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DOE-STD-1239-2024

DOE STANDARD

CHEMICAL SAFETY MANAGEMENT PROGRAM



**U.S. Department of Energy
Washington, D.C. 20585**

AREA SAFT

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FOREWORD

1. This Department of Energy (DOE) Standard has been approved for use by DOE, including the National Nuclear Security Administration (NNSA) and its contractors.
2. This Standard provides guidance for managing chemical safety at DOE sites and facilities. The methods in this Chemical Safety Management Program (CSMP) Standard are acceptable but not mandatory methods to be used for satisfying the requirements contained in 10 Code of Federal Regulations (CFR) Part 851, *Worker Safety and Health Program*, and for establishing a safety management program as defined in 10 CFR Part 830, *Nuclear Safety Management*. (NOTE: Nuclear Safety requirements, standards, and guides are only applicable to nuclear facilities).
3. This DOE Standard does not establish requirements. However, all or part of the provisions in this Standard can become requirements under any of the following circumstances:
 - They are explicitly stated to be requirements in a DOE-approved Worker Safety and Health Program (WSHP) and Documented Safety Analysis (DSA);
 - The Standard is incorporated into a contract; or
 - The Standard is adopted by the contractor into a DOE-approved implementation plan or program plan for satisfying a DOE requirement.
4. Beneficial comments or any pertinent data that may be of use in improving this document can be emailed to EHSS-11WSHPolicy@hq.doe.gov.

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1.0 TERMINOLOGY

1.1 Acronyms and Abbreviations

CFR	Code of Federal Regulations
CSMP	Chemical Safety Management Program
DEAR	Department of Energy Acquisition Regulation
DOE	Department of Energy
DOT	Department of Transportation
DSA	Documented Safety Analysis
EPA	Environmental Protection Agency
GHS	Globally Harmonized System of Classification and Labeling of Substances and Mixtures
HC	Hazard Category
HDBK	Handbook
HNOC	Hazard Not Otherwise Classified
IDLH	Immediately Dangerous to Life or Health
ISMS	Integrated Safety Management System
NFPA	National Fire Protection Association
O	Order
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
PSM	Process Safety Management
PAC	Protective Action Criteria
SDS	Safety Data Sheet
SMP	Safety Management Program
STD	Standard
TLV	Threshold Value Limit
WSHP	Worker Safety and Health Program

1.2 Definitions

Chemical. Any substance, or mixture of substances.¹

Chemical Inventory. The action of establishing a list of chemical products.

Co-located Worker. Anyone who performs assigned tasks in a nearby space, area, or facility. Examples include federal, contractor, or subcontractor personnel who normally work outside of the facility where the work is being performed such as those at nearby or adjacent facilities on site. For Hazard Category (HC) 1, 2, or 3 nuclear facilities, the applicable safe harbor methodology used to prepare the documented safety analysis (DSA), such as DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, may define the co-located worker at a specific distance from the facility.

Contractor. Any entity, including affiliated entities such as a parent corporation, under contract with DOE, or a subcontractor at any tier, that has responsibilities for performing work at a DOE site in furtherance of a DOE mission.²

Documented Safety Analysis (DSA). A documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment, including a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety.³

Energy Source. Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.⁴

Exposure. The state of being exposed to a hazard resulting in risk of an adverse consequence to workers, the public, the environment, or a facility.⁵

Exposure Assessment. The systematic collection and analysis of occupational hazards and exposure determinants such as work tasks; magnitude, frequency, variability, duration, and route of exposure; and the linkage of the resulting exposure profiles of individuals, similarly exposed groups, and facilities for the purposes of risk management and health surveillance.⁶

Facility. The buildings, utilities, structures, and other land improvements associated with an operation or service and dedicated to a common function.⁷

Graded Approach. The process of ensuring that the level of analysis, documentation, and actions used to comply with a requirement are commensurate with:

- The relative importance to safety, safeguards, and security;
- The magnitude of any hazards involved;

¹ 29 CFR § 1910.1200

² 10 CFR § 851.3

³ 10 CFR § 830.3

⁴ 29 CFR § 1910.147

⁵ DOE-HDBK-1163-2020

⁶ DOE G 440.1-1B, Chg 1

⁷ DOE G 450.4-1C

- The life cycle stage of a facility;
- The programmatic mission of a facility;
- The characteristics of a facility;
- The relative importance of radiological and non-radiological hazards; and
- Any other relevant factor.⁸

Hazard. A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to a person or damage to a facility or to the environment (without regard to the likelihood or credibility of hazard or accident scenarios or consequence mitigation).⁹

Hazard Analysis. The identification of materials, systems, processes, and facility characteristics that can produce undesirable consequences (hazard identification), followed by the assessment of hazardous situations associated with a process or activity (hazard evaluation). Qualitative techniques are usually employed to pinpoint weaknesses in design or operation of the facility that could lead to hazardous event scenarios. The hazard evaluation includes an examination of the complete spectrum of potential hazardous event scenarios that could expose members of the public, onsite workers, facility workers, and the environment to hazardous materials.¹⁰

Hazard Category (HC). The division of criteria within each hazard class, e.g., oral acute toxicity and flammable liquids include four hazard categories. These categories compare hazard severity within a hazard class and should not be taken as a comparison of hazard categories more generally.¹¹

