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ABSTRACT

Developed by workers, trainers, and professionals in the field, this guide contains a proposed national standard for hazardous materials management technology. The guide first discusses the need for and the development of skills standards, then introduces the hazardous materials management technology standard and the four subgroups of occupations in this category. The skills standard is divided into 13 job functions. The job functions serve as headings for general statements of occupational requirements, skills, and knowledge. Within each job function are supporting skills and knowledge that a hazardous materials management technology worker must possess to be able to accomplish the job function successfully. Immediately following the job functions is a more detailed breakdown of the supporting knowledge and skills related to the disciplines of mathematics chemistry, toxicology, physics, and computer technology. Following these related academic skills are statements regarding the application of the SCANS (Secretary's Commission on Achieving Necessary Skills) report to hazardous materials management technology and the relationship of the quality movement to the skills demanded of hazardous materials management technology. The final section of the standard gives guidance to curriculum developers for converting the defined skills into educational curricula. (KC)

NATIONAL VOLUNTARY SKILLS STANDARD

HAZARDOUS MATERIALS MANAGEMENT TECHNOLOGY

CENTER FOR OCCUPATIONAL RESEARCH & DEVELOPMENT

NATIONAL VOLUNTARY SKILLS STANDARD

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Project team members who have given guidance and direction through the entire project include: Robert Bear, P.E., Facilities and Environmental Consultants; Doug Feil, Hazardous Materials Research and Training Institute; and Jean Drevdahl, R.N., C.I.H., C.H.H.M.; and Jerry Riehl, Ph.D. who have served as Third-party Evaluators.

A coalition of experts in environmental technology has donated hundreds of hours to the project, shaping technical aspects of this standard. Their names and affiliations are given in the appendix.

The involvement of the following professional societies has made this standard known and recognized throughout their memberships. With their assistance, literally thousands of professionals have assisted with the development of the information provided in this standard. They are: Hazardous Materials Control Resources Institute (HMCRI), National Association of Environmental Professionals (NAEP), National Environmental Health Association (NEHA), National Environmental Training Association (NETA), and Partnership for Environmental Technology Education (PETE).

The significant contribution of all these individuals and organizations is hereby acknowledged and greatly appreciated.

James R. Johnson
Project Director

PREFACE

During the past decade, we have witnessed a phenomenal growth in the concern for the environment. This growth, as a result of ever-increasing federal, state, and local regulations and restrictions, has led to the development of numerous employment opportunities. For the most part, the employment opportunities have been filled by workers who have—for lack of a better phrase—grown up with the industry. These environmental workers obtained most of their skills through workshops and courses offered in response to regulations. Because the regulations were generalized for all industries, most training was also general and did not vary to meet the needs of local regions or industries. In addition, the majority of the workshops and compliance-based courses were not competency based. However, in recent years, the regulations and procedures have become more standardized and routine and concern for the minimization of costs in a competitive marketplace has increased. Thus, many of the responsibilities undertaken by professional- to technician-level personnel have required the individuals to have specific education, training and skills. This has caused the federal government to recognize the need for the development of measurable skill standards, i.e. nationally based norms, for these individuals.

The United States remains the only major industrialized nation without standards to define the skills required for industrial occupations. With few exceptions, our schools have been preparing people for vocations with only vague job descriptions to guide them. Schools can only guess at the demands of a particular occupation. For the most part, schools have been assisted in this guessing game by a small number of local industrial representatives. This has limited the effectiveness of programs designed to meet the needs of industry. It is little wonder that schools are criticized for producing students who cannot function productively in entry-level positions without long periods of on-the-job training. Additionally, as industry's need for qualified, knowledgeable technicians has increased during the past decade, the opportunities for schools to develop such programs have also increased.

The current federal administration's educational initiative is designed to address this and other educational problems. A multifaceted program and document called *Goals 2000: Educate America* have a top priority the development of skill standards for certain key occupations. This document represents the initial version of one of these standards: Hazardous Materials Management Technology.

A SKILLS STANDARD AND ITS DEVELOPMENT PROCESS

Skills Standard

A skills standard is defined as the knowledge, skills, attitudes, and level of ability needed to successfully function in an occupation. Currently, twenty-two different occupational skills standards-development projects are in process. In addition, projects are underway that will eventually identify and standardize foundational skills needed for all occupations. These skills are identified in the Secretary's Commission on Achieving Necessary Skills (SCANS) report relating to technical and interpersonal skills. Since occupational skills standards are a new concept in this country, there is no uniform developmental process for them.

The advantages of having skills standards include the following:

1. Employees will have a defined list of what skills are needed to be successful in the occupation.
2. Training providers will be able to be held more accountable, since a clear set of performance expectations will be outlined.
3. Skills standards will make United States businesses more competitive in the global marketplace, since workers will have knowledge of the tasks involved and the skills required to perform these tasks successfully.
4. Educational institutions and curriculum developers will have a clearly defined target established by industry.
5. More emphasis will be placed on job-related skills, and less on earning a baccalaureate degree.

Development Process

Guidelines for development of skills standards are generally accepted to be as follows:

1. Skills standards must be voluntary.
2. Standards must be industry based.
3. The occupation must be explored and defined in detail.
4. A coalition consisting of representatives from industry, business, and education must lead the development and validate the final result.
5. A list of tasks and associated skills must be disseminated, discussed, debated, and modified by experts in the field until a consensus is reached and the list is recognized as a Standard.

The professional staff at the Center for Occupational Research and Development (CORD) served as the working staff for a project to develop a skills standard for technicians who handle hazardous materials and hazardous waste. The CORD staff was directed by James Johnson, Project Director, who assembled a Project Team of independent consultants to assist in the development of the skills standard. The consultants provided the CORD staff with technical and evaluatory assistance throughout the program and served as integral members of the Project Team.

Members of the Project Team, including the consultants, presented focus-group meetings throughout the United States and attended advisory committee meetings. They also made presentations at several educational association meetings and hosted a dissemination workshop for two-year college educators.

In the development of the skills standards a national advisory committee was assembled to guide the project. The committee, consisting of 51 members (including representatives of various regulatory agencies), provided several different viewpoints. The composition of the advisory committee is shown in Table 1.

