as all of the elements contributing to the occurrence or nonoccurrence of a disease in a population.

$$z = \frac{X - \mu}{\sigma}$$

$$z = \frac{192 - 180}{32}$$

$$z = 0.375$$

Area = 0.146 (from table)

1 – (0.146 + 0.5) = 35% scored higher

28. Answer: **B**.

From the view of an optimist, you scored higher than 65% of all the safety professionals brave enough to take this exam since testing began back in 1978. Not bad!

29. Answer: **D**. In *Safety Management: A Human Approach,* 3rd edition, benefit-cost analysis is a tool to help management prioritize corrective actions. Although formal risk analyses identify corrective actions to reduce risk, a financial analysis is essential so managers have the information to make judgments on how to spend money and expend the efforts needed to reduce the identified risks by implementing the corrective actions. Without the financial impacts, a risk analysis is incomplete for the top management team.

30. Answer: **D**. The Total Quality Management (TQM) culture views accidents as mistakes or failures of the process. It then strives to correct the conditions that caused the failure. The process of modifying the conditions that led up to an accident is exactly the same as if one were correcting a defect in the quality of a finished product. In fact, often safety is one of the first projects identified for improvement during the start of the TQM process.

31. Answer: **D**. Competing with others for budget dollars is a way of life for a safety director/manager and is often more art than science. At least one element in safety management requires that the safety manager keep management aware of the risk involved in operations and the hazards of noncompliance. Many safety managers provide briefings as well as formal reports to ensure that senior management is fully aware of all the factors involving safety problems so that fully informed conscious decisions can be made.

32. Answer: **C**. In keeping with behavioral theory, the behavior of an individual can be affected by the consequences that follow the behavior. Consequences can be positive or negative and either strengthen or weaken behavior. If you know that putting money in a particular vending machine quite often will not produce a product you will soon stop using that machine. Likewise, to strengthen a behavior or response you need to provide a positive consequence or reinforcement. The positive reinforcement should be as soon as possible after the behavior to be the most effective. The behavioral aspects of safety management are very much in vogue today and there are many methods and techniques available to assist you in implementing such a process. If you wish to better understand the process before trying to digest the multitude of material available, I recommend an excellent, short book, *Performance Management—Improving Quality Productivity through Positive Reinforcement,* 3rd edition, by Aubrey C. Daniels, Ph.D.

33. Answer: **C**. Current theory holds that progressive discipline should be administered in an equitable, fair, and impartial manner. In order to be progressive, the discipline must be administered in steps. One example might include: a warning for first offense, time off without pay for the second offense, and dismissal for a third offense within some reasonable amount of time. You cannot jump from a warning to dismissal in one step; likewise, you cannot keep an infraction on a person's record for an excessive period of time. The difficulty in administering the policy in the health and safety arena is compounded by the fact that not all safety violations are equally serious. While you may not agree with any of this philosophy, do not let your personal feelings or your company policy interfere with your selection of the "best" answer should you encounter ethics questions come examination day.

34. Answer: **B**. The correct "book" answer is to follow company policy and administer progressive discipline. Selection "A" probably is in itself a violation of company policy and creates a different set of standards for this particular employee. Selection "C" is a very risky course of action and is likely to result in a challenge of authority from the worker in the near future. Selection "D" is, again, not in accordance with company policy and simply does not provide fair and equitable treatment to all workers. While you don't have to agree with this philosophy, you need to select the correct "book" answer exam day, or you will get this one wrong!

35. Answer: **C**. Selection "A" is not correct since OSHA does not demand that each employee be issued an individual respirator, although in many situations it is advisable for everyone to have an individual respirator. This is assuming engineering controls are not feasible to reduce the need for a respirator in the first place. Selection "B" is not correct. OSHA only requires respirators to be kept in a convenient, clean, and sanitary location. Selection "D" is not correct because OSHA requires fit testing based on exposure to a regulated area.

36. Answer: **C**. Construction safety plans are developed to provide the senior management team with information concerning:

    - a listing of actions to be taken in support of the safety effort (what will be done)
    - a schedule showing how the actions will be integrated into project scheduling tasks (when will it be done)
    - a listing of individual responsibilities (who does it)
    - budget data (how much will it cost)

    The plan allows senior management to communicate to the project superintendent and staff the details of what is expected and when. This sets the stage for compliance and fosters a true understanding of the integration of safety in task completion.

37. Answer: **C**. The best choice is to select personnel completely at random; that is, to use a random number table or computerized random number generator.

38. Answer: **A**. Contemporary management theory encourages decision making at the lowest level possible. This does not mean that the lowest paid employee makes all the decisions. The theory requires decisions to be made at the lowest level that possesses full knowledge of the necessary facts from which to base a reasonable decision. This means the decision of which tool to purchase might very well be made by the cement finisher, mason, ironworker, or the worker and his/her foreman. This "pushing down the decision" concept allows greater flexibility and more ownership of projects and programs.

39. Answer: **A**. Leading indicators are performance measures that show trends of activities that could ultimately result in losses. For example, a leading indicator could be the number of unsafe work practices observed in a warehouse during the month. Though none of the unsafe work practices resulted in a loss (a lagging indicator of loss prevention performance), action could still be taken from the leading indicator trend to reduce losses later.

40. Answer: **C**. Management by exception is a process devoted to conserving the manager's valuable time and energy by concentrating on problems and opportunities. Sometimes called the "if it ain't broke don't fix it" brand of management. Managers are encouraged to search for exceptions to normal. When such deviations are found they can exceed normal standards, in which case the manager seizes the opportunity and takes action to understand why. What are we doing that caused this exceptional performance? On the other hand, when a manager encounters an exception where performance is substandard the manager takes the opportunity to determine what went wrong and take corrective action.

41. Answer: **A**. In *System Safety Engineering and Management*, 2nd edition, by using the rare event approximation, the TOP event probability is the sum of the cut set probabilities.

    Cut set probabilities:

$$P_{AB} = p(A) \times p(B) = (1 \times 10^{-3})(1 \times 10^{-8}) = 1 \times 10^{-11}$$
$$P_{CD} = p(C) \times p(D) = (1 \times 10^{-6})(1 \times 10^{-3}) = 1 \times 10^{-9}$$
$$P_{DE} = p(D) \times p(E) = (1 \times 10^{-3})(1 \times 10^{-7}) = 1 \times 10^{-10}$$
$$P_{AB} + P_{CD} + P_{DE} = 1.0 \times 10^{-9}$$

    Note that if any of the minimal cut set event probabilities were higher than about 1×10^{-2}, using the rare event approximation would be inappropriate.

42. Answer: **C**. Management by objective (MBO) is also known as *management by results, management by goals,* and *work planning and review.* MBO involves a formal agreement between a supervisor and worker concerning:

    - the workers' performance objectives for a given period of time
    - the plan through which the objectives will be measured
    - the standards for measuring objective accomplishment
    - how the results will be reviewed

43. Answer: **A**. According to Dan Peterson in his book *Safety by Objectives*, there are five steps involved in SBO:

    - Obtain management-supervision agreement on objectives
    - Give the supervisors an opportunity to perform
    - Let them know how they are doing
    - Help, guide, and train them
    - Reward them according to their progress

44. Answer: **C**. Although the other selections are open to interpretation, answer "C" is clearly not correct. Tables depict exact information, whereas a graph is usually an approximation.

45. Answer: **D**. According to the *Handbook for Professional Managers,* the performance appraisal interview is more effective when the following are included:

    - The supervisor indicates that the subordinate is not unusual for having a problem;
    - The supervisor helps the subordinate see the importance of working on this problem;
    - The supervisor helps the subordinate find a positive approach to the problem; and
    - The supervisor tries to help the subordinate identify the nature of the problem, why it occurred, and its symptom.

46. Answer: **C**. Selection "A" is an example of negative reinforcement, which can also be effective in changing behavior. Some forms of inappropriate behavior should be met head on with gradually increasing discipline. Selection B, C, and D are all positive reinforcement. However, to be most effective reinforcement should not only be positive but should be given as soon as possible after the desired behavior.

    *Note: One excellent introductory text on antecedent, behavior, and consequence (ABC) analysis is *Performance Management—Improving Quality Productivity through Positive Reinforcement,* 3rd edition, by Aubrey C. Daniels, Ph.D., available from Performance Management Publications, Tucker, Georgia 30084, (404)-493-5080.

47. Answer: **A**. The straight or functional process line allows the hazardous processes to be isolated from the rest of the production or assembly process thus ensuring better protection of the facility and personnel. Product layout lines tend to group assembly or manufacturing together based on factors such as distance and homogeneous assignment rather than safety.

48. Answer: **C**. Computers must follow programmed strategy; they have no inductive capability and cannot perform complex tasks that require subject decision-making. They are very good at routine, repetitive tasking, and mathematical calculations.

49. Answer: **C**. The use of binary numbers to perform system safety analysis is commonplace. Binary numbering is a natural transformation for the Boolean expressions generated during various analyses. However, even single hung-bit problems can cause severe inaccuracy in this type of analysis as can be seen from **Table 40**.

Table 40 Decimal to Binary Conversion

Decimal	Binary	Decimal	Binary
1	00001	7	00111
2	00010	8	01000
3	00011	9	01001
4	00100	10	01010
5	00101	11	01011
6	00110	12	01100

50. Answer: **A**. This is a description of fault-tree analysis. There are several risk assessment techniques and accepted probabilistic risk assessment methodologies used in the environmental regulatory process for the ranking of environmental issues. The fault-tree analysis is one of these.

51. Answer: **D**. *Adsorption* involves an action that takes place at the surface of the adsorbent material where gas and solid make contact. The most widely used adsorbent for cleaning air is activated carbon, which most often is placed in canisters, perforated cans, or trays. Activated carbon has the ability to adsorb gases and vapors up to about 60% of its own weight. If the carbon is then heated, the captured material can then be reclaimed, making it an attractive and cost-effective process. *Combustion* is a process used for removal of gas or vapor if it can be oxidized to a harmless or odor-free state. Many times, this takes the form of a direct-flame afterburner. Catalysts are also used to great effect in paint disposal, animal fats, plastics, etc. *Condensation* is the process of lowering the temperature of the incoming air to change the vapor to a liquid state. The process uses various chillers, condensers, or refrigeration units to lower the temperature of the vapor. The process of *absorption* involves a scrubber where the material dissolves or reacts chemically with the gas or vapor that is to be removed.

52. Answer: **C**. Brucellosis is an infection caused by drinking unpasteurized milk from cows with Bang's disease. Pleurisy is the pain caused by lack of lubrication of the outer lung lining. Laryngitis is an inflammation of the larynx. Bursitis is an inflammation of the connective tissue around bone joints.

53. Answer: **A**. Threshold Limit Values (TLVs) refer to *airborne* concentrations of substances and represent conditions under which it is believed that *nearly all workers* may be repeatedly exposed day after day without adverse effect. Because of the wide variation in individual susceptibility a small percentage of workers may experience discomfort from some substances at concentrations at or below the TLV. TLVs are based on the best available information from industrial experience, *experimental* human and animal studies, and when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; the protection against impairment of health may be a guiding factor for some, whereas reasonable *freedom from irritation*, narcosis, nuisance, or other forms of stress may form the basis for others.

54. Answer: **B**. The Ames test is named after its chief developer, Dr. Bruce Ames, a biochemist at the University of California at Berkeley. The test uses various strains of Salmonella bacteria to screen suspect chemicals. The test does not measure carcinogenicity directly. It does, however, measure mutagenicity of a chemical. It is a widely accepted fact that almost all known mutagens are eventually found to be carcinogens.

55. Answer: **D**.

$$I_2 = I_1 \times \frac{(d_1)^2}{(d_2)^2}$$

$$I_2 = 50 \times \frac{(8)^2}{(1)^2}$$

$$I_2 = 50 \times \frac{64}{1}$$

$$I_2 = 3200 \text{ ftc}$$

56. Answer: **C**. *Hydrocarbons* are compounds that contain atoms of carbon and hydrogen only. They are broadly classified into two types: aliphatic and aromatic. *Aliphatic hydrocarbons* are subdivided into saturated and unsaturated compounds and include the alkanes: methane, ethane, propane, and butane. *Aromatic hydrocarbons* are derivative of the parent compound benzene. *Ethers* are members of a class of organic compound in which an oxygen atom has bridged between two hydrocarbon groups. Aliphatic ethers are highly volatile and extremely flammable. Hydrocarbons that have been partially halogenated burn but generally with much less ease than their nonhalogenated analogs. The fully *halogenated* derivatives such as carbon tetrachloride are noncombustible.

57. Answer: **C**.

$$\text{Pel} = \frac{10\ \text{mg/m}^3}{\%\text{SiO}_2 + 2}$$

$$\text{Pel} = \frac{10\ \text{mg/m}^3}{4 + 2}$$

$$\text{Pel} = \frac{10\ \text{mg/m}^3}{6}$$

$$\text{Pel} = 1.66$$

58. Answer: **A**.

$$\text{TLV}_m = \frac{C_1}{\text{TLV}_1} + \frac{C_2}{\text{TLV}_2} + \ldots + \frac{C_n}{\text{TLV}_n}$$

Where:

TLV_{mix} = Threshold Limit Value for a mixture of airborne chemicals with additive effects. If the sum is greater than one (1), then an overexposure exists.

C_1 = the measured airborne concentrations of the chemicals

TLV_1 = published Threshold Limit Value for the respective chemicals.

When two or more hazardous chemicals with similar toxic effects are present in the environment, the combined effect should be evaluated rather than the individual effect. *Note: The units can be either mg/m^3 or ppm but must be consistent in the equation.

$$\frac{30}{50} = .6$$

$$\frac{200}{350} = .57$$

$$\frac{150}{200} = .75$$

$$192\%$$

59. Answer: **B**. ANSI Z88.2 "Respirator Protection Factors" is to be used for guidance in the selection of respirators when complying with OSHA 1910.134 "Respiratory Protection." ANSI Z88.2 establishes some protection factors based on qualitative or quantitative fit testing. **Table 41** shows some information on various types of respirators.