Hazard Category (HC) 1, 2, and 3 DOE Nuclear Facilities. Nuclear facilities that meet the criteria for their respective HC consistent with the provisions of DOE-STD-1027-92, Chg 1. HC-1, 2, and 3 DOE nuclear facilities are required to have safety bases established in accordance with Subpart B of 10 CFR 830. Hazard categories are based on their radioactive material inventories and the potential consequences to the public, workers, and the environment. HC-1 represents the highest potential consequence and HC-3 represents the lowest potential consequence of the facilities required to establish safety bases.¹²

Hazardous Chemical. Any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.¹³

Hazard Class. The nature of the physical or health hazards, e.g., flammable solid, carcinogen, oral acute toxicity.¹⁴

Hazard Controls. Measures to eliminate, limit, or mitigate hazards to workers, the public, or the environment, including:

- Physical, design, structural, and engineering features;

⁸ 10 CFR § 830.3

⁹ 10 CFR § 830.3

¹⁰ DOE-STD-3009-2014

¹¹ 29 CFR § 1910.1200

¹² DOE-STD-3009-2014; DOE-STD-1027-2018

¹³ 29 CFR § 1910.1200

¹⁴ 29 CFR § 1910.1200

- Safety structures, systems, and components;
- Safety management programs;
- Technical safety requirements; and
- Other controls necessary to provide adequate protection from hazards.¹⁵

Note: Consider the physical structure, features, and operating constraints when choosing controls, as well as administrative or safety practices, personal protective equipment (PPE), processes, or procedures to prevent, control, or minimize dangers.

Hazard Identification. To identify existing and potential workplace hazards and assess the risk of associated workers injury and illness.¹⁶

Hazardous Material. Any solid, liquid, or gaseous material that is toxic, explosive, flammable, corrosive, or otherwise could adversely affect the health and safety of the public or the workers or harm the environment.¹⁷

Hazardous Material (DOT). A substance or material that the Secretary of the Department of Transportation (DOT) has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and has designated as hazardous under section 5103 of Federal hazardous materials transportation law (49 U.S.C. 5103). The term includes hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table (see 49 CFR 172.101), and materials that meet the defining criteria for hazard classes and divisions in 49 CFR Part 173.¹⁸

Hazardous Material (NFPA 400). A chemical or substance that is classified as a physical hazard material or a health hazard material, whether the chemical or substance is in usable or waste condition.

Hazard Not Otherwise Classified (HNOC). An adverse physical or health effect identified through evaluation of scientific evidence during the classification process that does not meet the specified criteria for the physical and health hazard classes addressed in 29 C.F.R. § 1910.1200(c). This does not extend coverage to adverse physical and health effects for which there is a hazard class addressed in this section, but the effect either falls below the cut-off value/concentration limit of the hazard class or is under a GHS HC that has not been adopted by Occupational Safety and Health Administration (OSHA) (e.g., acute toxicity Category 5).¹⁹ OSHA gives further guidance in applying the definition of HNOC:

- An adverse physical or health effect is a material impairment of health or functional capacity, as that phrase is used in section 6(b)(5) of the OSH Act, 29 U.S.C. § 655(b)(5), resulting from workplace exposure to a chemical.
- A health effect is determined in accordance with the weight of evidence criteria in A.0.3.
- The term physical effect generally refers to a material impairment of health or functional

¹⁵ DOE O 151.1D Chg 1 (MinChg)

¹⁶ 10 CFR § 851.21(a)

¹⁷ DOE STD-3009-2014; DOE O 232.2A Chg 1 (MinChg)

¹⁸ DOE O 460.1D Chg 1 (LtdChg)

¹⁹ 29 CFR § 1910.1200(c)

capacity caused by the intrinsic hazard(s) of a particular chemical in normal conditions of use or foreseeable emergencies. Scalds caused by exposure to chemicals at high temperatures and slips and falls caused by treading on a solid chemical shaped in a rounded form or spilled liquids are not covered physical effects under the HNOC definition...²⁰

Health Hazard. A chemical that is classified as posing one of the following hazardous effects:

- Acute toxicity (any route of exposure);
- Skin corrosion or irritation;
- Serious eye damage or eye irritation;
- Respiratory or skin sensitization;
- Germ cell mutagenicity;
- Carcinogenicity;
- Reproductive toxicity;
- Specific target organ toxicity (single or repeated exposure); or
- Aspiration hazard..²¹

Hierarchy of Controls. A system of preferences for hazard controls prioritized by anticipated effectiveness of the controls. Traditionally, the following hierarchy of controls is used:

1. Elimination or substitution of the hazards where feasible and appropriate;
2. Engineering controls where feasible and appropriate;
3. Work practices and administrative controls that limit worker exposures; and
4. Personal protective equipment..²²

Note: In the context of 10 CFR 830, refer to the discussion in Standard 3009-2014 or Standard 1189-2016.