HMMT Advisory Committee	
Industry	13
Consultant/Remediation	8
Municipal	2
Unions	3
Societies	6
Government	3
Military	3
Colleges (two- and four-year)	13

Table 1

Selected members of the advisory committee served on two subcommittees: one of them responsible for evaluating the certification requirements for Hazardous Materials Management Technician (HMMT) and the other for developing occupational titles.

Quality Assurance

A focused effort was made by the Project Team to validate the skills standard that was developed. These efforts included conducting meetings of professionals and people involved in education and industry at several locations throughout the United States. Focus-group meetings were held in different regions of the United States because it was recognized from the outset that the various regions have different employment trends that emphasize occupational needs. Additionally, as can be seen from the makeup of the National Advisory Committee, the Project Team assembled representatives from several types of industries, government and regulatory bodies, and educational institutions. The advisory committee gave oversight and guidance to the project. To further validate the Standard, a needs-assessment survey was widely disseminated throughout the membership of the following professional societies:

- Hazardous Materials Control Resources Institute
- National Environmental Health Association
- National Association of Environmental Professionals
- National Environmental Training Association.

The administration and membership (including students) of the Partnership for Environmental Technology Education (PETE) have assisted with the data-gathering and evaluation process.

An evaluation team consisting of Jerry Riehl and Jean Drevdahl reviewed and evaluated the project's progress toward accomplishing the stated goals. Reports of their evaluations along with recommended "mid-course" corrections were provided to the Department of Education and the Project Team every six months.

HAZARDOUS MATERIALS MANAGEMENT TECHNOLOGY

Environmental technology encompasses several important groups of occupations. Water and Waste Water Technology is one example; Hazardous Materials Management Technology is another.

However, within the field of hazardous materials management technology there are also different occupations, each requiring a different group of skills. In some environmental occupations, a Hazardous Materials Management Technician (HMMT) needs only a limited set of hazardous materials management skills while in other occupations a much more rigorous set of skills is required. Indeed, some occupations may even require that an HMMT obtain specialized skills in related occupational areas such as safety and health, management, regulations, laboratory operations, remediation, and so on. This concept is illustrated in Figure 1, which begins by showing that all technicians need foundational skills related to communications, mathematics, science, logical reasoning, and interpersonal relations.

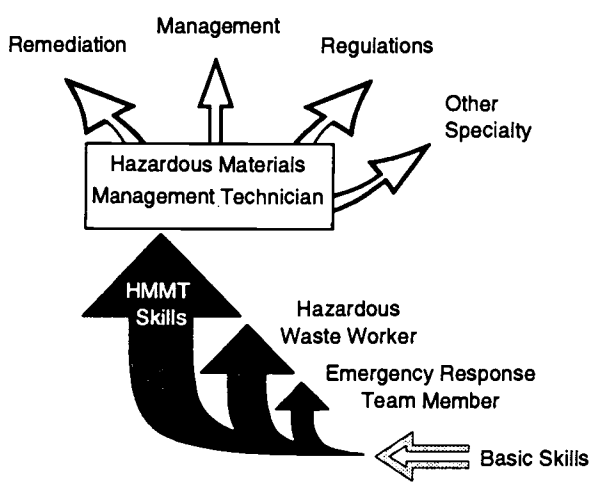

Figure 1

As occupational skills are acquired, a person may be employable in some hazardous materials management occupations (i.e., Hazardous Waste Worker) even though that person does not have all the skills required of an HMMT.

This project defines areas of specialization of HMMTs. The tasks performed by HMMTs can span a range of activities. To provide some parameters, the Advisory Committee *arbitrarily* grouped the activities of an HMMT into the following four subsections:

1. **Laboratory/Analytical Technician (LAT):** The primary area of specialty and focus for this individual is the analysis and testing of chemical compounds in a laboratory setting. The tasks this person may be required to accomplish range from the initial preparation of samples for analytical testing to the operation of complex and highly sensitive instrumentation.

2. **Compliance/Regulations Technician (CRT):** This individual's primary area of specialty and focus is interpreting and implementing regulations, and ensuring industry compliance with the same regulations. The tasks this person may be asked to accomplish range from inspection to enforcement, to suggestions of statements to meet changing or new regulations.

3. **Field Operations/Remediation Technician (FORT):** The FORT's primary area of specialty and focus is the practical aspects of working with mixed hazards and materials in the field. The tasks this person may be asked to accomplish

range from the collection of samples, data, and information to the implementation of remedial and corrective actions.

4. **Transportation/Storage/Disposal Technician (TSDT):**
This individual's primary area of specialty and focus is the methods and techniques for safe, effective, and efficient treatment, storage, and disposal of mixed materials and wastes. The tasks this person may be asked to accomplish range from the handling and transportation of hazardous materials and wastes to the implementation of effective treatment and disposal methods.

As previously stated, the tasks performed by an HMMT can span a wide range of activities. The above groupings have been arbitrarily created in an effort to provide some parameters for this assessment. Based on our experience in the field, we recognize that finely dividing the tasks into one category or another is impractical. HMMTs are called upon by their employers to be multifaceted, and there is no such thing as a typical day in the life of any of the above-stated groupings of individuals.

INTRODUCTION TO THE STANDARD

For the sake of clarity and organization, we have divided the Skills Standard into thirteen job functions. The job functions, as found on the following pages, are not listed in order of importance. They serve as headings for general statements of occupational requirements, skills, and knowledge. Within each job function are supporting skills and knowledge that an HMMT must possess to be able to accomplish the job function successfully. It should be noted that a supporting item may apply to more than one job function. However, the items are listed within that job function where they appear to be a primary skill. These job functions and the supporting knowledge and skills are considered to be the "occupational" portion of the standard.

Because of wide variation in the skills needed by different occupational groups within this technology, the Project Team did not include statements related to specific laws, rules, and regulations. Instead, the Skills Standard reflects a broad-stroke approach in the application of laws, rules, and regulations. Additionally, you will note the use of the term "such as" throughout the Skills Standard. This term was used to provide limited examples. Wherever the term is used, it is assumed that the reader will understand that the items that follow are not to be considered an exclusive list, but only examples, of applicable skills, equipment, and so on.

Immediately following the job functions is a more detailed breakdown of the supporting knowledge and skills related to the disciplines of mathematics, chemistry, toxicology, physics, and computer technology. Following these related academic skills are statements regarding the application of the SCANS report to HMMT and the relationship of the Quality Movement to the skills demanded of HMMTs. The final section of this Standard gives guidance to curriculum developers when they convert the defined skills into educational curricula.