Table 41 Types of Respirators and Protection Factors

Type of Respirator	Respirator Protection Factors		
	Qualitative	Quantitative	IDLH
Particulate-filter, vapor or gas, quarter or half mask. Includes combination filters.	10	Per-individual max of 100	NO
Particulate-filter, vapor or gas, full face piece. Includes combination filters.	100	Per-individual max of 100	NO
Powered particulate-filter, vapor or gas, full face piece any respiratory inlet covering.	No test required due to positive pressure. Max protection is 3000 with high efficiency filter.		NO
Air-line, demand, quarter or half mask face piece with or without escape provisions.	10	Per-individual must be less than IDLH	NO
Air-line, demand, full face piece with or without escape provisions.	100	Per-individual must be less than IDLH	NO
Air-line, continuous-flow, or pressure-demand type any face piece. Includes helmet, hood, or suit, without escape provisions.	No test required due to positive pressure. Cannot exceed IDLH concentration.		NO
Air-line, continuous-flow, or pressure-demand type any face piece. Includes helmet, hood, or suit with escape provisions.	No test required due to positive pressure. Max protection factor is 10,000.		YES
SCBA, demand type, open circuit or negative pressure type closed circuit, full face piece.	100	Per-individual must be less than IDLH	NO
SCBA, pressure demand type, open circuit or positive pressure closed circuit, any facepiece.	No test required due to positive pressure. Max PF is 10,000.		YES

60. Answer: **A**. In *Safety Management: A Human Approach*, 3rd edition, Line management is responsible and accountable for enforcing safety and health policies. In ineffective organizations, others actually may be responsible (or no one is responsible), but in reality, it is the responsibility of line management to ensure that their employees work in safe and healthful environment.

61. Answer: **C**.

Step 1: Determine volume.

$$\frac{20 \text{ ft}}{1} \times \frac{.305 \text{ m}}{1 \text{ ft}} = 6.1 \text{ m}$$

$$\frac{10 \text{ ft}}{1} \times \frac{.305 \text{ m}}{1 \text{ ft}} = 3.05 \text{ m}$$

$$6.1 \times 6.1 \times 3.05 = 113.5 \text{ m}^3$$

Step 2: Determine weight.

$$8.34 \text{ lbs/gal} \times 0.8 = 6.68 \text{ lbs/gal}$$

Step 3: Convert lbs to mg.

$$\frac{6.68 \text{ lb}}{1} \times \frac{.4545 \text{ kg}}{1 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1000 \text{ mg}}{1 \text{ g}}$$

$$= 3{,}036{,}060 = 3.03 \times 10^6$$

Step 4: Compute ppm.

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

$$\text{ppm} = \frac{(3.03 \times 10^6/113.5) \times 24.45}{92}$$

$$\text{ppm} = 7094$$

Alternate solution

Step 1: Determine volume.

$$20 \times 20 \times 10 = 4000 \text{ ft}^3$$

Step 2: Determine weight.

$$8.34 \text{ lbs/gal} \times 0.8 = 6.68 \text{ lbs/gal}$$

Step 3: Convert lbs to ft^3.

$$\frac{921 \text{ lbs}}{392 \text{ ft}^3} = \frac{6.68 \text{ lbs}}{? \text{ ft}^3}$$

$$?\text{ft}^3 = \frac{6.68 \text{ lbs} \times 392 \text{ ft}^3}{921 \text{ lbs}} = 28.46 \text{ ft}^3$$

Step 4: Compute ppm.

$$\text{ppm} = \frac{\text{ft}^3 \text{of Toluene}}{\text{Total Volume}} \times 1{,}000{,}000$$

$$\text{ppm} = \frac{28.46 \text{ ft}^3}{4000 \text{ ft}^3} \times 1{,}000{,}000 = 7115$$

62. Answer: **C**. In *Essentials of Organization Behavior,* 14th edition, managers have some discretion in the organization's structural decision. Even though the strategy, size, technology, and environment constrain structural options, managers still have influence on which structure is implemented. Given this discretion and the fact that some configurations appear to influence employee performance and satisfaction, managers should consider carefully the behavioral implications when they make structural decisions.

63. Answer: **D**. All of the listed consequences can result from the failure to adequately remediate chemical releases except for answer D. Another impact is a potential decrease in property value.

64. Answer: **A**. The preferred angle for fixed industrial stairs is 30 to 35°, 15° is the preferred angle for ramps or inclines, and 75 to 90° is the preferred angle for fixed ladders.

65. Answer: **A**.
a. Change ppm to mg/m^3

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

$$\frac{\text{mg}}{\text{m}^3} = \frac{\text{ppm} \times \text{MW}}{24.45} = \frac{6000 \times 58.08}{24.45} = 14{,}253 \text{ mg/m}^3$$

$$14{,}253 \frac{\text{mg}}{\text{m}^3} = 14.253 \frac{\text{g}}{\text{m}^3}$$

b. Calculate volume of the room

$$10 \text{ m} \times 10 \text{ m} \times 20 \text{ m} = 2000 \text{ m}^3$$

c. Calculate the concentration of acetone

$$2000 \text{ m}^3 \times 14.253 \text{ g/m}^3 = 28{,}506 \text{ g}$$

d. Calculate the weight in grams of acetone per liter. By definition, there are 1000 ccs or milliliters in a liter and 1 cc of water weighs one gram; therefore, 1 liter of water weighs 1000 grams.

$$1000 \text{ g/L} \times 0.79 \text{ (SG)} = 790 \text{ g/L (acetone)}$$

e. Convert to liters

$$28{,}506 \text{ g} \div 790 \text{ g/L} = 36.08 \text{ L}$$

66. Answer: **A**. There are three traditional levels of warnings:
    - Danger is used where there is an immediate hazard, which, if encountered, will result in severe personal injury or death.
    - Warning is the signal word for hazards or unsafe practices, which could result in severe personal injury or death.
    - Caution is for hazards or unsafe practices, which could usually result in minor personal injury, product damage, or property damage.

67. Answer: **A**. Since the force is being applied in the horizontal direction, the only force to be overcome is the friction between the crate and the floor. $F = \mu N = (0.40)(80 \text{ lb}) = 32 \text{ lb}$ Work $= Fs = (32 \text{ lb})(10 \text{ ft}) = 320 \text{ ft-lb}$

68. Answer: **B**. The coefficient of dynamic friction applies to an object in motion.

69. Answer: **B**. The American Society of Mechanical Engineers (ASME) is the primary agency providing oversight for boilers in the United States.

70. Answer: **A**. *ANSI Z16.1* deals with classification of injuries. *ANSI Z87.1* is concerned with Occupation and Educational Eye and Face Protection. *ANSI/NFPA Z12.1* addresses Floor and Wall Openings, Railings, and Toeboards. *ANSI Z358.1* is the standard for Emergency Eyewash and Shower Equipment.

71. Answer: **C**. The desire of a plaintiff to establish negligence by gaining access to records held by defendant has led to a recent increase in the use of the procedure known as *discovery*. Discovery is the legal process of determining as many facts as possible prior to a trial so that the truth will be established to the best of everyone's abilities. Records held by the defendant are requested in specific categories and must be produced as long as they fall under the broad potpourri of "documents a reasonable person would ask for with good cause"; of course, the data must relate to the case. This has the effect of allowing the plaintiff almost unlimited access to the defendant's files.

72. Answer: **A**. According to Dr. Peterson in *Techniques of Safety Management*, the Risk Score = Consequences × Exposure × Probability. Considering that fatality was most likely, Consequence = 25. Exposure is rarely = 1. Probability is remotely happens = 1.

$$\text{Risk Score} = (25 \times 1 \times 1) = 25$$

73. Answer: **C**. Accident investigation has as its primary purpose the prevention of similar occurrences and the discovery of hazards. The intent is not to place blame or administer discipline but rather to determine how responsibilities may be defined or clarified and to reduce error producing situations. Accident investigation should improve the safety of operations, if accident investigation is used for punitive measures, the tool has the reverse effect.

74. Answer: **C**. The critical pressure of a substance is that pressure at which no liquid-vapor phase transition occurs at any temperature.

75. Answer: **B**. The classic definition of tenosynovitis is an inflammation of a tendon sheath. Tenosynovitis is normally caused by an injury.

76. Answer: **D**. The weighting networks "scales" of sound measuring instruments are designed to approximate the equal loudness curves. The A scale is very discriminatory against low frequencies, the B scale moderately discriminatory, and the C scale is almost a direct reading. Thus, the C scale utilizing fast response would be the choice supplying a signal to an auxiliary instrument.

77. Answer: **C**. All expenses and profits must be calculated as present values.

Step 1: Calculate the present expense of leasing the machine for 10 years.

$$i = 0.15 \quad n = 10 \quad A = \$1500 \quad P = ?$$

$$P_{lease} = A\frac{(1+i)^n - 1}{i(1+i)^n}$$

$$P_{lease} = 1500 \times \frac{(1.15)^{10} - 1}{0.15 \times (1.15)^{10}} = \$7528$$

Keystrokes for the TI-30X IIS:

$$1\ 500 \times (1.15\text{^}10 - 1)/(.15 \times 1.15\text{^}10) = 7528$$

Keystrokes for the HP10BII:

1. 1500 (PMT KEY)
2. 15 (I/YR KEY)
3. 10 (N KEY)
4. (PV KEY) for the answer

Step 2: Calculate the present value of the maintenance agreement expense.

$$i = 0.15 \quad n = 10 \quad A = \$500 \quad P = ?$$

$$P_{maint} = A\frac{(1+i)^n - 1}{i(1+i)^n}$$

$$P_{maint} = 500 \times \frac{(1.15)^{10} - 1}{.15(1.15)^{10}} = \$2509$$

Keystrokes for the TI-30X IIS:

$$500 \times (1.15\text{^}10 - 1)/(.15 \times 1.15\text{^}10) = 2509$$

Keystrokes for the HP10BII:

1. 500 (PMT KEY)
2. 15 (I/YR KEY)
3. 10 (N KEY)
4. (PV KEY) for the answer

Step 3: Calculate the present value of selling the machine for scrap in 10 years.

$$i = 0.15 \quad n = 10 \quad F = \$5000 \quad P = ?$$

$$P_{scrap} = F[1+i]^{-n}$$

$$P_{scrap} = 5000 \times [1.15]^{-10} = \$1236$$

Keystrokes for the TI-30X IIS:

$$5000 \times 1.15\text{^} - 10 = 1236$$

Keystrokes for the HP10BII:

1. 5000 (FV KEY)
2. 15 (I/YR KEY)
3. 10 (N KEY)
4. (PV KEY) for the answer

Step 4: Calculate the present expense of buying the machine by adding the present value of maintenance costs and subtracting the present value of revenue for selling the machine as scrap in 10 years.

$$P_{buy} = P_{price} + P_{maint} - P_{scrap}$$

$$P_{buy} = 10{,}000 + 2509 - 1236$$

$$P_{buy} = \$11{,}273$$

$P_{buy}\$11{,}237 - P_{Lease}\$7528 = \$3709$ savings

The calculations illustrate it would be cheaper to lease the machine.

78. Answer: **B**. The cost to buy the machine remains the same as in the previous question at \$11,273. Using answers from the previous question:

Step 1: Calculate the cost of leasing the machine by adding the present value of maintenance costs to the present value of leasing the machine.

$$P = P_{lease} + P_{maint}$$

$$P = 7528 + 2509 = \$10{,}037$$

Step 2: Calculate percentage saved by leasing.

$$\%_{saved} = \frac{P_{buy} - P_{lease}}{P_{lease}} \times 100$$

$$\%_{saved} = \frac{11{,}273 - 10{,}037}{10{,}037} \times 100$$

$$\%_{saved} = 12.31\%$$

79. Answer: **B**. Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) are both scheduling techniques. Although they can be used by the system safety practitioner to spot bottlenecks and periods of production pressure, they are not considered to be true system safety techniques.

80. Answer: **A**.

a = 1/2 the load

c = stress on the sling

$$\sin A = \frac{a}{c}$$

$$c = \frac{a}{\sin A}$$

$$c = \frac{11{,}000}{\sin 55}$$

$$c = 13{,}428 \text{ lbs}$$

Sling angle and stress rules of thumb:

15° angle = twice the load

30° angle = the load

45° angle = 75% of load

60° angle = 58% load

90° angle = 50% of load

HINT: Double divided SLINGS are SIN full. Divide the load by number of sling legs and then divide again by sin of the angle. 22,000 ÷ 2 ÷ sin 55 = 13,428 lbs

81. Answer: **A**. The outer ear consists of the pinna, external auditory canal, and ear drum. The middle ear consists of the hammer, anvil, and Eustachian tube. The inner ear consists of the semicircular canals, cochlea, and cochlear nerve.

82. Answer: **B**. **Toggle switches** are easily seen and reliable in operation. They should preferably have only two positions: on and off. **Knobs** without click stops are suitable for fine and precise regulation over a wide range. **Limit switches** are operated by the motion of a machine part or presence of an object. They are used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point. **Push buttons** are to be operated by the pressure of either finger or hand and operate similar to a switch.

83. Answer: **D**.

$$\text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM}$$

$$\text{RWL (kg)} = 23\left(\frac{25}{\text{H}}\right)\left(1 - .033|V - 75|\right)\left(.82 + \frac{4.5}{\text{D}}\right)(1 - (0.0032 \times \text{A}))(\text{FM})(\text{CM})$$

$$\text{RWL (kg)} = 23\left(\frac{25}{45}\right)(1 - .033 \times 0)\left(.82 + \frac{4.5}{25}\right)(1 - (0.0032 \times 0))(1)(1)$$

$$\text{RWL (kg)} = 23 \times 0.555 \times 1 \times 1 \times 1 \times 1 \times 1$$

$$\text{RWL (kg)} = 12.77 \text{ kg}$$

84. Answer: **B**. According to the NSC *Fundamentals of Industrial Hygiene*, 5th edition, hydrogen sulfide is an interference agent with carbon monoxide sensors. In addition, carbon monoxide is an unusual constituent in the atmospheres of sanitary sewers. Given the sudden reading of a large (lethal) concentration of an unlikely component in a sanitary sewer and the presence of hydrogen sulfide is likely, the most probable explanation is that the hydrogen sulfide reading is correct and is causing an interference effect on the carbon monoxide sensor.