Integrated Safety Management System (ISMS). A safety management system that provides a formal, organized process whereby people plan, perform, assess, and improve the safe conduct of work efficiently and in a manner that ensures protection of workers, the public, and the environment. This management system is used to implement ISM to systematically integrate safety into management and work practices at all levels so that missions are accomplished while protecting the public, the worker, and the environment..²³

Nonreactor Nuclear Facility. Those facilities, activities or operations that involve, or will involve, radioactive and/or fissionable materials in such form and quantity that a nuclear or a nuclear explosive hazard potentially exists to workers, the public, or the environment, but does not include accelerators and their operations and does not include activities involving only incidental use and generation of radioactive materials or radiation such as check and calibration sources, use of radioactive sources in research and experimental and analytical laboratory activities, electron

²⁰ <https://www.osha.gov/laws-regs/standardinterpretations/2014-03-04-1>

²¹ 29 CFR § 1910.1200 (c)

²² 10 CFR § 851.22(b)

²³ DOE M 450.4-1

microscopes, and X-ray machines.²⁴

Nuclear Facility. A reactor or a nonreactor nuclear facility where an activity is conducted for or on behalf of DOE and includes any related area, structure, facility, or activity to the extent necessary to ensure proper implementation of the requirements established by 10 CFR Part 830.²⁵

Physical Hazard. A chemical that is classified as posing one of the following hazardous effects:

- Explosive;
- Flammable (gases, aerosols, liquids, or solids);
- Oxidizer (liquid, solid or gas);
- Self-reactive;
- Pyrophoric (liquid or solid);
- Self-heating;
- Organic peroxide;
- Corrosive to metal;
- Gas under pressure; or
- In contact with water emits flammable gas.

See Appendix B to 29 CFR § 1919.1200 – Physical Hazard Criteria.²⁶

Public. All individuals outside a DOE site boundary.²⁷

Protective Action Criteria (PAC). The level of hazardous material impact that, if observed or predicted, indicates action is needed to prevent or limit exposure of people to the hazard. PAC are used for both radiological and non-radiological consequence criteria in DOE facility emergency planning and response, e.g., building collapse zone, bomb threat.²⁸

Reactive Chemical. A substance's susceptibility to undergo a chemical reaction or change that may result in dangerous side effects, such as an explosion, burning, and corrosive or toxic emissions.²⁹ Reactive chemicals include self-reactive chemicals as defined in the GHS as thermally unstable liquid or solid substances liable to undergo a strongly exothermic decomposition even without participation of oxygen (air), self-heating substance (a solid or liquid chemical, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat).

Receptor. The generic term assigned to workers, the public, the environment, or the facility when they represent where the consequence of exposure to the hazard would occur.³⁰

Risk. The quantitative or qualitative expression of possibility of an event occurring that considers

²⁴ 10 CFR § 830.3

²⁵ 10 CFR § 830.3

²⁶ 29 CFR § 1919.1200(c)

²⁷ DOE-STD-3009-2014

²⁸ DOE O 151.1D Chg 1 (MinChg)

²⁹ 29 CFR 1910.1200

³⁰ DOE-HDBK-1163-2020

both the probability that a hazard will cause harm and the consequences of that event..³¹

Safe Harbor. An acceptable methodology for preparing a DSA as described in Table 1 of Appendix A to Subpart B of 10 CFR Part 830, which includes identified successor documents, and that, if followed, results in a contractor satisfying the regulatory requirements for a DSA..³²

Safety Management Program (SMP). A program designed to ensure that a facility is operated in a safe manner that adequately protects workers, the public, and the environment by covering a topic such as quality assurance; maintenance of safety systems; personnel training; conduct of operations; inadvertent criticality protection; emergency preparedness; fire protection; waste management; or radiological protection of workers, the public, and the environment..³³

Site. A DOE-owned or -leased area or location, or other area or location controlled by DOE, where activities and operations are performed at one or more facilities or places by a DOE contractor in furtherance of a DOE mission..³⁴

Standard Industrial Hazards. Hazards that are routinely encountered in general industry and construction. These workplace hazards are generally well understood and covered by codes, regulations, or other consensus Standards (e.g., National Fire Protection Association Standards, National Electric Code). These workplace hazards are addressed by provisions of 10 CFR Part 851, *Worker Safety and Health Program*, which requires identification and assessment of worker hazards and compliance with safety and health Standards that provide specific safe practices and controls..³⁵ For DOE HC-1, 2, and 3 facilities, standard industrial hazards are defined and managed within the scope of DOE-STD-3009-2014 and other applicable safe harbor methodologies.

Worker. An employee of a DOE contractor person who performs work in furtherance of a DOE mission at a covered workplace..³⁶

Workplace Hazard. A physical, chemical, biological, or safety hazard with any potential to cause illness, injury, or death to a person..³⁷

³¹ DOE-HDBK-1211-2014

³² DOE O 421.1, 65 Federal Register No.196 pages 60300-60301 (10 CFR Part 830 Interim final rule)

³³ 10 CFR § 830.3

³⁴ 10 CFR § 851.3

³⁵ 10 CFR § 851.3

³⁶ 10 CFR § 851.3

³⁷ 10 CFR § 851.3

2.0 INTRODUCTION

This Chemical Safety Management Program (CSMP) Technical Standard provides necessary tools and resources to create a program for the safe management of hazardous chemicals at DOE sites. This Standard also refers to applicable requirements in 10 CFR Part 851, *Worker Safety and Health Program* (10 CFR Part 851), and for establishing a safety management program as defined in 10 CFR Part 830, *Nuclear Safety Management* (10 CFR Part 830).

The objectives of this Standard are to:

1. Provide clear guidance and expectations for complying with requirements relating to chemical hazards at DOE sites and facilities, including HC-1, 2, and 3 nuclear facilities and below HC-3 nuclear facilities;
2. Increase efficiency and reduce redundancy during the development, implementation, and review of CSMP elements at each DOE site and facility; and
3. Integrate and ensure consistency with applicable DOE regulations, standards, handbooks, and guidance documents.

2.1 Purpose

To provide a standardized approach in development of a CSMP to ensure the safe management of chemicals across the DOE complex. This Standard provides guidance for developing and implementing a program consistent with DOE safety regulations via an acceptable (but not mandatory) method to implement the chemical safety requirements.