JOB FUNCTION (A):
Evaluate hazardous materials and hazardous waste sample data.

Supporting knowledge/skills:

- Perform mathematical calculations following existing formulas and reference materials
- Read and interpret blueprints, charts, curves, graphs, maps, plans, and spreadsheets from plotted and tabulated data
- Collect, tabulate, and assist in the evaluation of data, using appropriate techniques and technology such as:
  - calculators
  - computers
  - databases
  - graphics
  - spreadsheets
- Check laboratory and/or field sample analyses by comparing to regulatory limits

JOB FUNCTION (B):
Safely handle hazardous materials and hazardous wastes.

Supporting knowledge/skills:

- Use chemical reference materials to obtain information on proper chemical handling
- Recognize, apply, and respond appropriately to chemical-hazard information
- Direct personnel in the proper handling and control of hazardous materials and hazardous wastes
- Identify and implement safe ergonomic controls and procedures
- Demonstrate safe handling procedures for chemical containers such as:
  - bulk containers
  - drums
  - portable and stationary tanks
- Identify and respond to emergencies, alarms, and abnormal situations in accordance with written procedures
- Identify and implement safe chemical-handling procedures such as:
  - bonding
  - fire control
  - grounding
  - storage
  - vapor control
  - ventilation
- Provide on-the-job training as required

JOB FUNCTION (C):
Respond to hazardous-materials and hazardous-waste emergency situations in accordance with regulatory requirements.

Supporting knowledge/skills:

- Perform as a team member on an emergency-response team
- Ensure that adequate spill-control equipment and supplies are available at all times
- Develop and implement an emergency-response program
- Demonstrate competency and maintain certification in first aid and Cardio-Pulmonary Resuscitation
- Follow guidelines for controlling leaks from containers
- Consider environmental consequences of emergency situations and respond appropriately

JOB FUNCTION (D):
Operate equipment related to hazardous materials and hazardous-waste operations.

Supporting knowledge/skills:

- Identify and describe the safe and proper use of equipment such as:
  - drum crushers
  - hand tools
  - heavy equipment
  - monitoring and sampling equipment and instrumentation
  - motorized lifting devices
  - power tools
  - pumps, valves, and meters
- Identify, describe, and use appropriate equipment-decontamination procedures
- Identify, describe, and use appropriate operations and maintenance procedures, plans, and manuals
- Identify, describe, and use appropriate health and safety equipment such as:
  - communication systems
  - eyewashes and safety showers
  - fire extinguishers, vehicles, and equipment
  - first aid

JOB FUNCTION (E):
Identify and label hazardous materials and hazardous waste in accordance with regulatory requirements.

Supporting knowledge/skills:

- Identify, characterize, and label hazardous materials by chemical and physical properties, such as:
  - color
  - corrosivity
  - density
  - flammability
  - reactivity
  - specific gravity
  - toxicity
  - viscosity
- Identify and characterize hazardous wastes according to regulatory standards such as:
  - acute toxicity
  - corrosivity
  - ignitability
  - reactivity
  - toxic characteristic leachate procedure (TCLP)
- Provide proper labeling for hazardous wastes
- Use chemical reference materials to obtain identification and labeling information
- Check for correct labels and Material Safety Data Sheets (MSDSs) when shipment is received
- Label containers of repackaged materials with appropriate warnings and expiration information
- Direct personnel in the proper identification and labeling of hazardous materials

JOB FUNCTION (F):
Calibrate, operate, and maintain instrumentation.

Supporting knowledge/skills:

- Operate, record, and evaluate meter- and gauge-reading trends and implement appropriate actions
- Perform routine maintenance of equipment and instrumentation
- Operate gauges, meters, and monitoring and sampling instrumentation
- Calibrate and operate field and laboratory instrumentation such as:
  - air-monitoring instrumentation
  - groundwater-monitoring instrumentation
  - soil-monitoring instrumentation
  - solid-waste-monitoring instrumentation
  - surface-water-monitoring instrumentation
- Identify the need for and comply with factory calibration
- Describe the difference between fluid and factory calibration and demonstrate their appropriate use

JOB FUNCTION (G):
Compile, record, and maintain required documents for hazardous-materials and hazardous-waste management activities.

Supporting knowledge/skills:

- Compile and maintain a hazardous-materials inventory
- Compile and maintain documentation of hazardous materials, such as:
  - chain of custody
  - equipment calibration and maintenance
  - exception reports
  - field notebooks
  - incident documentation
  - laboratory data
  - manifests
  - MSDSs
  - purchase orders
  - shipping documents
  - vendor invoices
- Compile and maintain records to prepare compliance reports
- Ensure current MSDSs are available in the workplace
- Operate and maintain auditable record-keeping systems in accordance with regulatory requirements
- Conduct and maintain a hazardous-waste inventory
- Communicate with suppliers to obtain product identification and labeling
- Identify and maintain an inventory of empty and full containers
- Compile and maintain personal health and safety records
- Read and interpret blueprints, flow diagrams, and schematics

JOB FUNCTION (H):
Implement procedures to comply with appropriate regulations.

Supporting knowledge/skills:

- Read and apply regulatory standards to ensure compliance in operations
- Obtain hazardous-materials and hazardous-waste permits and/or approvals
- Describe the regulatory process, from the introduction of a bill to the promulgation of a regulation
- Identify and describe the penalties for noncompliance
- Differentiate between federal, state, and local hazardous-materials and hazardous-waste regulations and identify appropriate regulatory agencies
- Identify regulatory changes and the impact they have on an operation
- Comply with federal, state, and local hazardous-materials regulations
- Conduct audits and inspections to ensure hazardous-waste management activities are in compliance with federal, state, and local regulations
- Follow written, company-standard operating procedures
- Comply with federal, state, and local health and safety regulations
- Identify sources of current or timely regulatory information

JOB FUNCTION (I):
Implement applicable safety regulations and procedures.

Supporting knowledge/skills:

- Demonstrate safe health and work habits
- Read and implement regulatory standards and guidance relative to worker safety and health such as:
  - blood-borne pathogens
  - confined space
  - emergency egress
  - fire safety
  - hearing conservation
  - lockout/tagout
- Identify and describe unsafe workplace and job conditions and implement corrective actions

JOB FUNCTION (J):
Select and use appropriate personal protective equipment and respiratory protection.