85. Answer: **A**. 5-whys is a qualitative analytical technique to identify the root causes of an incident sequence by asking "why" at least five times. Once the causal factors (human errors, equipment malfunctions, etc.) are known, a 5-whys analysis can be performed on each causal factor to determine "why" the causal factor was allowed to exist.

86. Answer: **C**. According to OSHA, *Occupational Noise Exposure*, 29 CFR 1910.95 (b) (1) "When employees are subjected to sound exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of Table G-16, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table."

87. Answer: **C**. Completed operations liability insurance pays claims for damage caused by mistakes, imperfect ingredients, or foreign substances, as well as improper handling, labeling, packing, or delivering. The intent is to provide liability protection for defects, errors, or mistakes made in connection with the manufacture or preparation of products to be offered for sale. The protection also includes losses that can be attributed to defective materials.

Completed operations does not cover liability for accidents involving delivery, pickup and the existence of tools, uninstalled equipment, and the abandonment of unused materials. These would be covered under the Owners, Landlords, and Tenants (OL&T) and Manufacturers and Contractors (M&C) liability policies.

88. Answer: **D**. OSHA requires posting the citation at or near the location of the violation for 3 days or until corrected, whichever is longer.

89. Answer: **C**.

$$P_d = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times d^{4.87}}$$

$$d = \sqrt[4.87]{\frac{4.52 \times Q^{1.85}}{C^{1.85} \times P_d}}$$

$$d = \sqrt[4.87]{\frac{4.52 \times 4000^{1.85}}{100^{1.85} \times 0.04}}$$

$$d = \sqrt[4.87]{\frac{20842481.2}{200.47}}$$

$$d = \sqrt[4.87]{103965.5}$$

$$d = 10.72 \text{ in.}$$

Assuming this is a fire protection question, use the Hazen-Williams formula.

*Note: The calculated size of 10.72 is larger than 10-inch unlined pipe (10 × 102.4% = 10.24 in.), and so the best selection would be the more ***common 12-inch pipe***.

90. Answer: **B**. During hydraulic design of automatic sprinkler systems, NFPA 13 requires calculation of minimum allowable pressure and flows for fire sprinkler systems. Calculations are based on piping size, length, coefficient of roughness, and a sprinkler discharge coefficient "K," which is dependent upon the brand and model of sprinklers that are to be used

Step 1: Determine quantity of water required for this application

$$Q = \frac{0.178 \text{ gpm}}{\text{ft}^2} \times \frac{120 \text{ ft}^2}{1} = 21.4 \text{ gpm}$$

Step 2: Determine the required pressure in psi.

$$P = \left(\frac{Q}{K}\right)^2$$

$$P = \left(\frac{21.4}{5.8}\right)^2 = 3.69^2$$

$$P = 13.61 \text{ psi}$$

91. Answer: **C**.

Q_1 = intial flow

Q_2 = subsequent flow

R_1 = intial residual press.

R_2 = subsequent residual

S = static pressure

$$Q_2 = Q_1\left[\frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}\right]$$

$$Q_2 = 5700 \times \frac{(70 - 20)^{0.54}}{(70 - 36)^{0.54}}$$

$$Q_2 = 5700 \times 1.2315 = 7020 \text{ gpm}$$

92. Answer: **B**.

Light hazards require a minimum of 0.1 gpm/sq ft and an additional 100 gpm for hose stream demand.

Ordinary hazards require a minimum of 0.15 gpm/sq ft (Group I) and 0.2 gpm/sq ft (Group II) and an additional 250 gpm for hose stream demand.

Extra hazards require a minimum of 0.3 gpm/sq ft (Group I) and 0.4 gpm/sq ft (Group II) and an additional 500 gpm for hose stream demand.

93. Answer: **D**.

$$Q = AV$$

$$V = \frac{Q}{A}$$

$$A = \pi \times \left(\frac{3}{12}\right)^2$$

$$V = \frac{4400}{0.196}$$

$$V = 22{,}449$$

94. Answer: **A**.

$$V = 4005\sqrt{VP}$$

$$V = 4005 \times \sqrt{0.80}$$

$$V = 4005 \times 0.8944$$

$$V = 3282 \text{ ft per min}$$

95. Answer: **A**. According to United States Government Publishing Office, *264.34 Access to Communications or Alarm System*:

Whenever hazardous waste is being poured, mixed, spread, or otherwise handled, all personnel involved in the operation must have immediate access to an internal alarm or emergency communication device, either directly or through visual or voice contact with another employee, unless the Regional Administrator has ruled that such a device is not required under Sec. 264.32. If there is ever just one employee on the premises while the facility is operating, he/she must have immediate access to a device, such as a telephone (immediately available at the scene of operation) or a handheld two-way radio, capable of summoning external emergency assistance, unless the regional administrator has ruled that such a device is not required under Sec. 264.32.

96. Answer: **C**.

Cost incurred × 1000/total workhours is the formula for cost factor

$$\text{Cost Factor} = \frac{\text{Cost Incurred} \times 1000}{\text{Total Hours Worked}}$$

97. Answer: **D**. According to Willie Hammer in Handbook of System and Product Safety, answers a, b, and c are correct.

98. Answer: **A**. ISO 19011 defines a management system audit as follows:

"Systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled."

Reproduced from ISO 19011:2011(en), *Guidelines for Auditing Management Systems*.

Selection B is incorrect as audits must be for a stated purpose.

Selection C is the definition of an integrated audit. U.S. audits of publicly traded companies are governed by rules laid down by the Public Company Accounting Oversight Board (PCAOB), which was established by Section 404 of the Sarbanes–Oxley Act of 2002. Such an audit is called an "integrated audit," where auditors, in addition to an opinion on the financial statements, must also express an opinion on the *effectiveness* of a company's *internal control* over financial reporting, in accordance with PCAOB Auditing Standard No. 5.

Selection D identifies an environmental **management system** that enables organizations to develop their environmental performance through a process of continuous improvement.

ISO 19011 was designed to provide recommendations for Quality and Environmental Management Systems Audits.

Audit: A systematic, independent, and documented process for obtaining information and data (audit evidence) and evaluating it objectively to determine the extent to which defined audit criteria are fulfilled (**Table 42**).

Internal audits, sometimes called first-party audits, are conducted by the organization itself, or on its behalf, for management review and other internal purposes (e.g., to confirm the effectiveness of the management system or to obtain information for the improvement of the management system). Internal audits can form the basis for an organization's self-declaration of conformity. In many cases, particularly in small organizations, independence can be demonstrated by the freedom from responsibility for the activity being audited or freedom from bias and conflict of interest.

External audits include second- and third-party audits. Second-party audits are conducted by parties having an interest in the organization, such as customers, or by other persons on their behalf. Third-party audits are conducted by independent auditing organizations, such as regulators or those providing certification.

Combined audit is when two or more management systems of different disciplines (e.g., quality, environmental, occupational health and safety) are audited together.

Joint audit is when two or more auditing organizations cooperate to audit a single auditee.

Reproduced from ISO 19011:2011(en), *Guidelines for Auditing Management Systems*.

Table 42 Document Request for Auditing

Compliance and Management System Auditing	Management System Auditing
Organization chart identifying the names and titles of key personnel	Vision/mission statements and strategic plan
Identification of departments and operating groups with a description of the operations conducted	Environmental manual with ISO 14001 policies and management-level procedures that address the core elements of the EMS

(continues)

Table 42 Document Request for Auditing *(Continued)*

Compliance and Management System Auditing	Management System Auditing
General site-specific information describing number of employees, square feet of building space, location	Current EMS standard operating procedures (SOP) or work instructions for environmental requirements
Site plot plan showing buildings and setup of processes inside the buildings	Sustainability program and list of long-term sustainability objectives
Environmental policy	Listing of environmental aspects and impacts
Comprehensive list of buildings	Environmental performance metrics and identification of the environmental performance data that is currently collected
Process descriptions and flow charts for those with the greatest environmental risk	Listing of set environmental objectives and targets and the environmental management programs developed to achieve environmental objectives
Lists of raw materials, products, by-products, and waste streams	
Listing of environmental permits	
Listing of environmental plans and best management practices	
Training matrix showing environmental training required for job positions	
Most recent internal and/or external environmental audit reports	

99. Answer: **A**.

The guidance given in Clauses 5 to 7 of ISO 19011 is based on the six principles outlined below.

Integrity: the foundation of professionalism

Auditors and the person managing an audit program should:

- perform their work with honesty, diligence, and responsibility;
- observe and comply with any applicable legal requirements;
- demonstrate their competence while performing their work;
- perform their work in an impartial manner (i.e., remain fair and unbiased in all their dealings);
- be sensitive to any influences that may be exerted on their judgment while carrying out an audit.

Fair presentation: the obligation to report truthfully and accurately

Audit findings, audit conclusions, and audit reports should reflect truthfully and accurately the audit activities. Significant obstacles encountered during the audit and unresolved diverging opinions between the audit team and the auditee should be reported. The communication should be truthful, accurate, objective, timely, clear, and complete.

Due professional care: the application of diligence and judgment in auditing

Auditors should exercise due care in accordance with the importance of the task they perform and the confidence placed in them by the audit client and other interested parties. An important factor in carrying out their work with due professional care is having the ability to make reasoned judgments in all audit situations.

Confidentiality: security of information

Auditors should exercise discretion in the use and protection of information acquired in the course of their duties. Audit information should not be used inappropriately for personal gain by the auditor or the audit

client or in a manner detrimental to the legitimate interests of the auditee. This concept includes the proper handling of sensitive or confidential information.

Independence: the basis for the impartiality of the audit and objectivity of the audit conclusions

Auditors should be independent of the activity being audited wherever practicable and should in all cases act in a manner that is free from bias and conflict of interest. For internal audits, auditors should be independent from the operating managers of the function being audited. Auditors should maintain objectivity throughout the audit process to ensure that the audit findings and conclusions are based only on the audit evidence. For small organizations, it may not be possible for internal auditors to be fully independent of the activity being audited, but every effort should be made to remove bias and encourage objectivity.

Evidence-based approach: the rational method for reaching reliable and reproducible audit conclusions in a systematic audit process

Audit evidence should be verifiable. It will in general be based on samples of the information available, since an audit is conducted during a finite period of time and with finite resources. An appropriate use of sampling should be applied, since this is closely related to the confidence that can be placed in the audit.

100. Answer: **D**. Each individual audit should be based on documented audit objectives, scope, and criteria. These should be defined by the person managing the audit program and be consistent with the overall audit program objectives. The audit objectives define what is to be accomplished by the individual audit and may include the following:

- determination of the extent of conformity of the management system to be audited, or parts of it, with audit criteria
- determination of the extent of conformity of activities, processes, and products with the requirements and procedures of the management system
- evaluation of the capability of the management system to ensure compliance with legal and contractual
- requirements and other requirements to which the organization is committed
- evaluation of the effectiveness of the management system in meeting its specified objectives
- identification of areas for potential improvement of the management system

The audit scope should be consistent with the audit program and audit objectives. It includes such factors as physical locations, organizational units, activities, and processes to be audited, as well as the time period covered by the audit.

The audit criteria are used as a reference against which conformity is determined and may include applicable policies, procedures, standards, legal requirements, management system requirements, contractual requirements, sector codes of conduct, or other planned arrangements.

Self-Assessment 5 Questions

1. Which of the following concerning flammable indoor storage locations is false?

A. Normally limited to 660 gallons
B. Required to have a raised 4-inch sill
C. Required to have self-closing doors
D. Required to have fire walls

2. Which of the following *best* explains the term "BLEVE"?

A. Boiling Liquid Expanding Vapor Explosion
B. Burning Liquid & Expanding Vapor Explosion
C. Boiling Liquid Exacerbated Volume Expansion
D. Burning Liquid Elevated Volume Expansion

3. Which of the following would be considered a primary calibration standard for air-sampling pumps?

A. Wet-test meter
B. Dry-test meter
C. Rotameter
D. Spirometer

4. Which of the following is true concerning placement of underground flammable liquid storage tanks with respect to an existing building foundation? The distance from the tank to the foundation or support for Class I, II, and III liquids must be at least:

A. 1 foot.
B. 3 feet.
C. 2 foot for Class I and 3 feet for Class II.
D. 5 feet.

5. Which of the following would indicate seepage through the core wall on the downstream side of an earthen impounding reservoir water collection dam or berm?

A. Lush green grass growing on the downstream slope
B. Exposed gravel showing on the downstream slope
C. Large runoff channels on the upstream slope
D. Cracks in the paving on the downstream slope

6. Which of the following detectors is *best* suited for large, open areas?

A. Photoelectric
B. Rate compensation
C. Rate of rise
D. Bimetallic

7. Which of the following is true concerning placement of structural reinforcing steel in concrete beams that are supported on either end (assume no support in the middle of the span)?

A. Steel should be placed high.
B. Steel should be placed low.
C. Steel should be placed both high and low.
D. Steel should be on chairs in the middle of beams.

8. When using mobile cranes, the radius of a pick is always measured from the center of the load to which of the following points on the crane?

A. Data plate affixed to all cranes showing center point
B. Center of rotation after boom deflects under load
C. Right front tire tread
D. Aft outrigger beam

9. A motorcycle is moving at 60 mph and is acted on by a decelerating force of 32.2 ft/s^2. How many feet will it take the motorcycle to stop?

A. 180 feet
B. 160 feet
C. 140 feet
D. 120 feet

$$V^2 = V_0^2 + 2as$$

10. Which of the following describes materials that ignite spontaneously when in contact with air?

A. Pyrophoric
B. Hypergolic
C. Pyrolysis
D. Deflagration

11. Which of the following is true concerning the electrical ground fault circuit interrupter?

A. It requires an equipment ground to function.
B. It is a very slow-acting device.
C. It will not detect line-to-line faults.
D. It is not designed for personnel protection.