2.2 Applicability and Scope

This Standard applies to chemicals at all DOE sites and facilities, including chemicals at DOE HC-1, 2, and 3 nuclear facilities. The use of this Standard does not alter or replace any relevant rules, DOE directives, or standards. The scope of this Standard includes:

- The major chemical life cycle stages (i.e., acquisition, inventory and tracking, storage, transportation, processing and use, disposal); and
- All phases of a facility life cycle (i.e., design, construction, operations, decontamination and decommissioning).

For DOE HC-1, 2, and 3 nuclear facilities, a CSMP is available to be used as an SMP as discussed in 10 CFR 830, Subpart B, and the applicable DSA preparation methodology (i.e., safe harbor methodology). (See Appendix A of this Standard).

2.3 Shall, Should, and May

In this Standard, the word “shall” denotes a requirement; the word “should” denotes a recommendation; and the word “may” denotes permission, neither a requirement nor a recommendation. To claim full compliance with this Standard, all “shall” statements must be met.

3.0 CHEMICAL SAFETY MANAGEMENT PROGRAM

This Standard is made up of eleven programmatic elements, all of which are essential for a complete program. The CSMP elements reflect the life-cycle stages of the ISMS in DOE sites and facilities.

3.1 Chemical Inventory and Tracking

Chemical inventory and tracking are essential to identify and analyze chemical-related hazards for developing hazard controls to protect workers, the public, and the environment. Keeping an accurate inventory of chemicals is both a legal requirement for using, handling, and storing specific hazardous chemicals and a key part of communicating and managing chemical hazards. The chemical inventory can help with efficient ordering, locating chemicals, deliberate disposal, effective response, and compliance with hazardous material quantity limits.

3.1.1 The chemical inventory tracking system shall contain:

- An up-to-date list of the hazardous chemicals at each facility³⁸;
- A mechanism to track chemicals to ensure hazardous chemicals within an area/facility are identified on the hazardous chemical inventory;
- Chemical classification for the identification of both specific chemical hazards for a container as well as a summary of chemical hazards at the level of a facility or location within a facility (e.g., room);
- A list of attributes of the hazardous chemical (e.g., constituent chemicals, mixtures, location, and storage);
- A mechanism to provide and maintain the following items that are readily accessible to employees at work locations:
 - Location where a current copy of this CSMP or an implementing procedure of the CSMP can be found; and
 - An SDS for each hazardous chemical listed on the area-specific hazardous chemical inventory.
- Chemical quantities to ensure adequate, but not excess supplies;
- Information that would help personnel (e.g., firefighters and hazardous material workers) safely respond to emergencies (e.g., GHS warnings, signal words, pictograms, or United Nations/North American numbers);
- Consistency with fire and building code quantity limits; and
- An assigned custodian or owner.

3.1.2 Processes and procedures for active chemical inventory management shall include:

- The identification of roles and responsibilities for maintaining an accurate inventory (including but not limited to contractors and subcontractors); and

³⁸ 10 CFR § 851.26(a)(1); 10 CFR § 851.23(a)(3); 29 CFR § 1910.1200(e)(1(ii))

- A discussion on the need to perform periodic chemical inventory assessments to ensure the inventory is accurate. DOE sites and facilities shall determine the periodic review time frame.
- 3.1.3 Safety data sheets (SDS) for each hazardous chemical shall be made available and accessible to workers for review.³⁹
- 3.1.4 Chemical containers shall be labeled using:
- The GHS;
 - The original manufacturer label;
 - Other forms of warning to effectively communicate hazard information to workers when a chemical is produced in the laboratory⁴⁰; or
 - Required information to communicate chemical, hazards, and shelf-life when chemical is transferred from original container to intended use container or secondary container (e.g., five gallons of a hazardous chemical is transferred from a 55-gallon drum to a new container).
- 3.1.5 DOE sites and facilities shall provide chemical data to support regulatory reports (e.g., Tier 2).⁴¹
- 3.1.6 A CSMP shall identify the facilities with quantities of highly hazardous chemicals that require process safety management (PSM), risk management, and prior approval programs.⁴² (See DOE-HDBK-1101 for PSM Guidance).
1. DOE sites and facilities shall review, establish, and implement procedures to manage changes to chemicals, technology, equipment, and administrative processes under PSM or a risk management program.⁴³
 2. DOE sites and facilities should consider elimination or substitution of PSM-listed chemicals with non-PSM-listed chemicals or reducing quantities where possible.
 3. The PSM methodology applied to DOE non-PSM facilities should be implemented as best practices and using a graded approach at facilities with chemical inventories where quantities are below regulatory threshold quantities; many of the elements of PSM are already incorporated into this Standard.

3.2 Acquisition of Chemicals

Acquisition consists of approving and procuring chemicals and chemical products. Possible acquisition methods include materials supplied by subcontractors, excess chemicals obtained from other DOE sites, new research chemicals received from offsite for laboratory testing, and utilizing existing inventory. Chemical acquisition involves all of the following 3.2 subsections.