Supporting knowledge/skills:

- Use and interpret chemical reference materials in the selection of appropriate personal protective equipment (PPE) and respirators
- Communicate with suppliers and manufacturers to obtain personal protective and respiratory equipment information
- Identify, describe, and use PPE appropriate to the work conditions
- Identify and describe the elements of respiratory protection and PPE plans
- Identify, describe, and use respiratory protection appropriate to the work conditions
- Identify and describe hazards associated with the use and limitations of PPE and respiratory protection
- Maintain and inspect PPE and respiratory protection systems according to regulations

JOB FUNCTION (K):
Collect, prepare, document, and ship samples for analysis.

Supporting knowledge/skills:

- Perform and document sampling for hazardous-waste characterization purposes
- Perform field tests according to instructions and procedures
- Calibrate and operate, as required, field-test equipment such as:
  - air-monitoring equipment
  - bailers
  - hand augers
  - organic-vapor analyzers
  - pumps
  - radioactivity measuring equipment
  - split spoons
- In accordance with instructions and/or procedure, collect samples such as:
  - air and soil
  - bulk materials
  - groundwater
  - solid wastes
  - surface water
- Identify and demonstrate an ability to adjust procedures appropriately for potential sample interferences
- Decontaminate equipment in accordance with quality-control/quality-assurance procedures
- Identify and describe the appropriate use, limitations, and applications of sampling equipment such as:
  - colorimetric indicator
  - combustible-gas indicator
  - organic-vapor analyzer
- Perform personnel-exposure monitoring in accordance with appropriate standards such as:
  - noise monitoring
  - oxygen monitoring
  - radiation dosimetry
  - temperature extremes
  - threshold limit value—biological-exposure indices
- Prepare and ship samples to laboratory

JOB FUNCTION (L):
Transport and store hazardous materials and hazardous waste in accordance with applicable regulations.

Supporting knowledge/skills:

- Monitor documentation related to the shipment of hazardous materials and hazardous wastes
- Identify incompatible combinations of chemicals that could result in dangerous situations
- Label containers with appropriate identification and expiration information
- Safely package, load, document, and ship hazardous materials and hazardous wastes in compliance with appropriate regulations
- Inspect hazardous-waste storage areas for compliance with appropriate rules and regulations
- Properly segregate and store incompatible hazardous materials and hazardous wastes

JOB FUNCTION (M):
Operate hazardous-materials and hazardous-waste treatment and disposal systems.

Supporting knowledge/skills:

- Record and maintain documentation of operations activities
- Follow appropriate plans such as:
  - assessment plan
  - health and safety plan
  - initial sampling plan
  - remediation plan
  - risk-assessment plan
  - site-closure plan
  - standard operating procedures
  - waste-minimization plan
- Assist and contribute to the development and revision of plans and reports such as:
  - assessment plan
  - health and safety plan
  - initial sampling plan
  - remediation plan
  - risk-assessment plan
  - site-closure plan
  - standard operating procedures
  - waste-minimization plan
- Prepare and maintain hazardous-waste manifests and associated documents for inspection
- Select appropriate drums and containers
- Implement good housekeeping practices in the workplace
- Check and document activities of hazardous-waste treatment and disposal contractors
- Working individually or with others, develop improvements in the reduction, reuse, recycling, or disposal of waste streams
- Coordinate collection and disposal of empty containers
- Prepare accumulated hazardous waste for proper disposal
- Identify and describe treatment, removal, and disposal systems such as:
  - bio-remediation
  - chemical and physical
  - deep-well injection
  - incineration
  - vitrification
  - volatile organic compounds
- Identify and describe hazards associated with abatement of materials such as:
  - asbestos
  - fiberglass
  - lead
- Identify and describe hazards associated with treatment, removal, and disposal systems and operations
- Provide on-the-job training as required

RELATED ACADEMIC SKILLS

Mathematics

An HMMT requires a strong background in mathematics for two very important reasons. First, mathematics helps develop problem-solving skills and reasoning abilities that are required in every phase of a technician's occupational responsibilities. Second, specific mathematical skills are used as tools to solve specific job-related problems.

To develop problem-solving skills and reasoning abilities, an HMMT shall have completed with a secondary-level mathematics curriculum, including algebra and geometry, that adheres to the standards established by the National Council of Teachers of Mathematics (NCTM).

To summarize the specifics given in the NCTM Standards, an HMMT shall possess the following skills related to mathematical operations:

- Use a calculator to solve problems that have more than one step and involve fractions, decimals, and percents.
- Estimate answers to problems that involve several steps.
- Convert measurements for length, area, volume, capacity, and weight from English to metric units (and vice versa).
- Read, interpolate, and extrapolate data from tables and graphs.
- Calculate the perimeter, circumference, area, volume, and surface area of various two- and three-dimensional objects such as circles, rectangles, triangles, spheres, cylinders, rectangular solids, and cones.
- Read, interpret, and compare ratios.
- Solve problems related to proportions and concentrations using a variety of units including parts per million (PPM) and parts per billion (PPB).
- Read and use scale drawings to determine directions and distances on land maps.
- Read and write numbers in scientific notation and enter the values into a calculator to solve problems involving scientific notation.
- Translate a problem into an equation, then simplify and solve the equation.
- Read, write, and rearrange parts of an equation and solve for a given variable by substituting appropriate numerical values.
- Graph data as points on a coordinate system and determine the slope of a graphed line.
- Relate the slope of the line to gradients on topographic maps.
- Read and interpolate data from both linear and logarithmic graphs and scales.
- Distinguish between mean, mode, and median as measures of central tendency, and calculate these from a set of data.
- Draw a histogram to represent frequency distributions of data.
- Distinguish between range, trend, and standard deviation as measures of variability.
- Interpret the characteristics of a normal statistical bell curve.

Chemistry

Skills related to the science of chemistry are essential to an HMMT. These skills must be identified with practical field applications and not specifically oriented toward laboratory or research chemistry. An understanding of the interrelationship of chemistry and biological systems is important. The following list gives specific skills related to chemistry that an HMMT must possess. The list does not include basic definitions and underlying theories that may be necessary for competency in these skills.