12. During a flow test on a fire supply water system, the flow at 3000 gpm has dropped the flow from 69 psi to 34 psi. What flow is available at 20 psi residual?

A. 1800 gpm
B. 2400 gpm
C. 3600 gpm
D. 4800 gpm

$$\frac{Q_1}{Q_1} = \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

13. Which of the following describes a violent reaction, which occurs when two materials come in contact with each other?

A. Pyrophoric
B. Hypergolic
C. Pyrolysis
D. Deflagration

14. Find the velocity pressure in a 1.5 inch (actual diameter) open-ended pipe with 250 gallons per minute of water flowing?

A. 11.4 psi
B. 14 psi
C. 4.4 psi
D. 25.4 psi

$$P_v = \frac{Q^2}{891d^4}$$

15. Which ISO standard addresses environmental management systems?

A. 9001
B. 45001
C. 19011
D. 14001

16. The minimum energy for ignition of a corn dust cloud is 38 millijoules. Given the formula $E = 1/2\ CV^2$, what would the energy be for a 50,000-volt static spark if the capacitance of the material involved was 95 micromicrofarads?

A. Not enough to cause ignition
B. Barely enough to cause ignition
C. Twice as much as is required
D. Three times as much as is required

17. In completing a Product Safety Failure Modes and Effects Analysis (FMEA), the safety professional should *not* include which of the following?

A. Advertising
B. Packing
C. Service
D. Other products in the same category

18. In comparison to the process of fault-tree analysis, the Failure Modes and Effects Analysis requires:

A. more time.
B. less time.
C. more knowledge.
D. less knowledge.

19. Which of the following system safety analysis technique is aligned in the correct order with respect to the amount of time necessary to conduct the analysis? Order of ranking is from most time consuming to least time consuming.

A. FTA, MORT, FMEA
B. ETA, FMEA, FTA
C. MORT, FTA, FMEA
D. MORT, FTA, ETA

20. Assuming a complete and equal transfer of stress forces during an entire lifting sequence, how much weight can be safely handled when picking with a three-legged sling (sling angle to load is 30 degrees) if the sling safe working load limits are 10,000 pounds each?

A. 10,000
B. 15,000
C. 30,000
D. 6666

$$\sin A = \frac{a}{c} \quad \cos A = \frac{b}{c} \quad \tan A = \frac{a}{b}$$

21. The performance of all fans and blowers is governed by certain rules of physics known as "Fan Laws." The CFM, RPM, SP, and HP are all related to each other in a known manner, and when one changes, all the others change. If a ventilation system currently in use has a motor generating 5/8 horsepower producing 5000 ft^3/m at 1000 revolutions per minute and develops 0.5 inches of water static pressure, which of the following sets of conditions would produce a new output from this system of 6500 cfm?

A. RPM = up 31%, SP = up 30%, HP = up 75%
B. RPM = up 30%, SP = up 70%, HP = up 120%
C. RPM = up 30%, SP = up 120%, HP = up 70%
D. RPM = up 31%, SP = up 85%, HP = up 100%

22. What is a project' s scope?

A. The work required to initiate and sustain a project towards completion.
B. Only the work required to complete the project successfully.
C. The work required by the project manager to fulfill the work breakdown structure.
D. Only the work defined in the project's charter.

23. Which *best* describes a project's work breakdown structure?

A. A process where the project's milestones arc decomposed into more tactical milestones and attributed to specific project team resources
B. A process by which the individual tasks necessary to perform a project are identified and presented such that the project's resources are identified, and the project's milestones are delivered
C. A formal decomposition of the necessary resources that will perform the project's objectives presented in terms of project milestones
D. A hierarchical decomposition of the work to be performed by project team resources, based on the project's objectives and presented in discreet deliverables and milestones

24. The attendance at safety meetings at a particular plant has a coefficient of correlation of –0.7 to –0.9. This would indicate:

A. a strong positive correlation.
B. a strong negative correlation.
C. no correlation.
D. spurious correlation.

25. Which should a safety professional recommend to line management when significant process or operational changes are being considered?

A. Performing comprehensive, change analyses during the decision-making process
B. Ensuring all recommendations from root cause analyses have been implemented
C. Obtaining buy-in from all employees of the benefits related to the process changes
D. Obtaining buy-in from shareholders

26. At the end of each year for 15 years, you have deposited $5000 in a mutual fund that has remained constant at 11% interest. How much is now in the fund?

A. $172,000
B. $162,000
C. $182,000
D. $174,000

$$F = A\left(\frac{(1+i)^n - 1}{i}\right)$$

27. Which of the following is a major benefit in using PERT?

A. Calculation of total mishap rate in hundreds
B. Calculation of time lost from production
C. Calculation of cost overruns
D. Calculation of estimated time to complete projects

28. One of the most important steps in the establishment of a training program is to set sound, obtainable objectives. In which part of the training program development should objectives be established?

A. As early as possible
B. Toward the end of development
C. Before equipment money is allocated
D. When instructors are hired

29. One of the inherent functions of management is that of decision-making. Which of the following theories is correct concerning decision-making?

A. Decisions should always be made as rapidly as possible.
B. Decisions should be made at the lowest level possible.
C. Decisions should always be cost effective.
D. Decisions are made by managers only according to contract rules.

30. Which of the following is an example of *pure* risk?

A. Death
B. Injury that would prevent making a living
C. A company business failure
D. Divorce

31. Which of the following events would *not* be covered by a typical fire and ultra-extended coverage insurance policy?

A. Automobiles on site
B. Aircraft crashing into plant
C. Hail damage
D. Smoke damage

32. Which of the following equations depicts the principle of the exponential law of reliability?

A. $R = e^{-MTBF}$
B. $R = e^{-\lambda t}$
C. $R = R_1 \times R_2 \times R_3 \ldots$
D. $R = R_1 + R_2 + R_3 \ldots$

33. Which of the following *best* describes the insurance term "experience modification"?

A. Rebate for good performance
B. Increased premium because of performance
C. Additional coverage for loss modification
D. Adjustment of manual rating based on performance

34. Because of high eye and foot injury rates, management at a union labor manufacturing plant must take action. Which action should a safety professional perform first?

A. Survey the facilities and operations to determine probable causes of the injuries.
B. Initiate a personal protective equipment program that will include provision of both safety glasses with side shields and hard-toed shoes.
C. Schedule a meeting with the head of the local union to review the injury problems.
D. Charter a facility-wide safety committee.

35. If $100,000 is paid into a savings account which pays 14% interest, how much can be withdrawn annually for 8 years with nothing remaining after the last withdrawal?

A. $22,000
B. $21,560
C. $23,965
D. $24,550

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right)$$

36. Calculate the incidence rate for a company if the recordable accidents are 40 and the total hours worked are 1,500,000:

A. 5.3
B. 8.7
C. 10.2
D. 11.5

37. Which of the following does *not* describe the workers' compensation concept of "whole-man"?

A. Concept considers functional effects of the loss
B. Compares functions after disability with normal fully functional man
C. Disability is rated as a percentage of the whole-man
D. Compares actual lost wages compared to potential wages

38. The *primary* reason for post-training testing is:

A. to weed out weak performers.
B. to spot workers who have "attitude" problems.
C. to identify gaps in the training program.
D. to allow the learners to see how much they learned.

39. In the study of insurance, the term "risk" is often defined as having two components: pure risk and speculative risk. Which of the following is *not* an example of pure risk?

A. Business failure
B. Hailstorm
C. Liability arising from negligent conduct
D. Auto accident with damage and injury

40. In a large corporation that produces a variety of products, the product safety staff is assigned to the risk management department. Under this arrangement, which of the following tasks would most likely *not* be assigned to the product safety office?

A. Recall of defective products
B. Prepare product safety policy for senior management
C. Review histories of hazards, mishaps, and recalls in an attempt to prevent additional mistakes
D. Review proposed instruction manuals and warning labels

41. Which of the following conditions is *most correct* concerning a worker who is 30 years of age and already has a whole-body exposure of 30 rem?

A. The worker cannot exceed 1¼ rems per calendar quarter because his age is equal to or greater than his whole-body exposure.
B. The worker can exceed the 1¼ standard only under emergency conditions but can never exceed 3 rem per quarter.
C. The worker can be exposed to greater than 1¼ rem but cannot exceed 3 rem per calendar quarter as long as the accumulated occupational dose to the whole-body does not exceed his age.
D. The worker can be exposed to greater than 1¼ rem but cannot exceed 3 rem per calendar quarter as long as the accumulated occupational dose to the whole body does not exceed 5(N–18) rem.

42. How can line management help ensure line supervisors are held accountable for safety performance?

A. Develop a culture where management relies on self-directed work teams to enforce safety accountability among work groups.
B. Build written management safety policies and enforcement principles into line supervisor accountability.
C. Require management safety policies to prescribe line supervisors as the point-of-contact for line safety.
D. Perform training for all employees identifying line supervisors as the principle enforcement agent for line safety.

43. Sometimes during the process of safety and health program audits it is not desirable to base the effectiveness of the safety program effort on accident or mishap rates. Often other indicators are used. Which of the following indicators would be the *least effective* in predicting the future success of the safety and health effort?

A. Performing in-depth inspections of the workplace
B. Performing in-depth accident investigations
C. Preparing detailed briefings of program status for senior management
D. Recording accident data on the OSHA 300

44. Which one of the following system safety tools would *not* be appropriate for analysis of a complex system?

A. Fault Tree Analysis
B. Multilinear Events Sequencing
C. Job Safety Analysis
D. Failure Modes and Effect Analysis

45. A safety and health consultant has the opportunity to bid on a contract with a profit value of $5000. The cost of submitting a bid is $350. The chance of getting this contract needs to be at least_____ before bidding is economically feasible.

A. 9%
B. 7%
C. 5%
D. 3%

46. A safety and health consultant has a 60% chance of making a profit of $6000 on a mishap investigation contract. However, there is also a 40% chance of losing $2000. What is the profit expectation for this job?

A. $4400
B. $6000
C. $3600
D. $2800

47. Which of the following *best* describes the interface between management and the company medical service?

A. Management has little control over policy or budget.
B. Management has no oversight in this technical area.
C. The medical department controls their own budget and determines the role and scope of medical service.
D. Management controls policy and budget.

48. A structural mishap at one of the buildings at your plant has occurred and you are assuming command of the incident. From most important to least important, which of the following *best* indicates the correct order of actions you should take?

1. Arrive safely
2. Care for the injured
3. Size up the situation
4. Protect property

A. 1,2,3,4
B. 1,3,2,4
C. 1,4,2,3
D. 1,2,4,3

49. The following table shows estimates of the error rates within the project development phases of a system. What is the *best* estimate of the mean error rate?

Error Rates within Project Development Phases

Phase	Errors per 100 Object Instructions
Validation and Acceptance	0.734
Integration Test	0.591
Operational Demonstration	0.382
Preoperations Exercise	0.325

A. 1 error per 50 instructions
B. 1 error per 200 instructions
C. 1 error per 1000 instructions
D. 1 error per 2000 instructions

50. Which of the following queries would produce the *most useful* information in determining the effectiveness of accident prevention training among recently hired employees within a particular department?

A. Accident, inspection, training
B. Employee, training, accident
C. Employee, training, equipment
D. Accident, equipment, inspection, training

51. Which of the following tables would be the *most effective* addition to the existing database described in the previous questions?

A. Health Hazards
B. Payroll
C. Security and Access Control
D. SDS

52. Which of the following is *most correct* concerning sanding of asbestos-containing flooring material in accordance with OSHA regulations?

A. A ventilation system must be installed that captures all ACM above the PEL.
B. The surface area must be wetted, enclosed, or effectively ventilated prior to sanding.
C. Sanding must be done in a wet state sufficient to prevent the emission of airborne fibers so as to expose employees to levels in excess of the TWA and/or excursion limit.
D. Sanding of asbestos-containing flooring material is prohibited.

53. According to the moment concept of biomechanical lifting equivalents, various loading results in bending moments on the sacro-lumbar joint. The theory is developed based on a variable "D," which is the distance from the joints of the lumbar spine to the front of the abdomen. The variable is adjusted for each individual. The "L" is a measured distance from one side of a cube of uniform density, shown as "W." With appropriate units the formula $(D + \frac{1}{2}L)(W) = M_E$ yields a lifting equivalent measured in inch pounds. What would the M_E be for a lift of 15 lbs if D = 8 and L = 10?

A. 195
B. 250
C. 155
D. 270

54. Explosive magazines are *not* required for storage of which of the following explosives?

A. PETN
B. TNT
C. Ammonium nitrate
D. RDX

55. The safety function should give attention to outside influences such as the external environment, community interest, and other external concerns. What is the management style that reacts to outside influences such as these?

A. Traditional style
B. Contingency style
C. Humanization style
D. Participation style

56. The data below shows the costs and risk reduction benefits associated with installing a new safer system in your plant. If the cost-benefit ratio is defined as the cost in dollars associated with the reduction of each fatality gained by installing the new system, then what is the cost-benefit ratio for installing the system?

New system	$25,000
Average fatalities if not installed	.025
Average fatalities if installed	.011

A. 1 million/fatality
B. 1.786 million/fatality
C. 2.273 million/fatality
D. 0.694 million/fatality

57. Which of the following is *true* concerning the dangers posed by current X-ray machines?

A. Biggest hazard is nonionizing radiation.
B. Biggest hazard is ionizing radiation.
C. Biggest hazard is high voltage.
D. Biggest hazard is chemical decomposition.

58. What part of the eye is acutely damaged by the welder's flash of ultraviolet rays?

A. Pupil
B. Sclera
C. Cornea
D. Retina

59. Which of the following *best* describes the action of dust particles entering the respiratory tract?

A. When < 5 microns in size dust is trapped in the throat.
B. When > 10 microns in size dust is trapped in the upper respiratory system.
C. All respirable dust eventually reaches the lungs.
D. Respirable dust can be seen with the naked eye.