³⁹ 10 CFR § 851.23(a)(3); 29 CFR § 1910.1200(b)(4)(ii)

⁴⁰ 29 CFR § 1910.1450(h)

⁴¹ 40 CFR Part 71, *Federal Operating Permit Programs*

⁴² 29 CFR § 1910.119; 40 CFR § 68, DOE-HDBK-1100-2004; DOE-HDBK-1101-2004

⁴³ 29 CFR § 1910.119(I)

- 3.2.1 Facilities shall ensure the quantity of chemicals ordered does not exceed the established limits for the facility or site.⁴⁴ DOE sites and facilities shall establish procedures for acquired chemicals including but not limited to chemical inventory, SDSs, a description of use for the chemical, safe handling, and hazard controls.
- 3.2.2 A CSMP shall establish measures to promote cost-effective waste prevention and reduction in all operations and facilities through purchase of materials or products (including packaging) to reduce their amount or toxicity before they are discarded.
- 3.2.3 A CSMP shall prevent or decrease the amount of waste being generated through waste prevention, recycling, or purchasing recycled and environmentally preferable products.⁴⁵
- 3.2.4 Prior to ordering new chemicals, facilities should conduct a search of existing inventories and complete an initial hazard analysis.
- 3.2.5 Facilities should conduct a review of storage requirements and storage availability for chemicals new to the receiving facility to ensure chemical quantities are within the established area, safety basis, control set, or control area.
- 3.2.6 The statutory and regulatory mandates for acquisition of products are:
1. Purchasing preference;
 2. DOE Acquisition Guide for best practices;
 3. Federal Acquisition Regulation requirements; and
 4. Other applicable Federal procurement policies.⁴⁶
- 3.2.7 DOE sites and facilities should review the CSMP for best practices regarding the acquisition of chemicals and should evaluate the following factors prior to purchase:
- Waste prevention (including toxicity reduction or elimination);
 - Volume of chemical necessary for project/work;
 - Risk of injury or illness using GHS hazard designations from the SDS;
 - Reuse of products;
 - Life cycle cost;
 - Elimination of virgin material requirements;
 - Use of biobased products;
 - Use of recovered materials;
 - Recyclability;
 - Use of environmentally preferable products;
 - Energy efficiency;

⁴⁴ 40 CFR Part 355 Appendix A, Appendix B, and Emergency Planning and Community Right-to-Know Act Sections 311-312

⁴⁵ 48 CFR § 52.223-10, *Waste Reduction Program*; 10 CFR § 830.122(d); 10 CFR § 830.122(g); DOE O 414.1D, Attachment 2, 4, and 7

⁴⁶ 48 CFR Part 523, *Environment, Energy and Water Efficiency, Renewable Energy Technologies, Occupational Safety*; 40 CFR Part 355 Appendix A, Appendix B, and Emergency Planning and Community Right-to-Know Act Sections 311-312; 48 CFR § 970.23, *Environmental, Conservation, and Occupational Safety Programs*

- Water savings; and
- Ultimate disposal.⁴⁷

3.2.8 DOE sites and facilities should prioritize the purchase of BioPreferred or biobased products by the United States Department of Agriculture as allowed.⁴⁸

3.2.9 A CSMP should incorporate procedures to reduce reliance on ozone-depleting substances, identified under the EPA's Significant New Alternatives Policy program.⁴⁹

3.3 Hazard Analysis and Exposure Assessment of Chemicals

Identify and analyze chemical risks throughout their life cycle (i.e., acquisition, transport, storage, use, processing, and disposal). DOE site or facility management shall assess work operations using hazardous chemicals to ensure protection of workers, the public, and the environment.

3.3.1 DOE sites and facilities shall evaluate chemical hazards and implement appropriate hazard controls to minimize risk consistent with national consensus codes and standards or other regulatory requirements by using Permissible Exposure Limit (PEL), Threshold Value Limit (TLV), or other known exposure limits to help with assessment.

3.3.2 For chemical hazards that were not previously identified during initial hazard assessment, facility design, or the development of procedure, DOE sites and facilities shall prioritize and implement control measures based on the risk to employees, implement interim protective measures prior to final abatement, and protect personnel from hazardous safety and health conditions.⁵⁰

3.3.3 Line managers shall ensure exposure assessments are performed and completed using accepted exposure assessment methodologies.⁵¹ Identification of chemical hazards should use a systematic approach and account for:

- GHS hazard classifications (e.g., chemicals posing acute toxicity, carcinogens, aspiration hazards, simple asphyxiants, explosives, flammable gases, self-reactive chemicals, self-heating chemicals) and ensure that reactive chemicals are identified, using a GHS hazard class where applicable or by identifying them as HNOC.⁵²;
- Unbound engineered nanoparticles;
- Multiple hazards near each other (proximity);
- Chemicals confined under pressure (i.e., cylinders or pressurized processes) and temperature extremes;
- Incompatibilities between chemicals or chemicals and storage containers, and reactions between chemicals and water or oxygen. When identifying potential incompatibilities, consider all chemicals, not just those classified as hazardous;

⁴⁷ 48 CFR § 970.2301, *Contract Clauses*

⁴⁸ 48 CFR Subpart 23.4

⁴⁹ 48 CFR Subpart 23.8, *Ozone-Depleting Substances and Greenhouse Gases*

⁵⁰ 10 CFR § 851.22(a)(2)

⁵¹ 10 CFR Part 851.21; 10 CFR Part 851.23; 10 CFR Part 851 Appendix A, § 6

⁵² 10 CFR § 851.21; 29 CFR § 1910.1200

- Chemicals that pose hazards when heated (e.g., fire, energetic decomposition, gas generation);
- Materials that react or change as they age, resulting in different hazards (e.g., peroxide formers); and
- A review of previous incidents at the site or facility (or similar sites or facilities) involving the chemical being analyzed.