- Read and understand MSDSs.
- Use chemical handbooks to determine the chemical and physical properties of elements and substances.
- Describe the differences between ideal and real gases and give illustrations of each difference.
- Show the relationship between pressure, volume, and temperature for ideal gases.
- Measure atmospheric pressure and distinguish between atmospheric and gauge pressure.
- Measure the mass and volume of solids and liquids, and calculate their densities.
- Calculate the density of a gas.
- Determine the melting point and the boiling point of substances by using chemical reference materials.
- Classify and give common examples of pure substances and homogeneous and heterogeneous mixtures.
- Define acids, bases, and salts in terms of their properties, reactivities, and corrosivities.
- Perform laboratory and field tests to determine the purity of a water sample.
- Describe the properties of solutions, and define solvents (including water) and solutes.
- Calculate molar, molal, weight percent, volume percent, and normal concentrations of solutions.
- Perform a titration to determine the concentration of an acid or base.
- Demonstrate the differences between inorganic and organic chemicals in terms of their densities and flammabilities.
- Use proper handling techniques for chemicals in general, and describe actions necessary in case of accidents.
- Demonstrate general laboratory safety practices and the use of safety equipment.
- Define toxicity, flammability, corrosivity, and reactivity.
- Identify the hazardous properties of common chemical elements in terms of their toxicity, flammability, corrosivity, or reactivity.
- Define pH and use common indicators and meters to determine the pH of soil, liquid, and dissolved gaseous materials.
- Describe alpha, beta, and gamma radiation in terms of their penetration through different materials and the effect such radiation has on body tissue.
- Demonstrate the transmutation of elements that takes place in alpha and beta decay.
- Define the half-life of radioactive species and measure the level of radiation with common instruments and dosimetry techniques.

Toxicology

The following skills relate to the body's reaction to exposure to hazardous materials and hazardous wastes.

- Conduct a hazard analysis on a product based on the toxicological properties listed on the MSDS and reference sources.
- Demonstrate and apply the concepts of toxicological hazards such as: target organ, Threshold Limit Values (TLV), Time-Weighted Average (TWA), Short-Term Exposure Limit (STEL), Ceiling (C).
- Describe possible signs and symptoms of adverse exposure to a particular compound based on the chemical composition.
- Follow appropriate first aid measures to minimize acute or chronic effects after exposure to a chemical.
- Describe the routes of exposure for chemicals to enter the body.
- List the common ways of describing the chemical toxicology, such as: dose, dose/response, LD_{50}, LC_{50}.
- Determine if an exposure poses an acute, chronic, or acute and chronic effect on an individual.
- Describe common types of chemical interactions, such as: additive, synergistic, potentiation, and antagonistic.
- Explain the procedure and results obtained from a TCLP toxicity text.
- Describe potential adverse effects of chemicals on the major target organs in the body: liver, lungs, kidney, skin.
- Consult with reference materials to determine the target organ of a chemical to properly protect against exposure.
- Apply information on an MSDS to safely respond to a spill. This could include: emergency response, personal protective equipment, spill-clean-up material.
- Describe the signs and symptoms of exposure to a chemical being used allowing you to determine if there has been an exposure due to failure of chemical protective clothing (CPC).
- Describe the function of the skin as a protective barrier and how damaged skin could lead to increased absorption of the chemical and local or systemic effects.
- Apply treatment procedures for chemical inhalation, ingestion, percutaneous absorption, or mucous-membrane contact with chemical if CPC fails.
- Demonstrate the use of appropriate measures to treat a person or equipment during an exposure incident.
- Describe the adverse reactions of chemicals that could affect the body and the procedure used to minimize exposure. Describe the proper treatment protocol if there is an exposure.

Physics

The ability to integrate and use different aspects of technology and to envision a "systems" approach to solving problems is very important for an HMMT. Therefore, competency in applying physics concepts to mechanical, thermal, electrical, and fluid systems must be demonstrated. Specifically, physics-related skills that must be performed or understood to fulfill the job functions of an HMMT are as follows:

- Describe what force, pressure, voltage, and temperature difference have in common, and predict what happens to an object when unbalanced forces act on it.
- Measure the mass and volume of an object and, from the results, calculate density and specific gravity.
- Measure atmospheric pressure and distinguish between absolute and gauge pressure.
- Determine the pressure in a fluid as a function of depth in the fluid.
- Differentiate between AC and DC electricity, and use a voltmeter to measure voltage at different points in a circuit.
- Define work in terms of force, distance, and energy, and calculate work done in mechanical, fluid, and electrical systems.
- Identify differences between open and closed fluid systems, and describe what is meant by work done in a fluid system.
- Measure and calculate rate in mechanical, fluid, electrical, and thermal systems.
- Measure and calculate volume-flow rate and mass-flow rate in various fluid systems.
- Measure resistance in mechanical, fluid, electrical, and thermal energy systems.
- Distinguish between streamlined and turbulent flow, and identify sources of resistance for a fluid moving through a pipe.
- Describe the relationship between potential energy, kinetic energy, and heat energy in the conservation-of-energy law.
- Define power as it applies to mechanical, electrical, fluid, and thermal energy systems.
- Measure and calculate the mechanical advantage of force transformers in mechanical, fluid, and electrical systems. These will include levers, belt- and gear-drive systems, hydraulic jacks, and voltage transformers.
- Describe the effects of momentum in mechanical and fluid systems.
- Explain how pumps and fans convert mechanical or electrical energy to fluid energy.
- Define and measure the efficiency of an energy convertor such as a motor or a pump.
- Explain the function of a fluid transducer such as a bourdon gauge, a barometer, a flowmeter, or an anemometer.

Computer Skills

All employment environments in which HMMTs work require some useful knowledge and skills related to computer applications. The following computer skills are typically required for computer literacy in today's work environment:

Hardware

- Identify common computer hardware such as a keyboard, monitor, diskette drive, mouse, CD-ROM, tape drive, printer, and the casement housing the computer's electronics.
- Turn ON a computer system (i.e., the "computer," monitor, and printer).
- Reboot the computer system.
- Distinguish between different types of common data disks (i.e., 5.25" diskette, 3.5" diskette, hard diskette, CD-ROM).
- Distinguish between different types of common diskette drives (i.e., 5.25" diskette, 3.5" diskette, hard diskette, CD-ROM).
- Describe the function of a diskette.
- Identify Drive A, Drive B, Drive C, and additional drives.