60. Which of the following factors tells you the *most* about how long it will take to recover from the damaging effects of an electrical shock?

A. Duration of the electrical shock
B. Resistance of the body at time of contact
C. Path of current flow through the body
D. Amount of EMF available at time of contact

61. Assuming complete evaporation and no air change, what is the concentration in PPM given the following conditions? A one-half-gallon beaker of Benzene falls to the floor and breaks in a lab room that is 20 ft × 20 ft × 10 ft. The MW of Benzene is 78, and the SG is 0.6.

A. 3795 ppm
B. 4160 ppm
C. 3150 ppm
D. 2710 ppm

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

62. The process that involves oxidation of gas or vapor to remove contaminates is known as:

A. adsorption.
B. absorption.
C. combustion.
D. condensation.

63. During an inspection, you sample continuously for an 8-hour period and measure the following concentrations: toluene 5.5 hrs at 50 ppm – TLV = 100 ppm, acetone 2 hrs at 400 ppm – TLV = 400 ppm, MEK 8 hrs at 100 ppm – TLV 200 ppm. What is the percentage of the TLV for this mixture?

A. 100%
B. 109%
C. 112%
D. 89%

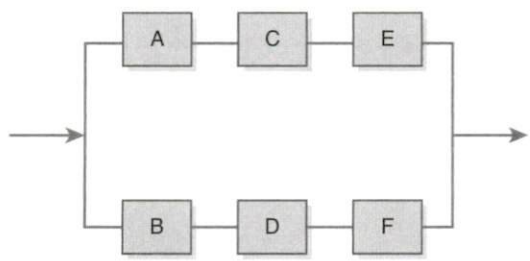
$$\text{TLV}_m = \frac{C_1}{\text{TLV}_1} + \frac{C_2}{\text{TLV}_2} + \ldots + \frac{C_n}{\text{TLV}_n}$$

64. If a light source has a surface illumination of 70 at 1 unit, what will the illumination be when measured at 5 additional units?

A. 22
B. 2
C. 3
D. 4.4

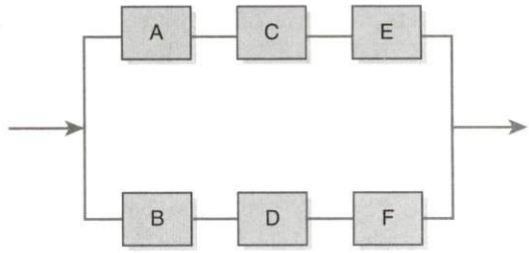
$$I_2 = I_1 \times \frac{(d_1)^2}{(d_2)^2}$$

65. Which of the following fails to correctly depict the cut sets for the following system diagram?



A. A, B, C
B. A, C, E
C. B, C
D. D, E, F

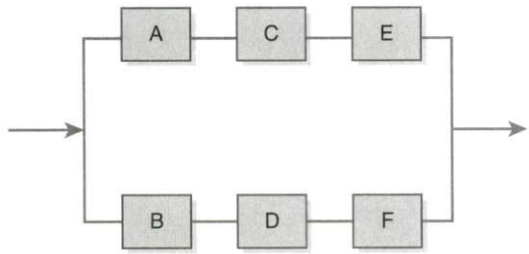
66. Which of the following correctly shows the "minimum" cut sets for the illustration?



A. (A, B) & (B, C)
B. A, B
C. A, B, C
D. (A, C) & (B, F)

67. A failure rate for each component is listed in the table.

Components	Failure Probability
A	10^{-4}
B	10^{-3}
C	10^{-5}
D	10^{-5}
E	10^{-3}
F	10^{-4}



Assume the minimum cut sets are AB, CD, and EF. What is the TOP event probability for this system?

A. 1×10^{-7}
B. 1×10^{-10}
C. 1×10^{-7}
D. 2.001×10^{-7}

68. How much Toluene (MW of 92) would have to be evaporated in a 15,000-ft^3 room to reach the LEL of 1.2%? Assume a safety factor of 10.

A. 4.2 lbs
B. 15 lbs
C. 18.4 lbs
D. 2.4 lbs

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

69. Which of the following agencies regulates pressure vessel design?

A. NIOSH
B. OSHA
C. EPA
D. ASME

70. Which of the following NFPA standards deals with fire extinguishers?

A. NFPA 10
B. NFPA 70
C. NFPA 13
D. NFPA 40

71. The term "consideration" in a legal contract is *best* defined by which of the following?

A. A value, legal tender
B. Must consider both sides in arbitration
C. Money must actually be transferred
D. Consideration of all pertinent laws must be accomplished

72. Air samples in a facility are taken over a 4-month period. Based on the sample data obtained, the mean concentration of the contaminant of interest was calculated as 0.5 ppm with a standard deviation of 0.5 ppm. The range was 0 ppm to 1 ppm. Approximately 120 samples were taken. The lower limit of detection of the sampling device for the contaminant of interest is 1 ppm. What is the *best* conclusion to draw from this information?

A. There is a 68% chance that the mean concentration of the contaminant of interest is 0.5 ppm in the warehouse.
B. There is a 95% chance that the mean concentration of the contaminant of interest is at or above 1 ppm in the warehouse.
C. There is a presence of the contaminant of interest at or below 1 ppm in the warehouse.
D. The sampling data are too imprecise from which to make any valid conclusion.

73. OSHA recommends what level of lighting for general construction area work?

A. 5 foot-candles
B. 10 foot-candles
C. 15 foot-candles
D. 20 foot-candles

74. A safety professional's number one goal should be to:

A. provide a workplace with zero hazards.
B. ensure compliance with 29 CFR 1910/26.
C. ensure that all processes are hazard free.
D. achieve optimal safety performance that permits profitable operations.

75. A standard that is specific, that is, has application for a specific industry only, is:

A. a performance standard.
B. a specification standard.
C. a vertical standard.
D. a horizontal standard.

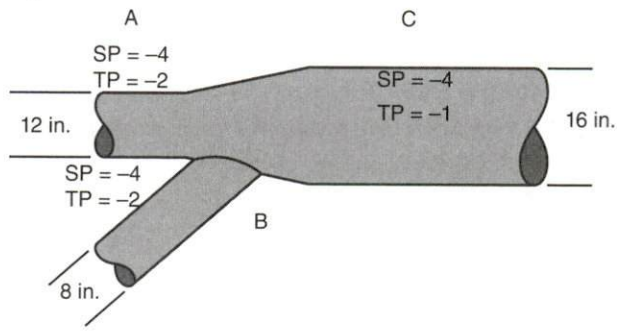
76. Which of the following industries have achieved tremendous reduction in accidental losses through the use of strict compliance with stringent codes and standards?

A. Mining and tunneling, aviation, and railroads
B. Pressure vessels, elevators, and construction
C. Pressure vessels, elevators, and aircraft
D. Hand tools, petrochemical, and mining

77. Given the following conditions, what is the velocity at point C?

$$TP = SP + VP$$

$$V = 4005\sqrt{VP}$$



A. 7500 fpm
B. 6940 fpm
C. 4354 fpm
D. 5020 fpm

78. Which of the following techniques uses deductive analysis?

A. Failure Mode and Effect Analysis (FMEA)
B. Fault-Tree Analysis
C. Preliminary Hazard Analysis (PHA)
D. Operational Hazard Analysis (OHA)

79. What is the failure rate of a device that has four components connected in parallel? Each component has a failure rate of 0.005.

A. 0.02
B. 6.25×10^{-10}
C. 0.000000625
D. 6.25

80. Which of the following would be the correct sampling/analytical method for formaldehyde?

A. Filters + Impingers and Visible Absorption Spectrometry
B. Filters + Tubes and Flame Ion Detection
C. Urine, End of Shift, and UV Detection
D. Solid Sorbent Tube and Visible Absorption Spectrophotometry

81. Hantavirus Pulmonary Syndrome (HPS) is a disease often found in rural areas of the western United States. Which of the following statements is *not* true concerning HPS?

A. HPS is transmitted to humans through infected rodent urine, saliva, or droppings.
B. HPS is a respiratory disease.
C. HPS can be spread from person to person.
D. The virus can be killed by most household disinfectants.

82. When testing for cholinesterase inhibitors, what do you look for in the blood?

A. Aromatic hydrocarbons
B. Chlorinated hydrocarbons
C. Polychlorinated biphenyls
D. Organophosphates

83. Which of the following statements concerning risk acceptance by the general public is correct?

A. Risk acceptance is a constant throughout the world.
B. Risk is accepted when it is important to do so.
C. People readily accept the process of assigning dollar values to human suffering.
D. Risk acceptance is highly subject to social values.

84. What is the maximum distance allowed between ladders used for ingress/egress of a trench?

A. 10 feet
B. 25 feet
C. 50 feet
D. 75 feet

85. What kind of plan is associated with defining mission element needs by identifying (1) safety deficiencies in an existing system and (2) opportunities to improve the mission capability?

A. System safety program plan
B. Critical items listing plan
C. Interface hazard analysis is plan
D. Operating hazard plan

86. Which of the following *best* describes the purpose of hold harmless agreements?

A. Prevent plaintiff from bringing suit
B. To prevent hazardous materials from entering the market
C. To prevent lawsuits
D. To protect the court system

87. Which statement is true about the composition of a safety advisory committee?

A. The safety manager should chair the committee.
B. Everyone should take turns as a committee member.
C. The committee should evaluate its performance against its established goals.
D. The committee should include representatives of every department.

88. When performing a training needs analysis, what is the fundamental question that a safety professional must ask?

A. Will this organization's management commit to implementing this training?
B. Will this organization's employees implement that which they learn during training?
C. Will this organization accept the learning objectives?
D. Will training resolve this organization's needs?

89. The term "caveat emptor" (let the buyer beware) has changed in recent times to _____.

A. caveat venditor
B. caveat sellitor
C. the law of privity of contract
D. the law of implied warranty

90. Which of the following *best* describes the principle of fault tree equivalence?

A. The use of Boolean algebra principles to a fault tree for simplification
B. The tool used to make fault trees look like success trees
C. Reduction to minimal cut sets
D. Fault trees drawn by different engineers look different but when reduced have equivalence

91. If you are going to select a software program to track and monitor your accidents and rates, the *best* option would be:

A. a database.
B. a spreadsheet.
C. word processing.
D. financial management.

92. Which of the following is a software language used on the Internet?

A. HTTP
B. FTP
C. HTML
D. ISP

93. In a business or industrial setting, there are powerful reasons to focus on behavior before attitudes. These include all the following *except:*

A. a change in behavior does lead to a change in attitude.
B. a change in behavior does not lead to a change in attitude.
C. behavior can be measured and therefore managed.
D. attitudes present major measurement problems.

94. Which is an example of a well-constructed training objective?

A. Students will understand the safety policy.
B. General industry training standards
C. Each student can demonstrate the proper electrical procedures.
D. Supervisors will be motivated to deliver safety training.

95. Which of the following is the *most accurate* concerning the listing of a material as a carcinogen on the Safety Data Sheet (SDS)?

A. If there is a report anywhere listing the chemical as a carcinogen, then it must be listed as a carcinogen on the SDS.
B. If the substance is identified as an IARC Group 3 or higher, it must be listed on the SDS as a carcinogen.
C. If the substance is identified on the National Toxicology Program "Annual Report on Carcinogens," it must be listed on the SDS.
D. If the agent was listed in an in vitro study as a possible Group 4 carcinogen risk according to IARC.

96. Which statement is *most important* when evaluating computer-based training (CBT) or self-directed distance learning?

A. CBT augments professional and managerial training but is generally unsuitable for line employee training.
B. CST augments line employee and line supervisory training but is generally unsuitable for professional and managerial training.
C. CBT augments all forms of training due to its low cost and flexibility.
D. A needs analysis must be conducted before any decision to use CBT is made.

97. When developed properly, knowledge assessment instruments that use _____ items are most objective and permit reliable statistics to be obtained.

A. matching-style
B. essay-style
C. short answer–style
D. multiple-choice

98. Which of the following is *not* a principal purpose for product warning labels?

A. Inform user of a hazard or danger
B. Inform user of the possible effects of misuse
C. Inform user of the legal recourse available
D. Inform user of the ways to reduce likelihood of injury

99. Danger is used where there is an immediate hazard, which if encountered will result in:

A. death or severe personal injury.
B. death, severe personal injury, or extensive property damage.
C. death, extensive property damage, extensive product damage, and severe personal injury.
D. death, loss of livelihood, and property damage.

100. The purpose of the Delphi technique is to elicit information and judgments from participants to facilitate problem-solving, planning, and decision-making. It does so without physically assembling the contributors. The Delphi technique includes all the following *except:*

A. the process is completed in one iteration.
B. the questions are structured for short written responses.
C. there is generally a guarantee of anonymity.
D. information is generally exchanged via mail or e-mail.

Self-Assessment 5 Answers

1. Answer: **A**. Storage in indoor storage rooms must comply with NFPA 30, which limits the storage quantity based on the fire resistance of the construction and the installation of a sprinkler system. An indoor, flammable liquid storage area used for storing AND mixing class IA materials must meet the requirements in NFPA 30.

   - Walls with a fire-resistant rating as specified in NFPA 30, Table 4-4.2.1
   - Fire doors or an automatic closing fire door
   - Exterior access for fire fighting
   - Approved ventilation and intake air
   - Containment of the flammable liquid
   - Class I, Division I electrical wiring

   Fire extinguishers should be located outside the room but within 10 feet from the door.

2. Answer: **A**. The term "BLEVE" is the acronym for a Boiling Liquid Expanding Vapor Explosion, which is a major container rupture due to a form of pressure release explosion.

3. Answer: **D**. A spirometer is considered to be a primary. All the other meters listed are secondary standards.

4. Answer: **A**. NFPA 30 specifies that underground storage tanks should be placed not less than 1 foot from existing foundations or supports. The intent here is to ensure that the loads carried by the foundation or supports will not transfer to the tank. Separation distances from *property lines* differ with the class of fluid stored.