3.3.4 DOE sites and facilities should evaluate chemical hazards at the activity-level, process-level, facility-level, and/or the site-level for chemical hazards that exceed standard industrial hazard criteria or applicable chemical screening criteria by:

- Performing a preliminary hazard evaluation before modifications to existing facilities and equipment. Facilities can identify changes that should be evaluated to verify operations remain within the bounds of the hazard analysis.
- Conducting a hazard analysis for the chemical processes which should:
 - Consider normal (including startup, operation, maintenance, and shutdown), abnormal, and accident conditions;
 - Identify risk scenarios and evaluate their consequences qualitatively; and
 - Include suitable techniques (e.g., what-if, checklist, or Hazard and Operability Analysis).⁵³
- Identifying changes to verify operations remain within the bounds of the hazard analysis.
- Identifying and assigning prevention or mitigation measures to minimize risk (e.g., frequency/likelihood or consequence/severity).
- Documenting initial conditions and assumptions (e.g., environmental, test, process operating conditions) to identify when hazardous situations may present during chemical use, operations, or maintenance activities.
- Incorporating best practices for hazard analysis from DOE's Handbook for Integration of Hazard Analysis.⁵⁴
- Evaluating hazardous conditions that may release significant quantities of hazardous chemicals or have the potential for exposures exceeding DOE PAC values for the receptors of concern (e.g., public, facility worker, co-located worker). Note: PAC values are used in Emergency Planning Hazards Assessments and DSA.⁵⁵
- Periodically verifying hazard analysis findings and documentation for accuracy and maintain records of hazard analyses for the lifetime of the facility.

3.4 Chemical Hazard Controls

Use hazard evaluation tools such as exposure assessment, job hazard analysis, process hazard analysis, fire hazard analysis, DSA, and emergency planning hazard assessment where appropriate.

⁵³ 29 CFR § 1910.119

⁵⁴ DOE Handbook 1163-2020

⁵⁵ DOE O 151.1D, DOE-STD-3009-2014

DOE-STD-1239-2024

Select hazard controls by using the hierarchy of controls such as elimination, substitution, engineering, administrative, and/or personal protective equipment..⁵⁶

- 3.4.1 DOE sites and facilities shall establish hazard controls identified in facility design or process development for hazardous chemicals. For existing chemical hazards, sites and facilities shall prioritize and implement control measures based on risk to workers, protective measures, and employee protection from hazardous chemical conditions,⁵⁷ and ensure that procedures appropriately incorporate the controls that were selected based on the hazard evaluation.
- 3.4.2 DOE sites and facilities shall ensure a Chemical Hygiene Plan is in place and a Chemical Hygiene Officer is assigned for laboratory operations..⁵⁸ When applicable, use a Hazard Communication Program..⁵⁹
- 3.4.3 A CSMP shall provide workers access to SDSs, hazard information, and labeling.
- 3.4.4 A CSMP should use the hierarchy of controls to reduce the chemical exposure risk to workers. The hierarchy of controls for chemical management uses five phases in this sequence.
 - 1. Elimination entails removing the chemical hazard entirely. (Facilities may remove a chemical product from the workplace by prohibiting or restricting its use onsite.)
 - 2. Substitution is the process of replacing a chemical hazard with one that poses a lower risk.
 - 3. Engineering controls include adding a barrier between employees and chemical hazards or reducing hazardous conditions.
 - 4. Administrative controls involve modifying workplace practices to reduce exposure.
 - 5. Personal Protective Equipment (PPE) to protect employees from chemical hazards. The type and use of PPE should be determined by DOE sites and facilities when handling chemicals.
- 3.4.5 DOE sites and facilities should set hazardous chemical inventory limitations using hazard analysis as a part of a CSMP. This includes providing chemical inventory limitations to procurement professionals to inform decision making prior to purchase and reduce the risk of exceeding facility restrictions.
- 3.4.6 A CSMP should establish preventive or mitigative controls for scenarios involving the discharge of large quantities of hazardous substances and ensure their efficacy through proper design, inspection, and maintenance.
- 3.4.7 A CSMP should identify and implement codes or standards that are applicable and document any exemptions or equivalencies.
- 3.4.8 A CSMP should determine the minimal set of controls that should be in place for normal operations to be conducted. For operating procedures in the case of PSM, provide explicit instructions for conducting each covered process's activities safely in accordance with the process safety data

⁵⁶ 10 CFR Part 851.22; DOE-STD-1189-2016, section 4.1.4

⁵⁷ 10 CFR § 851.22(a)

⁵⁸ 29 CFR § 1910.1450

⁵⁹ 29 CFR § 1910.1200; 29 CFR § 1910.1450

(including determining operational limits such as consequences of deviation and steps required to correct or avoid deviation⁶⁰).

3.4.9 DOE sites or facilities should develop chemical safety training which includes:

- Methods to identify hazardous chemical presence or release and to determine suitable lower hazard chemicals;
- Discussion of chemical hazards such as physical, health, simple asphyxiation, combustible dust, pyrophoric gas, and HNO₃;
- Measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals (e.g., appropriate work practices, emergency procedures, medical consultations, and personal protective equipment);
- Using the hierarchy of controls for chemicals in the workplace and their use in the various work control methods (e.g., procedures, work orders, preventative maintenance, hazard analysis, etc.);
- Details of the hazard communication program developed by the employer (including an explanation of the labels received on shipped containers and workplace labeling system used by their employer) and the SDS (including the order of information and how employees can obtain and use the appropriate hazard information); and
- Information about the GHS.