Operating System

- Explain what an operating system is.
- Explain what a formatted diskette is.
- Format a diskette.
- Copy all files on one diskette to another diskette
- Copy one file on one diskette to another diskette.
- Delete a file.
- Identify a system prompt and basic dialog box.
- Describe the action required by a system prompt or basic dialog box.
- Describe a computer program.

Word Processor

- Load a word-processing program.
- Use a menu to select specified features of a program.
- Describe what a word-processing program does.
- Access and use HELP screens.
- Use arrow keys or mouse to move cursor to various parts of monitor display.
- Move individual characters or blocks of data from one location of a document to another.
- Move data from one document to another.
- Copy data from one document to another.
- Save data entered into a word-processing program to a diskette.
- Load a word-processing data file.
- Delete individual characters or blocks of data within a document.
- Place page breaks within a document.
- Use a "search" command to locate a character or a string of characters within a document.
- Use the "replace" command to locate and change a character or a sequence of characters within a document.
- Use the "undo" command to reverse the previous edit.
- Use a "spell checker" to locate and correct misspelled text within a document.
- Print a document.
- Use word-processing program to create a correspondence document that follows standard formatting guidelines for margins, tabs, and line spacing.

RELATED ACADEMIC SKILLS

Spreadsheet

- Describe what a spreadsheet program does.
- Load a spreadsheet program.
- Enter data into rows of a spreadsheet.
- Enter data into columns of a spreadsheet.
- Sum the data of a spreadsheet column.
- Sum the data of a spreadsheet row.
- Use simple formulas in spreadsheet cells to calculate desired values from data in other cells.
- Use a spreadsheet program to make a line chart of data.
- Use a spreadsheet program to make a bar chart of data.
- Use a spreadsheet program to make a circular (pie) chart of data.
- Save data entered into a spreadsheet program to a diskette.
- Load a spreadsheet file.

Database

- Describe what a database program does.
- Load a database program.
- Enter data into a database table.
- Save data entered into a database program to a diskette.
- Load a database table.
- Search for information in a (query) database table.

Communication, Network, On-line Service, and the Internet

- Set up and use a communications program (for the correct bit per second (bps) rate, parity, databits and stop bit e.g., 9600, N81 for 9600 bps, no parity, 8 data bits, and 1 stop bit) to communicate with a computer at another location.
- Connect to a dial-up, on-line service and search for programs or data, and participate in discussion groups or forums.
- Download file(s) from a remote computer to a local computer using a communications program.
- Access MSDS or other available databases via the Internet.

EMPLOYABILITY SKILLS

HMMTs, like other workers in industry, must have the-three part foundation and the five competencies described in the 1991 Secretary's Commission on Achieving Necessary Skills (SCANS) report. These SCANS skills are the workplace know-how that defines effective job performance today and therefore lies at the heart of job performance. No skills standard would be complete without this foundation and these competencies called employability skills.

The employability skills are covered in detail under particular sections of the HMMT Skills Standard while others are mentioned only in this section. This is not meant to downplay the need for HMMTs to have all the employability skills, but only to emphasize by stating in both places the particular areas of concentration HMMTs must have to perform well in their particular area of specialty.

FOUNDATION

Basic Skills

Reading: Locate, understand, and interpret written information in prose and in documents such as manuals, graphs, and schedules by being able to:

- determine the main idea or essential message
- identify relevant details, facts, and specifications
- infer or locate the meaning of unknown or technical vocabulary
- judge the accuracy, appropriateness, and plausibility of reports or other writing

Writing: Communicate thoughts, ideas, information, and messages in writing by being able to:

- create documents such as letters, memos, directions, manuals, reports, graphs, and flowcharts
- develop supporting documentation to the appropriate level of detail
- revise for correct information and appropriate emphasis
- edit for form, grammar, spelling, and punctuation

Arithmetic: Perform basic computations by being able to:

- use basic numerical concepts such as whole numbers and percentages in practical situations
- make reasonable estimates of arithmetic results without a calculator
- use charts to obtain or convey quantitative information

Mathematics: Perform basic mathematical logic by being able to:

- approach practical problems by choosing appropriately from a variety of mathematical techniques
- use quantitative data to construct logical explanations for real-world situations
- express mathematical ideas and concepts orally and in writing
- understand the role of chance in the occurrence and prediction of events

Listening: Receive, attend to, interpret, and respond to verbal messages and other cues, such as body language, in ways that are appropriate to the purpose. By listening, be able to:

- comprehend
- learn from
- critically evaluate
- appreciate
- support a speaker

Speaking: Speak by being able to:

- organize ideas and communicate oral messages appropriate to listeners and situations
- participate in conversations, discussions, and group presentations
- select an appropriate medium for conveying a message
- use verbal language and other cues, such as body language, appropriate in style, tone, and level of complexity to the audience and the occasion
- speak clearly and communicate a message
- understand and respond to listener feedback
- ask questions when needed

Thinking Skills

Creative Thinking: Generate new ideas by being able to:

- use imagination freely
- combine ideas or information in new ways
- make connections between seemingly unrelated ideas
- reshape goals in ways that reveal new possibilities

Decision Making: Demonstrate effective decision-making skills as follows:

- specify goals and restraints
- generate alternatives
- consider risks
- evaluate and choose the best alternatives

Problem Solving: Demonstrate the following problem-solving skills:

- recognize that a problem exists
- identify possible reasons for the problem
- devise and implement a plan of action to resolve the problem
- evaluate and monitor the progress of an action plan
- revise plan as indicated by findings

Seeing Things in the Mind's Eye: Organize and process symbols, pictures, graphs, objects, and other information by being able to:

- see a building from a blueprint
- understand a system's operation from schematics
- picture the flow of work activities from a narrative description

Knowing How to Learn: Acquire and apply new knowledge and skills by using efficient learning techniques in both familiar and changing situations by being aware of learning tools such as:

- personal learning styles
- formal learning strategies
- informal learning strategies

Reasoning: Discover a rule or principle underlying the relationship between two or more objects and apply it in solving a problem by being able to:

- use logic to draw conclusions from available information
- extract rules or principles from a set of objects or written text
- apply rules and principles to a new situation
- determine which conclusions are correct when given a set of facts and a set of conclusions