5. Answer: **B**. The presence of lush green grass on the downstream side of a dam or berm indicates dangerous conditions that should be investigated. Downstream slopes are sometimes protected against natural erosion by shallow root vegetation, but this practice is not widespread so normally the presence of obviously well-fed vegetation is a trouble indication. However, a more predominate indicator is the exposed gravel, which indicates seepage in enough quantity to have washed away the fines (fine sand) or other surface covering on the sides of the dam. This indicator of major seepage should be investigated immediately.

6. Answer: **A**. All of the devices listed are heat detectors with the exception of the photoelectric smoke detectors, which is answer A. Smoke detectors are better suited for large open areas than heat detectors because smoke does not dissipate as rapidly as heat does in the same size space.

7. Answer: **B**. Concrete structures must resist two kinds of forces: *compression and tension*. Design of concrete slabs, beams, and girders involves the computation of how much steel is required for strength in *tension* and how much concrete is required for strength in *compression*. The placement of reinforcement is a critical function if the structure is to resist the forces placed on it. All metal reinforcement should be accurately placed and supported at the proper height by concrete or metal chairs to prevent movement during pouring. The actual placement in the slab or beam is dependent on the forces the slab will see. When a beam is supported at two or more points it will tend to break by pulling apart at the bottom—so *to add strength we place steel near the bottom surface where it is needed most*. When a beam is supported at one point, it is likely to fail by pulling apart at its upper surface first—so we need to place reinforcing as high as possible (but not generally closer to the surface than 1 inch). The weakness of concrete in tension is illustrated in the failure of a cantilevered beam, which fails at the top of the slab and requires the steel to be concentrated at the top of the slab.

8. Answer: **B**. The load radius is calculated by measuring from the crane's center of rotation to the center of the load *after boom deflection*. A data plate is required on all cranes and is located near the boom foot. The data plate shows the distance from the center of rotation, and this value is added to the distance from the load center to obtain the load radius.

9. Answer: **D**.

Step 1: Convert MPH to ft per sec.

$$\frac{60 \text{ mph}}{1} \times \frac{1.47 \text{ fps}}{1 \text{ mph}}$$

$$= 88 \text{ ft/sec}$$

Step 2: Solve for s when $V^2 = 0$.

$$V^2 = V_0^2 + 2as$$

$$V^2 = 0$$

$$0 = V_0^2 + 2as$$

$$0 = (88 \text{ ft/sec})^2 + 2(-32.2 \text{ ft/sec}^2)s$$

$$0 = 7744 + (-64.4)s$$

$$64.4s = 7744$$

$$s = 120.25 \text{ ft}$$

10. Answer: **A**. *Pyrophoric* materials ignite spontaneously when in contact with air. *Hypergolic* describes a violent reaction, which occurs when two materials come in contact with each other. *Pyrolysis* is the process of decomposition in the presence of heat. *Deflagration* is a rapid burning fire that produces flame speed that travels slower than the speed of sound.

11. Answer: **C**. The ground-fault circuit interrupter is a fast-action device, which senses a small current leakage to ground and, in a fraction of a second, shuts off the electricity and *interrupts* the faulty flow to ground. Placed between the electrical service and the tool or appliance it serves, the GFCI continually matches the amount of current going to and from the tool along the normal path of the circuit conductors. Whenever the amount *going* differs from the amount *returning* by a set trip level, the GFCI interrupts the electric power within 1/40th of a second. This difference in current is called leakage current to ground and the path it takes to ground could be through a person—in which case, the rapid response of the GFCI is fast enough to prevent electrocution. This protection provided by the GFCI is independent of the condition of the equipment grounding conductor; thus, the GFCI can provide protection even if the equipment grounding conductor becomes inoperative. **The device will not detect line-to-line faults.**

12. Answer: **C**.

$$\frac{Q_1}{Q_1} = \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

$$Q_2 = Q_1 \frac{(S - R_2)^{0.54}}{(S - R_1)^{0.54}}$$

$$Q_2 = 3000 \times \frac{(69 - 20)^{0.54}}{(69 - 34)^{0.54}}$$

$$Q_2 = 3000 \times 1.199$$

$$Q_2 = 3598 \text{ gpm}$$

13. Answer: **B**. *Hypergolic* describes a violent reaction that occurs when two materials come in contact with each other. *Pyrophoric* materials ignite spontaneously when in contact with air. *Pyrolysis* is the process of decomposition in the presence of heat. *Deflagration* is a rapid burning fire that produces flame speed that travels slower than the speed of sound.

14. Answer: **B**.

$$P_v = \frac{Q^2}{891d^4}$$

$$P_v = \frac{250^2}{891 \times 1.5^4}$$

$$P_v = \frac{62500}{4511}$$

$$P_v = 13.86 \text{ psi}$$

15. Answer: **D**. The ISO 9000 ("quality management") and ISO 14000 ("environmental management") families are among ISO's most widely known standards ever. ISO 9000 has become an international reference for quality requirements in business to business dealings, and ISO 14000 looks set to achieve at least as much, if not more, in helping organizations to meet their environmental challenges.

16. Answer: **D**.

$$E = \frac{1}{2} \times CV^2$$

$$E = \frac{1}{2} \times \left(\frac{95}{1 \times 10^{12}}\right) \times (5 \times 10^4)^2$$

$$E = 0.5 \times (9.5 \times 10^{-11}) \times (2.5 \times 10^9)$$

$$E = 0.119 \text{ or } 119 \text{ millijoule s}$$

Where E = Energy in joules

C = Capacitance in farads

V = Voltage

*Note: Micromicro or 1×10^{-12} is an outdated term for the SI unit "pico." Therefore, 95 mmF = 95 pF. Although discouraged, the term is still widely used.

17. Answer: **A**. The complete delivery system should be evaluated if one is performing a FMEA for a deliverable product. This would include "cradle to grave" coverage, such as, shipping, packing, installation, service, disposal, etc. This would, of course, not be required if the FMEA was to be performed on a nonproduct, such as a process or piece of equipment used in an industrial setting or for a one-time operation.

18. Answer: **A**. The process of examining the entire system, subsystem, procedure, component, interface, etc. is extremely time consuming. Much more so than the fault tree, which only concentrates on failures that could cause great harm. There is no particular difference in actual system knowledge required between the two techniques.

19. Answer: **B**. Of the techniques listed Event Tree Analysis (ETA), is by far the most time consuming. It requires the selection of initiating events *both wanted and unwanted* and evaluates the consequences, again both *wanted and unwanted*. Alternate paths are then developed to consider each consequence of the different paths as independent initiating events. Next in order of time required is the Failure Modes and Effects Analysis, which is an in-depth analysis of components element by element. Taking the least amount of time is the Fault Tree

Analysis (FTA), which identifies an undesirable event and establishes the faults that would cause such a situation.

Note:

ETA = Event Tree Analysis
MORT = Management Oversight and Risk Tree
FMEA = Failure Modes and Effects Analysis
FTA = Fault Tree Analysis

20. Answer: **B**.

$$\sin A = \frac{a}{c} \qquad c = 30{,}000$$

$$a = \sin A \times c$$

$$a = \sin 30 \times 30{,}000 = 15{,}000 \text{ lbs}$$

HINT: Double divided SLINGS are SIN full. Divide the load by the number of sling legs and then divide again by the sin of the angle.

$$\text{Load} \div 3 \div \sin 30 = 10{,}000 \text{ lbs}$$

$$\text{Load} = 10{,}000 \times 3 \times \sin 30$$

$$\text{Load} = 15{,}000 \text{ lbs}$$

21. Answer: **B**.

Note: CFM varies directly as Fan Speed, TP and SP varies as the square of the fan speed, HP varies as the cube of the fan speed.

Step 1: Calculate the ratio of the new CFM to existing CFM.

$$\text{Ratio} = \frac{\text{CFM new}}{\text{CFM existing}}$$

$$R = \frac{6500}{5000}$$

$$R = 1.3 \text{ or } 130\%$$

Step 2: Multiply ratio times existing RPM to determine new RPM.

$$\text{New RPM} = 1.3 \times 1000$$

$$\text{New RPM} = 1300$$

Step 3: Multiply ratio^2 times existing SP to determine new SP.

$$\text{New SP} = (1.3)^2 \times 0.5$$

$$\text{New SP} = 1.69 \times 0.5$$

$$\text{New SP} = 0.845 \text{ inches W.G.}$$

Step 4: Multiply ratio^3 times existing HP to determine new HP

$$\text{New HP} = (1.3)^3 \times 0.625$$

$$\text{New HP} = 2.2 \times 0.625$$

$$\text{New HP} = 1.37$$

The new conditions = 6500 cfm (up 30%), 1300 rpm (up 30%), 0.845" SP (up 70%), 1.37 horsepower (up 120%)

22. Answer: **B**. *A Guide to the Project Management Book of Knowledge,* 3rd edition. The scope contains only the work that, when completed properly, will cause the project to be a success. The scope contains all of the agreed to by the project sponsor and stakeholders.

23. Answer: **D**. *A Guide to the Project Management Book of Knowledge,* 3rd edition. The project's work breakdown structure (WBS) is hierarchical in nature. At each level is a discreet project deliverable or project package with associated milestones. Each subordinate WBS can be rolled into its related higher-level package, or deliverable, such that at the top is the project itself.

24. Answer: **B**. A result near 1 indicates that the values have a strong linear relationship. A result near 0 indicates the values are only slightly related. A value near −1 indicates the values are very closely related but in a negative way (increase in one is related to a decrease in the other). In safety work, a correlation between + to −0.6 is discounted. A coefficient of correlation of −0.7 to −0.9 would indicate a strong negative correlation.

25. Answer: **A**. According to the *Guidelines for Risk Based Process Safety,* a formal change analysis is essential when any kind of significant process or operational changes are anticipated. Even major equipment changes or procedural changes should induce formal and systematic change analyses. Change analysis is a form of risk assessment. Then, usual formal techniques can be used (e.g., HAZOP, What-if/Checklist); however, a custom approach can also be used.

26. Answer: **A**.

$$i = .11 \qquad n = 15 \qquad P = \$5000 \qquad F = ?$$

$$F = A\left(\frac{(1+i)^n - 1}{i}\right)$$

$$F = 5000 \times \left(\frac{(1+.11)^{15} - 1}{.11}\right)$$

$$F = \$172{,}027$$

27. Answer: **D**. Program Evaluation Review Technique (PERT) is the presentation of events, tasks, and activities on a network in sequential form with completion time estimates. The Safety Engineer can use this scheduling "model" to uncover bottlenecks and possible hazards that may arise from the order of work, or from changes in the setup or environment that may arise.

28. Answer: **A**. The development and establishment of training objects must by necessity be one of the first steps taken in the development of any training program.

29. Answer: **B**. Decisions should always be made at the lowest level possible to ensure that pertinent factors are considered. This assumes that the level chosen has all the pertinent factors available from which an informed decision can be made.

30. Answer: **A**. Pure risk is an event of failure from which there is no possible recovery. The only example cited is that of death and then only if viewed from a personal viewpoint. Individuals avoid risk when the probability of loss is high, even though the consequences may be small. They also appear to accept natural risks more readily than human errors. Some people refer to the risk as background risks.

31. Answer: **B**. It is possible to obtain insurance for just about any major mishap; however, the basic fire and extended coverage policy would not cover an aircraft accident in your plant. The other choices would fall under the general umbrella of coverage afforded by these types of policies.

32. Answer: **B**.

$$R = e^{-\lambda t} = e^{-t/m}$$

Where: e = 2.718
λ = failure rate
T = operating time
M = M T B F

The mathematical expression indicating the probability of components in a constant failure rate system to operate successfully to the end of a time period is the **exponential law of reliability.**

33. Answer: **D**. Experience modification indicates an adjustment of the manual rate due to past loss experience.

34. Answer: **A**. In *Accident Prevention Manual for Business and Industry: Administration and Programs,* a key part of risk management is investigating incidents and taking corrective actions based upon the facts associated with the incidents. An essential aspect of the investigation process is understanding the causal factors and the subsequent root causes of the incidents so appropriate corrective actions can be identified and implemented.

35. Answer: **B**.

$$i = 14 \quad n = 8 \quad P = \$100{,}000 \quad A = ?$$

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n - 1}\right)$$

$$A = 100{,}000 \times \left(\frac{.14\ (1.14)^8}{(1.14)^8 - 1}\right)$$

$$A = \$21{,}557$$

36. Answer: **A** The formula to calculate **incident rate** is recordable accidents times 200,000 divided by the total man-hours worked. This formula yields the rate of injuries per hundred workers.

37. Answer: **D**. The whole-man theory compares the function of a whole unimpaired man with the ability to function after a disabling injury. The disability is rated in percentage and then compared to the income potential. Answer D more appropriately describes the concept of "lost wages," which considers the reduction in earnings that was caused by the accident compared to a standard that approximates what the worker would have earned if uninjured. The compensation attempts to make up the difference.

38. Answer: **C**. In the practice of safety and health, training is often offered as a universal solution. However, safety and health training should be targeted to real problems. Training should only be recommended as the solution to problems where increased knowledge or skill is needed or where required by directive. There are two objectives to after training testing. First, to see if the student has gained skill or knowledge in the subject area. Second, to assist the developer and instructor in evaluating the effectiveness of instruction. For example, if a significant percentage of the students in an average class cannot perform up to the specifications outlined in the lesson plans, then the instruction is simply not working. The problem could be the atmosphere, the instructional method, instruction techniques, the instructor, training material, etc. In any event, changes are in order. Effective training is a complex task in which evaluation of the instruction is often overlooked.