3.4.10 A CSMP should implement safety protocols (e.g., install perchlorate wash-down systems, work at “laboratory scale”)⁶¹ when feasible in laboratory.

3.4.11 A CSMP may use Maximum Achievable Control Technology criteria for hazardous air pollutant source categories,⁶² when feasible.

3.4.12 DOE sites and facilities should choose chemical and physical hazard compatible PPE and resolve PPE conflicts (such as chemical and radiological protection).⁶³

3.5 Inspections and Surveillance

Chemical-specific inspections aim to identify and document potential chemical-specific concerns and difficulties to avoid future accidents or occurrences. A chemical inspection program consists of all of the following 3.5 subsections.

3.5.1 DOE sites and facilities shall conduct regular inspections (as defined by hazard analysis) based on hazardous chemical inventory, storage, equipment, and facilities. Line managers and workers are encouraged to participate in inspections and recommend corrective actions.

3.5.2 A CSMP shall maintain records of all hazardous chemical inspections for DOE sites and facilities.

3.5.3 Inspection frequency should be based on relevant manufacturer's recommendations, quality controls

⁶⁰ 29 CFR § 1910.119(f)

⁶¹ 29 CFR § 1910.1450

⁶² 40 CFR Part 63, National Emission Standards for Hazardous Air Pollutants by Source Categories

⁶³ 29 CFR § 1910.132(d)

for hazardous substances, safety and health rules and requirements, and engineering standards.

3.5.4 DOE sites and facilities should develop a program or procedure for inspecting chemicals.

3.5.5 A CSMP should establish and document surveillance requirements for hazardous chemicals.

Examples of surveillance include, but are not limited to:

- Inspections by fire protection officials on the management and storage of hazardous materials.⁶⁴;
- Review of the chemical inventory by emergency managers to ensure adequate emergency preparedness.⁶⁵;
- Inclusion of a qualified worker safety and health professional in work planning and control activities, including access to chemical information, to enable timely worker exposure assessments.⁶⁶ Worker safety and health professionals should evaluate chemicals and include them in a comprehensive industrial hygiene program, which includes surveys, exposure monitoring, anticipating, and controlling of chemical hazards, and mitigation for risk⁶⁷;
- Ensure trained and competent pressure safety professionals have access to chemical safety information for design, construction, testing, repair, maintenance, and operation of pressure systems.⁶⁸;
- Provide access to chemical inventory and safety information for environmental managers for purposes of satellite waste management for small and large quantity generators⁶⁹; and
- Front line supervisors and subject matter expert workers should provide oversight and assessment related to surveillance duties.

3.6 Storage of Hazardous Chemicals

Storage of hazardous chemicals includes used (e.g., waste) and unused chemicals; sealed, opened, or only partially full containers; working solutions; research-generated samples; containers for one-time use; and chemical residues left in tanks, pipes, or other containers.

3.6.1 A CSMP should follow and implement applicable chemical storage regulations as appropriate (e.g., OSHA's Materials Handling and Storage,⁷⁰ NFPA's Flammable and Combustible Liquids Code,⁷¹ EPA's Clean Air Act (CAA), and the Emergency Planning and Community Right to Know Act (state, county, or local). It should document allowed quantities, forms, sizes, stacking limitations, ventilation, and temperature when designing and operating storage rooms, when applicable.

⁶⁴ National Fire Protection Agency (NFPA) Code 400, Annex C

⁶⁵ DOE G 151.1-1B, Chapter 2

⁶⁶ 10 CFR Part 851, Appendix A.6

⁶⁷ 10 CFR Part 851, Appendix A.6

⁶⁸ 10 CFR Part 851, Appendix A.4

⁶⁹ 40 CFR § 262.15, *Satellite accumulation area regulations for small and large quantity generators*

⁷⁰ 29 CFR § 1910.176

⁷¹ NFPA 30

3.6.2 A CSMP should separate or segregate incompatible materials using distance, separate secondary containers, or separate storage cabinets or storage rooms, as appropriate.

3.6.3 A CSMP should track time-sensitive chemicals (e.g., peroxide formers).

3.7 Transportation of Chemicals

Transportation includes:

- DOT-regulated public road movement;
- Site transportation on non-public highways; and
- Building-to-building movement.

3.7.1 Transporting hazardous chemicals is regulated by DOT for public highways and DOE for non-public (DOE-owned) routes. Transportation excludes distribution in the interior of a building.⁷²

Below are some DOT-specific requirements for chemicals:

- Transport hazardous chemicals over public roads in compliance with DOT regulations⁷³;
- DOE sites or facilities should ensure onsite transfers of dangerous chemicals and repackaging of dangerous chemicals meet the original DOT specifications or obtain DOE approval of alternative packaging as described in the appropriate site transportation document;
- DOE sites or facilities should implement a site-specific shipping and receiving program or policy that includes DOT rules for labeling, placarding, and communicating hazards⁷⁴; and
- Provide DOT training to employees responsible for shipping and receiving chemicals.

3.7.2 Before delivering chemicals to a DOE site or facility, the contractor shall inform the receiving facility of the chemicals, their quantities, and packaging.

3.7.3 DOE sites and facilities should create SDSs for chemicals made on site when the chemicals will be transported to other sites or locations.⁷⁵

3.7.4 A CSMP should identify how movement of chemicals on site between buildings (e.g., building-to-building) is performed in accordance with procedures.