Personal Qualities

Responsibility: Exert high levels of effort to attain goals and persevere hard to become excellent at doing tasks by having the ability to:

- set high standards
- pay attention to details
- work well
- display a high level of concentration even when assigned an unpleasant task
- maintain high standards of attendance, punctuality, enthusiasm, vitality, and optimism in approaching and completing tasks

Self-Esteem: Demonstrate belief in own self-worth and maintain a positive view of self by exhibiting:

- knowledge of own skills and abilities
- awareness of impact on others
- knowledge of own emotional capacity and needs, and how to address them

Sociability: Demonstrate understanding, friendliness, adaptability, empathy, and politeness in new and ongoing group settings by being able to:

- assert self in familiar and unfamiliar social situations
- relate well to others
- respond appropriately to situations
- take interest in what others say and do

Self-Management: Assess own knowledge, skills, and abilities accurately by being able to:

- set well-defined and realistic personal goals
- monitor progress toward goal attainment
- motivate self through goal achievement
- exhibit self-control
- respond to feedback unemotionally and non-defensively
- be a "self-starter"

Integrity/Honesty: Be trusted and exhibit that trustworthiness by demonstrating the ability to:

- know when a decision or behavior breaks with commonly held personal or societal values
- understand the impact of violating beliefs and codes of an organization, self, or others
- choose an ethical course of action in all work assignments and personal involvement with others

COMPETENCIES

Resources

Identify, organize, plan for the use of, allocate resources to, and be able to demonstrate abilities in the following areas:

Time: Schedule time:

- select goal-related activities
- rank activities
- allocate time
- prepare and follow schedule

Money: Demonstrate financial responsibility:

- use and prepare budgets
- make forecasts
- keep records
- make adjustments to meet objectives

Material/Facilities: Manage materials and facilities by being able to:

- acquire supplies
- store supplies
- allocate and use materials or space efficiently

Human Resources: Understand the human element of the workplace by being able to:

- assess knowledge and skills of people
- distribute work according to knowledge and skills
- evaluate performance
- provide feedback

Interpersonal: Work with others and demonstrate the ability to:

- participate as a member of a team and contribute to the group effort
- teach others new skills
- work to satisfy customers' expectations
- exercise leadership
- communicate ideas that justify position
- persuade and convince others
- responsibly challenge existing procedures and policies
- negotiate agreements involving exchanges of resource and the resolutions of issues of divergent interests
- work well with persons from diverse backgrounds

Information: Acquire and use information:

- identify, assimilate, and integrate information from diverse sources
- prepare, maintain, and interpret quantitative and qualitative records
- convert information from one form to another
- convey information orally and in writing as the need arises

System: Understand complex interrelationships:

- comprehend own work in the context of the work of those around them
- understand how parts of systems are connected and anticipate consequences of system changes
- monitor and correct own performance
- identify trends and anomalies in system performance
- integrate multiple displays of data
- link symbols with real phenomena (e.g., display on computer screen with machine performance)

Technology: Work with a variety of technologies:

- select appropriate procedures, tools, or equipment including computers and related technologies
- apply technology to task by understanding overall intent and proper procedures for setup and operation of equipment
- maintain and troubleshoot equipment including computers and other technologies to prevent, identify, or solve problems

It is assumed that because of the basic nature of the employability skills that they would be an integral part of the education process.

Many of these skills are necessary in the quality process that most companies now use in the workplace. This has made them even more an entry-level job requirement.

HMMT AND THE QUALITY MOVEMENT

The HMMT will be required to be part of any quality team or work group. Often the HMMT will be asked to be the expert or to research the hazardous materials issues in production-improvement ideas. HMMTs will also be part of quality teams or work groups in the hazardous materials area of their plants or operation. It is necessary for the HMMT to have the ability to work in groups and to do basic statistical quality control, which are two fundamental areas of the quality process and the backbone of quality-process skills.

Knowledge of quality-process skills is necessary for all employees entering the workplace. These skills are used in a number of programs identified as Total Quality Management, Continuous Improvement, Zero Defects, Quality Circles, and so on, but all part of the Quality Movement. This movement can generally be thought of as a systematic approach that uses objective methods to improve productivity through employee involvement in continuous improvement of all products and services. Each quality program is different in content but generally requires the same skills of workers.

Quality Control and Assurance

An HMMT should have a basic understanding of statistical quality control and should have abilities in the following areas:

Process: Describe a manufacturing or production process by being able to:

- make a process chart
- construct histograms, run charts, scatter diagrams, and normal distribution curves from data obtained by counting or measuring
- determine production quality by calculating process capability and tolerance bands and comparing them to a normal distribution curve

Control: Adjust a process by using information from a control chart, which requires the ability to:

- design control charts for X and R for a process
- use a measurement-control chart for X and R to keep a process in control
- use an attribute-control chart for P to keep a process in control

Statistics: Use basic statistical measures to track work processes by being able to:

- calculate mean, mode, and median for a set of data
- draw a histogram to represent frequency distributions of data
- calculate the range and standard deviation to describe a set of data

Probability: Use statistical probabilities to determine the rate of occurrence in a process by being able to:

- find the probability of a simple event
- determine the number of ways a simple event can occur
- draw a diagram and/or a chart to help find probability

Group Process

The HMMT should be able to work in a quality-process team and should have abilities in:

Teamwork: Participate as member of a team and contribute to the group effort by having the ability to:

- exercise leadership
  1. communicate ideas that justify position
  2. persuade and convince others
  3. responsibly challenge existing procedures and policies
- employ the appropriate team role in contributing to the group effort
- negotiate agreements between groups or individuals with conflicting issues
- work well with persons from diverse backgrounds

Communication: Communicate and listen in a group setting by being able to:

- receive, attend to, interpret, and respond to verbal messages and other cues, such as body language, in ways that are appropriate to the purpose
- organize ideas and communicate oral messages appropriate to listeners and situations
- participate in conversations, discussions, and group discussions
- select an appropriate medium for conveying a message
- use verbal language and other cues, such as body language, appropriate in style, tone, and level of complexity to the audience and the occasion
- speak clearly and communicate a message
- understand and respond to listener feedback
- ask appropriate questions

Problem Solving/Decision Making: Demonstrate effective problem-solving and decision-making skills as follows:

- recognize that a problem exists
- identify possible reasons for the discrepancy
- specify goals and restraints
- generate alternatives
- consider risks
- evaluate and choose the best alternatives
- devise and implement a plan of action to resolve a problem
- evaluate and monitor action-plan progress
- revise plan as necessary

RELATING SKILLS STANDARD TO EDUCATIONAL PROGRAMS

Educational programs designed to prepare people with the skills identified in this standard may be varied in length and design. Programs may differ according to local employment needs, geographical area, and the diverse backgrounds of the individuals entering the program. This Standard is considered to be the "national norm" for defining an HMMT. Local advisory committees consisting of industrial experts, potential employers, and educational representatives must evaluate the Standard and adapt it to the local employment needs and training resources available.