39. Answer: **A**. In insurance terms, "risk" is usually separated into two entities: pure risk and speculative risk. *Pure risk* implies two outcomes (i.e., fiscal loss or no fiscal loss). The choices are to have a loss or not to have a loss; however, there is no choice that could be considered a gain. To have a loss is certainly not a gain, and to not have a loss is neutral. Pure risk is generally divided into personal and property. *Speculative loss* implies three choices: loss, no loss, or gain. Speculation in the stock market implies three choices: the stock goes up (gain), the stock goes down (loss), the stock remains the same (neutral). Speculative risks are sometimes called "business risks." The distinction is made in the study of insurance to illustrate the concept that only rarely is insurance applied to speculative risk. Most all insurance attempts to protect one from the misfortune of loss, that is, pure risk.

    When doing a basic risk analysis, consider the following: Could the benefits be produced if the resources were used elsewhere, possibly to reduce another risk? Could the same degree of risk reduction be accomplished at a lower cost? At what point are the benefits of further risk reduction no longer worth the extra cost?

40. Answer: **A**. In a large organization the product safety office would probably not be directly involved in product recall. The recall of defective items is a terribly complicated and time-consuming process that demands the attention of various disciplines. The actual mechanics of the process is best left to operations.

41. Answer: **D**. OSHA and the scientific community in general agree that the dose of ionizing radiation to the whole body should not exceed 5(N-18) rems where "N" equals the worker's age in years. Additionally, OSHA does not normally permit employers to expose workers in restricted areas to whole body exposure greater than 1¼ rems per calendar quarter. The whole body includes: head and trunk, active blood-forming organs, lens of the eyes, or the gonads. However, there are certain conditions where employers can exceed the quarter dose. OSHA at 1910.96 allows exposure above the 1¼ rem quarterly limit so long as:

    - during any calendar quarter, the dose to the whole body shall not exceed 3 rems
    - the dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 × (N −18) rems, where "N" equals the individual's age in years at his last birthday
    - the employer maintains adequate past and current exposure records which show the employees accumulated occupational dose

    $$D_{MAX} = 5(N - 18)$$

    $$D_{MAX} = 5 \times (30 - 18)$$

    $$D_{MAX} = 5 \times 12$$

    $$D_{MAX} = 60$$

    Step 1: Determine the maximum whole-body dose.

    $$D_{ACC} = D_{Present} + D_{Failure}$$

    $$D_{ACC} = 30 + 3$$

    $$D_{ACC} = 33$$

    Step 2: Determine the accumulated occupational dose in exposure this quarter were to be 3 rems.

    Step 3: Since D_{ACC} is less than D_{MAX}, the exposure is permitted. (OSHA, *Ionizing Radiation*)

42. Answer: **B**. In Peterson's *Techniques of Safety Management: A Systems Approach,* 4th edition, line supervisors will do what they perceive is being measured and what they perceived they will be rewarded for doing. Therefore, written expectations and written policies for enforcement and accountability should be incorporated into line supervision at every level of management.

43. Answer: **D**. This is a very subjective question. Every safety and health manager has his or her own ideas on what constitutes a satisfactory management effort and what indicators should be used to gauge that effort. I don't believe there is a safety scholar, professor, theorist, or lecturer who has not been involved in the debate in the last 20 years. However, it is my opinion that the recording of accident data on the OSHA Form 300 could be left to another entity, perhaps the occupational health nurse, without endangering the fabric of the safety and health effort. The other items listed may not all make your top "ten things to do" list, but they are among the functions most often listed by your peers.

44. Answer: **C**. Of the techniques listed for answers in this question, Job Safety Analysis would be the least effective. JSA tends to be too task oriented to be used successfully in a very complex operation.

    Fault-tree analysis is excellent for scaling down huge complex systems, although the tree itself becomes fairly complex.

    Multilinear Events Sequencing (MES) is an accident investigation tool developed by Ludwig Benner Jr. of the National Transportation Safety Board and used extensively in aircraft mishap investigation. MES is a flow-charting methodology that, as the name implies, puts pertinent events in sequence. The attribute that really makes MES a star performer is the addition of a timeline thus allowing duration, interval, and sequence dimensions to be visualized—a concept very useful in accident investigation.

    Failure Modes and Effects Analysis was originally a reliability tool developed to allow predictions for the reliability of complex systems. It uses a tabular format to identify failures and the effect on the overall system. It is an excellent tool for spotting single point failures but does not include any human interface.

45. Answer: **B**.

$$\frac{350}{5000} = 7\%$$

46. Answer: **D**.

$$(\$6000 \times 60\%) + (-\$2000 \times 40\%) = \$2800$$

47. Answer: **D**. The company medical service is a resource controlled by management who determines the budget, sets policy, and therefore controls the role and size/scope of the effort.

48. Answer: **B**. In this case the initial actions, it would appear, have already been taken. Your remaining action would probably center around preventing a second accident and preserving evidence. However, in answer to the question, it is generally accepted within the health and safety community that the order of sequence for accident investigation should be:

    Arrive safely: You cannot do anyone any good if you are involved in an accident yourself racing to the scene of a tragedy.

    Size up: The professional fire service uses the term "size up" to indicate the time spent observing and analyzing the event. The same tactic should be used by investigators to determine what evidence must be protected, who is involved, who is on the scene, is the site now safe, or is another mishap about to occur, etc. Experience will allow you to accomplish this task very rapidly.

    Care for the injured: If necessary, the investigator should help the injured and protect property. However, the investigator's job is to gather facts not provide emergency service. Generally, this job is best left to others. It is fine to render aid if you are needed, but don't get in the way of the professionals. Protect property of the second accident is an important prevention aspect of the accident investigator's job. Because of their observation skills and training safety, professionals can often spot unsafe conditions that others involved in the emergency will not see. You must above all else not allow an accident to escalate into a disaster.

49. Answer: **B**. According to *Assurance Technologies, Inc.* the mean error rate is found by summing individually the errors and instructions and dividing the sum of the errors by the sum of the instructions (**Table 43**).

Table 43 Errors per 100 Object Instructions

Errors per 100 Object Instructions	Instructions
0.734	100
0.591	100
0.382	100
0.325	100
Total = 2.032	Total = 400

2.032 errors/400 instructions ≈ 1 error per 200 instructions

50. Answer: **B**. Selection "B" would provide the best synthesis of information.

51. Answer: **A**. Assuming that the table "Health Hazards" would include MSDS information and workplace exposure monitoring, it would be the most useful addition to the existing relational database.

52. Answer: **D**. OSHA 1910.1001(f)(1)(x) states, "Flooring. Sanding of asbestos-containing flooring material is prohibited."

53. Answer: **A**.

$$M_E = \left(D + \frac{1}{2}L\right)(W)$$

$$M_E = (8 + 5) \times 15$$

$$M_E = 13 \times 15$$

$$M_E = 195$$

54. Answer: **C**. PETN (pronounced "pettin") is pentaerythritol tetranitrate and is a secondary high explosive, which is frequently used in the fabric-wrapped cord called primacord. TNT is trinitrotoluene a very high primary explosive. RDX is cyclonite, which is a powerful secondary high explosive. All of these explosives require magazines for extended storage. Ammonium nitrate normally does not require such precautions. However, if it has been mixed, then more strident requirements may have to be met. For example, the mixture of 80 parts of ammonium nitrate and 20 parts of TNT creates the mixture *amatol,* which has been used very successfully by both the military and the mining industry as a primary explosive.

55. Answer: **B**. Contingency means that one thing depends upon other things, and for organizations to be effective, there must be a "goodness of fit" between their structure and the conditions in their external environment. What works in one setting may not work in another. There is no one best way. The correct management approach is contingent upon the organization's situation.

56. Answer: **B**.

Cost = $25,000

Benefit = .025 – .011 = .014, a reduction of.014 fatalities.

Cost to Benefit = 25000:0.014 or 1,786,000:1 $\frac{25000}{0.014} = 1{,}785{,}714$

57. Answer: **C**. The biggest hazard from modern X-ray equipment is high voltage.

58. Answer: **C**. Welder's flash produces ultraviolet and infrared energy sources; however, the most common injuries comes from damage to the cornea from ultraviolet rays. Infrared would pass through the cornea and cause damage to the retina.

59. Answer: **B**. As a general rule, dust must be smaller than 5 microns to reach the inner recesses of the lungs. Larger particles are trapped in the nasal passages, throat, larynx, trachea, and bronchi. They are then swallowed or expectorated. *Very small particles on the order of .1 to 1 micron are lodged in the alveoli.*

60. Answer: **B**. The single most important factor influencing the amount of damage caused by an electrical contact accident is the resistance of the body at the time of contact.

61. Answer: **C**.

Step 1: Determine volume.

$$\frac{20 \text{ ft}}{1} \times \frac{.305 \text{ m}}{1 \text{ ft}} = 6.1 \text{ m}$$

$$\frac{10 \text{ ft}}{1} \times \frac{.305 \text{ m}}{1 \text{ ft}} = 3.05 \text{ m}$$

$$6.1 \times 6.1 \times 3.05 = 113.5 \text{ m}^3$$

Remember: The beaker that broke was only one-half gallon.

Step 2: Determine weight.

$$8.34 \text{ lbs/gal} \times 0.6 = 5 \text{ lbs/gal}$$

Step 3: Convert lbs to mg.

$$\frac{2.5 \text{ lb}}{1} \times \frac{.4545 \text{ kg}}{1 \text{ lb}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1000 \text{ mg}}{1 \text{ g}}$$

$$= 1{,}136{,}250$$

$$= 1.14 \times 10^6 \text{ mg}$$

Step 4: Compute ppm.

$$\text{ppm} = \frac{\text{mg/m}^3 \times 24.45}{\text{MW}}$$

$$\text{ppm} = \frac{(1.14 \times 10^6/113.5) \times 24.45}{78}$$

$$\text{ppm} = 3138$$

62. Answer: **C**. All of the processes listed are used in air cleaning of gases and vapors. However, the method cited is that of *combustion*. Oxidation is a key word here. Combustion is a process used for removal of gas or vapor if it can be "oxidized" to a harmless or odor-free state. Many times, this takes the form of a direct-flame afterburner. Catalysts are also used to great effect in paint disposal, animal fats, plastics, etc. *Condensation* is the process of lowering the temperature of the incoming air to change the vapor to a liquid state. The process uses various chillers, condensers, or refrigeration units to lower the temperature of the vapor. *Adsorption* involves an action that takes place at the surface of the adsorbent material where gas and solid make contact. The most widely used adsorbent for cleaning air is activated carbon, which most often is placed in canisters, perforated cans, or trays. Activated carbon has the ability to adsorb gases and vapors up to about 60% of its own weight. If the carbon is then heated, the captured material can then be reclaimed, making it an attractive and cost-effective process. *Absorption* is the process of using a liquid that dissolves or chemically reacts with the gas or vapor that is to be removed.

63. Answer: **B**.

$$\text{TLV}_m = \frac{C_1}{\text{TLV}_1} + \frac{C_2}{\text{TLV}_2} + \cdots + \frac{C_n}{\text{TLV}_n}$$

Where:

TLV_{mix} = Threshold Limit Value for a mixture of airborne chemicals with additive effects. If the sum is greater than one (1), then an overexposure exists.

C_1 = the measured airborne concentrations of the chemicals.

TLV_1 = published Threshold Limit Value for the respective chemicals.

When two or more hazardous chemicals with similar toxic effects are present in the environment, the combined effect should be evaluated rather than the individual effect. NOTE: The units can be either mg/m^3 or ppm but must be consistent in the equation.

$$\frac{50}{100} \times \frac{5.5}{8} = 0.3438$$

$$\frac{400}{400} \times \frac{2}{8} = 0.25$$

$$\frac{100}{200} \times \frac{8}{8} = 0.5$$

$$109\%$$

64. Answer: **B**.

$$I_2 = I_1 \times \frac{(d_1)^2}{(d_2)^2}$$

$$I_2 = 70 \times \frac{(1)^2}{(6)^2}$$

$$I_2 = 70 \times \frac{1}{36}$$

$$I_2 = 1.94$$

65. Answer: **B**.

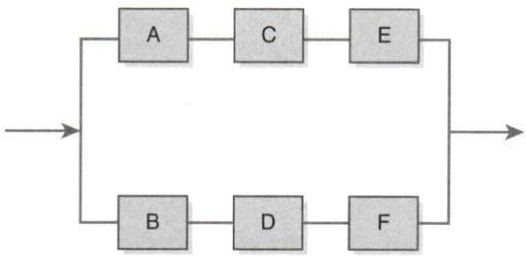


Figure 48 Cut Sets Example 1

A cut set is defined as the point or points at which the system can be cut to ensure nonoperation. The system shown in **Figure 48** has two paths A-C-E or B-D-F. Either of these paths will allow operation—so you must cut both of these paths to prevent operation. By inspection we can see that some possible cut sets for this system are:

(A,B,C,D) – (A,D) – (A,D,F) – (B,C,D,E), etc.

Answer "B," cutting A, C, and E, would still allow the system to operate through the B, D, F path.

66. Answer: **B**. Minimum cut sets must not include any other cut set and still prevent the system from operating. Answer "B" would **cut** system operation and does not contain any other cut sets. Cut sets are used to estimate the probability of system failure. The minimum cut sets establish an upper boundary for estimating the probability of at least one of the cut sets entering a fault state that causes system failure.