In his 1990 book titled *Training the Technical Work Force*, Anthony Carnevale states,

> "Although many technicians are graduates of four-year colleges, many have developed their skills and knowledge through technical or vocational schools, community colleges, or on-the-job training. After technical and nontechnical professionals (i.e. doctors, engineers, and scientists), technicians are the most highly educated and well-trained employees in the American workforce. ...Technicians usually receive training that applies directly to their jobs. This training has its basis in theory but is focused more directly on the application of theory to the job than is training for technical professionals."

This description directly applies to an HMMT.

In the view of the developers of this Standard, specifying the number of hours for training programs is inadequate. Although the duration of a training program does give an indication of its rigor, too many variables are left undefined when duration of the program is the primary specification. The committee believes that an HMMT cannot be adequately prepared by attending a "short course" consisting of a few hours of training. On the other hand, the committee does not specify that a technician must complete the requirements of a particular degree (i.e. Associate of Science, Bachelor of Science, or other). Instead the Standard places emphasis on the mastery of given skills rather than completion of degree requirements. However, as an indication of program rigor, it is anticipated that training programs equivalent to traditional two-year community or technical college programs will be needed for a high school graduate to acquire the skills needed by an HMMT.

Educational programs that will allow students to become competent in the sophisticated technical skills demanded of today's technicians must begin in the elementary and middle school. Many of the skills identified in the SCANS report should be developed at this level. A Tech Prep program with a "seamless" curriculum running from the secondary school to a postsecondary program is recommended for the preparation of HMMTs. At the secondary-school level, specific skills in mathematics, science, and the application of technology should be mastered. Most of the mathematics, chemistry, and physics skills listed as "Related Academic Skills" can be developed at the secondary level, with refinement of these skills coming at the postsecondary level. The specific occupational skills can best be addressed in postsecondary programs having a strong worksite learning component.

RELATING SKILLS STANDARD TO EDUCATIONAL PROGRAMS

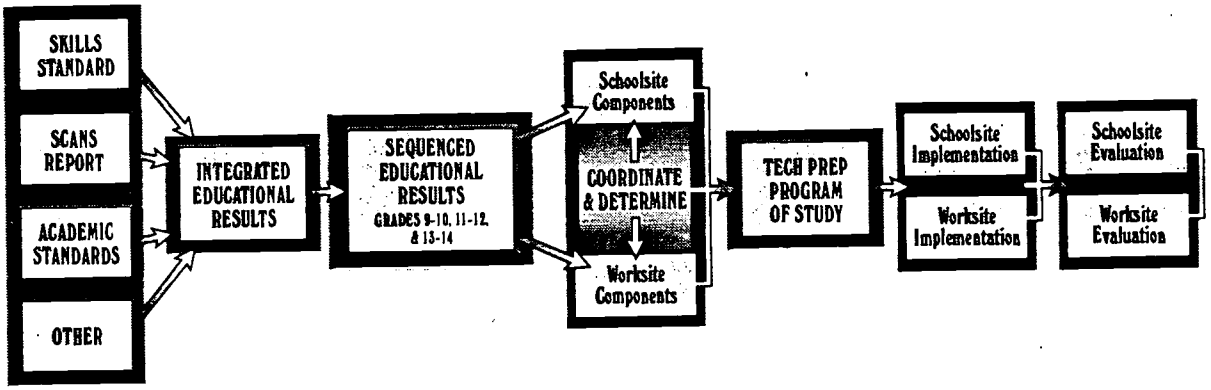

Figure 2

When developing an educational program for HMMTs, the curriculum developer must implement a planning procedure such as the one outlined before courses or text materials are chosen. Figure 2 shows multistep procedures that can be described as follows.

Step 1: Identify all the standards that must be used to define an Integrated Educational Result. Skills standards identify occupational requirements, while other standards specify additional requirements. For instance, the National Council of Teachers of Mathematics (NCTM) has established a standard for secondary-level mathematics courses. The SCANS report, published by the United States Department of Labor, identified skills that should to be addressed at all levels of education. Collectively, these standards and skills must be incorporated into an HMMT educational program. Integrating these standards in terms of educational results is the second step in the process.

Step 2: Integrate concepts from various disciplines across the curriculum.

Step 3: Look at the sequence and level of skill developments identified. Decisions about the grade level or student-development level most appropriate for the introduction of the various skills, competencies, and standards can then be made.

Hands-on educational activities are encouraged in a Hazardous Materials Management Technology program. Recently, issues related to school-to-work transitions and worksite learning have added dimensions not formerly addressed in most curriculum designs. Although assumptions can and have been made about the ways in which worksite learning can be accomplished, planning has rarely focused on expected results or methods of evaluating those results.

Step 4: Justify the need to move to a worksite learning activity rather than a schoolsite activity. Many of the skills represented by the Standard and by SCANS information can be acquired in a classroom, laboratory, or simulated work environment. However, certain skills may be best addressed at a worksite, in an on-the-job environment. This determination must be based on sound reason and closely coordinated with the schoolsite curriculum. Many of the skills defined in this Standard can be integrated into secondary-level training programs that articulate with postsecondary programs.

Step 5: Therefore, a Tech Prep program is strongly recommended for the preparation of HMMTs since it places emphasis on a curriculum that progresses seamelessly from the secondary through the postsecondary level, and to employment. In addition, Tech Prep places very high importance on the "contextual" methods of learning that have proven successful for technician-level training.

Steps 6-7: As the curriculum is implemented, constant evaluation must be provided to verify that the requirements of the Standard are being met.

APPENDIX

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