67. Answer: **D**.

Table 44 Failure Probability for Each Component in System Diagram

Components	Failure Probability
A	10^{-4}
B	10^{-3}
C	10^{-5}
D	10^{-5}
E	10^{-3}
F	10^{-4}

Using the rare event approximation, the TOP event probability is the sum of the cut set probabilities (**Table 44** and **Figure 48**).

$$P_{AB} = (1 \times 10^{-4}) \times (1 \times 10^{-3}) = 1 \times 10^{-7}$$
$$P_{CD} = (1 \times 10^{-5}) \times (1 \times 10^{-5}) = 1 \times 10^{-10}$$
$$P_{EF} = (1 \times 10^{-3}) \times (1 \times 10^{-4}) = 1 \times 10^{-7}$$
$$P_{AB} + P_{CD} + P_{EF} = 1 \times 10^{-7} + 1 \times 10^{-10} + 1 \times 10^{-7} = 2.001 \times 10^{-7}$$

68. Answer: **A**.

Step 1: Determine volume.

$$\frac{15{,}000 \text{ ft}^3}{1} \times \frac{1 \text{ m}^3}{(3.28 \text{ ft} \times 3.28 \text{ ft} \times 3.28 \text{ ft})} = 425 \text{ m}^3$$

Step 2: Determine desired ppm using a safety factor of 10.

$$\frac{1.2\% \times 1{,}000{,}000}{10} = 1200 \text{ ppm}$$

Step 3: Compute mg/m^3 from standardized formula.

$$\text{ppm} = \frac{mg/m^3 \times 24.45}{MW}$$

$$mg/m^3 = \frac{MW \times \text{ppm}}{24.45}$$

$$mg/m^3 = \frac{92 \times 1200}{24.45} = 4515$$

Step 4: Multiply by m^3 (area) to obtain total weight.

$$4515 \text{ mg} \times 425 \text{ m}^3 = 1{,}919{,}018 \text{ mg}$$

Step 5: Convert mg to lbs.

$$\frac{1{,}919{,}018 \text{ mg}}{1} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ lb}}{454 \text{ g}} = 4.22 \text{ lb}$$

Alternate solution using ratio and proportion.

*Note: Dilution questions such as this can often be reduced to simple terms and solved with ratio and proportion. This has the real advantage of not letting yourself get lost in the formulas.

Step 1: How much contaminant is required to reach the concentration.

$$\left(\frac{1.2\%}{10}\right) \times 15{,}000 \text{ ft}^3 = 18 \text{ ft}^3$$

Step 2: How much weight will produce 18 ft^3 of vapor. Remember that 1 lb-mole of a gas occupies 392 ft^3.

$$\frac{92 \text{ lb}}{392 \text{ ft}^3} = \frac{X \text{ lbs}}{18 \text{ ft}^3}$$

$$X = \frac{18 \times 92}{392}$$

$$X = 4.22 \text{ lbs}$$

69. Answer: **D**. The ASME (American Society of Mechanical Engineers) provides agency regulation of pressure vessels in the United States.

70. Answer: **A**. NFPA 10 is the Standard for Portable Fire Extinguishers. When selecting a portable fire extinguisher for flammable liquids, the highest priority is the use of pressurized water and carbon dioxide extinguishers.

71. Answer: **A**. Consideration involves the transfer of something of value, which can be money or other items on which a value can be placed by competent authority.

72. Answer: **C**. According to *Fundamentals of Industrial Hygiene*, in this case the sampling device is nearing its sampling and measurement limits, and its measurements are suspect. Even though the device has detected the contaminant, performing any reliable statistical analysis on these readings is not possible. The only real conclusion that can be drawn is that there is a presence of the contaminant at or below the detection limit of the sampling device.

73. Answer: **A**. OSHA 1926.56 requires 5 foot-candles for general construction work areas. The table below may offer some assistance. Remember the table is for **Minimum Illumination for Safety of Personnel.** For areas or operations not covered in the table, or for illumination levels for efficient visual performance rather than for safety alone refer to ANSI/IES RP7-1983, see "Practices for Industrial Lighting," for recommended values. From **Table 45**, general construction area lighting should be a minimum of 5 foot-candles.

Table 45 Minimum Illumination for Safety of Personnel

Foot-candles	Area of Operation
5	General construction; concrete placement, excavation and waste areas, accessways, active storage areas, loading platforms, refueling, and field maintenance areas
5	Indoors: warehouses, corridors, hallways, and exitways
5	Tunnels, shafts, and general underground work areas
10	General construction plant and shops (batch plants, screening plants, mechanical and electric equipment rooms, carpenter shops, rigging lofts and active storerooms, barracks, toilets
10	Underground operations involving work at a heading involving drilling, mucking, and scaling
30	First-aid, stations, infirmaries, and offices

74. Answer: **D**. The management skill of the safety professional must ensure the highest level of safety possible along with meeting the other company goals. This can often lead to areas of conflict within an organization that will test the management skills of the safety professional.

    During the decision-making process for a major or operational change, the safety professional should recommend to line management the results of a change analysis that impacts the proposed change. A formal change analysis is essential when any kind of significant change is proposed. Change analysis is a form of risk assessment and a standard HAZOP, what-if checklist or a custom approach may be used.

75. Answer: **C**. A vertical standard applies to a single industry. A specification standard demands precise compliance with exacting codes, frequently detailing exact specifications for materials, sizes, etc. A performance standard tells us that we must comply and leaves the details up to the industry.

76. Answer: **C**. Several industries have made drastic improvements in their accident experience. Included in this group are aviation, pressure vessels, and elevators.

77. Answer: **B**.

    Step 1: Determine VP.

$$TP = SP + VP$$
$$VP = TP - SP$$
$$VP = -1 - (-4)$$
$$VP = 3$$

    Step 2: Determine velocity.

$$V = 4005\sqrt{VP}$$
$$V = 4005\sqrt{3}$$
$$V = 4005 \times 1.73$$
$$V = 6937 \text{ fpm}$$

78. Answer: **B**. Deductive analysis involves reasoning from the general to the specific. Of the choices listed, only fault tree analysis involves this technique.

79. Answer: **B**. For components in parallel, the total failure rate is the product of the individual components' failure rate. $0.005 \times 0.005 \times 0.005 \times 0.005 = 0.005^4$ or 6.25×10^{-10}.

80. Answer: **A**. Selection A "Filters + Impingers and Visible Absorption Spectrometry" is the only possible method for formaldehyde and is the most sensitive formaldehyde method in the NIOSH Manual of Analytical Methods. It is able to measure ceiling levels in the 0.1-ppm range and is best suited for area samples.

81. Answer: **C**. Hantavirus pulmonary syndrome is a very serious, often deadly, disease spread from wild rodents (the deer mouse is a primary carrier) to people. The virus is found in rodent urine, saliva, and feces and gets in the air as mist from urine and saliva or dust from feces. Breathing the virus is the most common way of becoming infected; however, you can also become infected by touching the mouth or nose after handling contaminated material or from a rodent's bite. It is not spread from person to person. The first symptoms are flu-like, but the primary symptom is difficulty in breathing, which is caused by fluid buildup in the lungs and quickly progresses to an inability to breathe. The virus can be killed by most household disinfectants, such as bleach or alcohol.

82. Answer: **D**. In the transfer of energy from one part of the nerve to the next part, the chemical acetylcholine is essential, and the enzyme cholinesterase sees to it that the level of acetylcholine is maintained at the proper levels. As soon as that enzyme is inhibited, then the acetylcholine level starts increasing and reaches the level where it is incompatible with the transfer of nervous energy and the nervous system undergoes a collapse and fails to work. The triggers do not fire the way they should. Some cholinesterase inhibitors include organic phosphates and organophosphate pesticides, such as parathion or carbamate pesticides, such as carbofuran.

83. Answer: **D**. The subject of risk acceptance by the world population is an *extremely* complex subject. People accept risk for various social and economic reasons. People will generally accept a voluntary risk and reject the same involuntary risk. It has been estimated that the public will accept a natural disaster 100 times quicker than the same disaster caused by human error. Factors that influence people to lower their perceptions of risk include their understanding of whether the exposure is mandatory.

84. Answer: **C**. OSHA 1926.651 (c)(2) states that ladders used for egress from a trench shall be located to "require no more than 25 feet of lateral travel for employees."

85. Answer: **A**. According to the *System Safety Analysis Handbook,* 2nd edition, by the System Safety Society. This defines a system safety program plan. This plan also helps define the system safety program milestones and provides the program with a time schedule for the various tasks.

86. Answer: **C**. Hold harmless clauses in contracts between employers and manufactures are common but rarely enforceable. In the standard clause, the employer agrees to hold the manufacture or producer harmless in the event of a third-party lawsuit. In practice, the court rarely upholds the clause unless both parties are knowledgeable and are posturing from an equal position of strength. In which case neither party needs hold harmless clauses.

87. Answer: **C**. According to the NSC *Accident Prevention Manual for Business and Industry: Administration and Programs,* 12th edition, a committee is not successful unless it seeks to ensure that its existence is making a difference. A committee should have established goals and should measure itself against these goals periodically.

88. Answer: **D**. According to *Developing Safety Training Programs,* the basic question is: Is this a training issue? The other questions are secondary.

89. Answer: **A**. Largely as a result of the change from privity of contract to strict liability in tort, the marketplace has become a place where the seller must beware *(caveat venditor)*. Manufacturers are strictly liable for any damage or injury caused by their products, even if they took all possible care in developing and marketing of these products. Sometimes called "absolute seller liability."

90. Answer: **D**. Answer "A" and "C" refer to the principle of fault tree reduction; that is, the fault tree is reduced to minimum cut sets. The principle of equivalence is correctly expressed in selection "D." Fault trees drawn by different safety practitioners will frequently look different; however, they will have the same minimum cut sets, thereby rendering the same results.

91. Answer: **B**. A spreadsheet is a computer program that enables you to develop and perform all sorts of calculations between the text and values stored in the document. Most spreadsheets include charting and limited database capabilities. If you need a system to let your safety managers at multiple locations interact directly with each other by computer, the recommended system is the WebEx interactive Internet conferencing tool by WebEx Communications, Inc. It permits real-time conferencing and the real-time visual exchange and collaboration with digital information.

92. Answer: **C**. HTTP is short for ***H**yper **T**ext **T**ransfer **P**rotocol*, the underlying protocol used by the World Wide Web.

    FTP is short for ***F**ile **T**ransfer **P**rotocol,* the protocol used on the Internet for sending files.

    HTML is short for ***H**yper**T**ext **M**arkup **L**anguage,* the authoring language used to create documents on the World Wide Web. HTML is similar to SGML, although it is not a strict subset. Other languages that are sometimes used are Visual Basic or JAVA.

    ISP is short for ***I**nternet **S**ervice **P**rovider,* a company that provides access to the Internet to the user's personal computer.

93. Answer: **B**. According to *The Behavior-Based Safety Process*, a change in behavior does lead to a change in attitude.

94. Answer **C**. According to *Developing Safety Training Programs,* a learning objective must identify what the student will be able to do at the end of the training program.

95. Answer: **C**. OSHA states, "Chemical manufacturers, importers and employers evaluating chemicals shall treat the following sources as establishing that a chemical is a carcinogen or potential carcinogen for hazard communication purposes:

    National Toxicology Program (NTP), "Annual Report on Carcinogens" (latest edition); International Agency for Research on Cancer (IARC) "Monographs" (latest edition)

29 CFR part 1910, subpart Z, Toxic and Hazardous Substances"

*Note: The "Registry of Toxic Effects of Chemical Substances" published by the National Institute for Occupational Safety and Health (NIOSH) indicates whether a chemical has been found by NTP or IARC to be a potential carcinogen.

The IARC provides a summary classification of a chemical's carcinogenic risk according to the following table:

Group 1 The agent is carcinogenic to humans

Group 2A The agent is probably carcinogenic to humans

Group 2B The agent is possibly carcinogenic to humans

Group 3 The agent is not classifiable as to its carcinogenicity to humans

Group 4 The agent is probably not carcinogenic to humans

All IARC listed chemicals in Groups 1 and 2A must include appropriate entries on both the MSDSs and on the label. Group 2B chemicals need be noted only on the MSDSs. The use of in vitro (short term) testing (such as the Ames assay) has not been specifically addressed in the Hazard Communication Standard. However, it is the consensus within OSHA that the results of an "in vitro" test alone do not represent significant enough information to establish a health hazard for purposes of the hazard communication standard.

96. Answer: **D**. According to *Developing Safety Training Programs*, regardless of the available technology, a needs analysis must be conducted first. Once the decision to train is made, methods then can be considered.

97. Answer: **D**. Well-developed multiple-choice items on knowledge assessment instruments (tests) permit the most objective pass/fail decisions to be made and the most reliable performance statistics to be calculated. The other item types require varying degrees of subjectivity and are more difficult to calculate reliability statistics.

98. Answer: **C**. There a generally four purposes of warning labels:

- To inform the users of a hazard or danger of which they may not be aware, which is inherent in the use or reasonably foreseeable misuse of the product
- To provide users with information regarding the likelihood or severity of injury from the use or reasonably foreseeable misuse of the product (i.e., inform the user of the proper way to use the product)
- To remind users of a danger at the time and place where the danger is most likely to be encountered
- To inform users or potential users how to reduce the likelihood and or severity of injury
- Although there are many legal reasons for providing adequate warning labels on products, advice on legal recourse is not at the present time one of them. According to CPSC, a private labeler must include the identification of the private labeler, the identification of the manufacturer, and a statement of compliance of the product with all applicable standards. Legally, the burden is upon the manufacturer to provide the warning.

99. Answer: **A**. There are three traditional levels of warnings:

Danger is used where there is an immediate hazard, which, if encountered, will result in severe personal injury or death.

Warning is the signal word for hazards or unsafe practices, which could result in severe personal injury or death.

Caution is for hazards or unsafe practices, which could usually result in minor personal injury, product damage, or property damage.

100. Answer: **A**. The purpose of the Delphi technique is to elicit information and judgments from participants to facilitate problem-solving, planning, and decision-making. It does so without physically assembling the contributors and keeps their identity confidential. Instead, information is exchanged via mail, FAX, or e-mail. This technique is designed to take advantage of participants' creativity as well as the facilitating effects of group involvement and interaction. It is structured to capitalize on the merits of group problem-solving and minimize the liabilities of group problem-solving. It uses prepared questionnaires that require short answers and requires numerous iterations to complete the process.

References

Many of these publications can be ordered online via websites such as asse.org; nsc.org; Amazon.com; Barnesandnoble.com; etc. By comparison price shopping, some good deals on these books may be found.

The purpose of our self-study workbook is to give study effort direction. This workbook effectively narrows down the enormous amount of test material that must be mastered. Knowing what to study is not enough. Candidates must also study the **right** material, specifically, the right reference material. Finding the right books from which to study is probably the most important single element in developing a personal study plan. It is imperative to take some time and do it correctly.

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