3.7.5 A CSMP may create procedures to take advantage of the general knowledge of DOT Materials of Trade when transporting hazardous materials at the contractor's warehouse facility.⁷⁶

3.8 Processing and Use of Chemicals

Processing and use of chemicals includes operations, maintenance, and mission-related tasks that employ hazardous chemicals in processing and usage (e.g., construction, deactivation,

⁷² DOE O 460.1D, *Hazardous Materials Packaging and Transportation Safety*

⁷³ 49 CFR Chapter 1, *Pipeline and Hazardous Materials Safety Administration, Department of Transportation*

⁷⁴ 49 CFR Part 172, Subpart E (labeling) or Subpart F (placarding); 29 CFR § 1910.1200

⁷⁵ 29 CFR § 1910.1200(g)(1)

⁷⁶ 49 CFR § 173.6

decontamination, demolition of facilities).

- 3.8.1 A CSMP shall manage chemicals and chemical compounds from acquisition to disposal.
- 3.8.2 DOE sites and facilities shall conduct work using applicable safe work practices and hazard controls.
- 3.8.3 DOE sites and facilities shall ensure training of personnel in emergency response procedures in case of a spill, operational abnormality, or emergency when using chemicals as a part of emergency management and industrial hygiene programs.
- 3.8.4 DOE sites and facilities shall coordinate emergency response protocols with emergency management, including protocols for responding to chemical monitoring alarms and a response for potential Immediately Dangerous to Life or Health (IDLH) situations, such as oxygen alarms.
- 3.8.5 DOE sites and facilities that use chemicals in pressure systems shall have procedures that inform workers of hazards and protective measures.⁷⁷ Pressure system procedures shall fulfill American Society of Mechanical Engineers standards, or state or local rules where national consensus codes are not applicable.⁷⁸
- 3.8.6 DOE sites and facilities shall ensure that incompatible chemicals do not mix. If mixing such chemicals is required for facility operations, then they should ensure that any reactions are controlled to avoid adverse effects (e.g., by controlling amounts, concentrations, temperatures, or pressures).
- 3.8.7 Operations using explosives should list chemicals used in operations, specifications of approved chemicals, and hazards involving chemicals.⁷⁹
- 3.8.8 DOE sites and facilities should install chemical monitoring systems, where appropriate, as determined by a hazard assessment in chemical use and storage areas. Alarms should be set for the monitors to assure safe evacuation of personnel and interlocks installed to isolate leaks or releases at the source. Facilities with significant quantities of hazardous chemicals should have public address systems to warn all facility workers, including those who may not be aware of the situation, and direct them to take protective actions (e.g., evacuation).
- 3.8.9 DOE sites and facilities should employ pressure relief devices where required or appropriate, and ensure chemical piping systems are maintained in accordance with applicable consensus standards.
- 3.8.10 DOE sites and facilities should be designed to include appropriate provisions to monitor chemical releases remotely as indicated by a hazard assessment, so emergency responders may assess the facility conditions before entering.
- 3.8.11 DOE sites and facilities should evaluate the use of ventilation system designs (e.g., dispersion at the exhaust point/stack outside the facility) for work tasks that have potential chemical exposure to workers.

⁷⁷ 10 CFR § 851.21

⁷⁸ 10 CFR Part 851 Appendix A.4.a

⁷⁹ DOE-STD-1212-2019, Chg 1

- 3.8.12 Responding to a chemical monitor or oxygen alarm should be done by trained and qualified personnel who don appropriate PPE including a Self-Contained Breathing Apparatus (SCBA)⁸⁰ for unknown concentrations or IDLH conditions.

3.9 Disposition of Chemicals

Reuse, recycling, and disposal are the main methods for disposing of chemicals. Reusing, transferring, giving, selling, destroying, or disposing of chemicals and chemical products are examples of disposition. Disposal as waste is the least desirable option in the chemical disposition process. Chemical reuse, when safe to do so, is the preferred way to use up chemicals. Disposal specifications include all of the following 3.9 subsections:

- 3.9.1 A CSMP shall establish processes for determining the safe disposal of surplus, unused, expired, or unusable chemicals.
- 3.9.2 A CSMP shall implement a program or strategy for waste reduction using efforts that should stress acquisition of the minimum amounts of chemicals needed and a means for rapid disposal when they are no longer required or acceptable for use.
- 3.9.3 A CSMP shall comply with applicable EPA, OSHA, and DOE treatment and storage facility regulations when disposing of chemicals.⁸¹
- 3.9.4 A CSMP shall implement waste labeling requirements per the Resource Conservation and Recovery Act and other federal, state, and local regulations.⁸²
- 3.9.5 A CSMP should monitor the lifecycle of chemicals with a particular focus on age- or time-related deterioration (i.e., reactivity, instability, shock-sensitivity, degradation products) or expiration date, and dispose of them once considered unnecessary or ineffective.
- 3.9.6 A CSMP should include packaging requirements, disposal destination, separation of reactive chemicals, compatibility, and segregation of hazardous and non-hazardous waste streams in the documented technique or process for the safe disposal of chemicals.
- 3.9.7 A CSMP should establish strategies and methods to handle hazardous solid waste, mixed trash, universal waste, and other regulated waste.
- 3.9.8 A CSMP should align and consult disposal procedures with waste categorization methodology and SDSs when examining potential threats.

⁸⁰ 29 CFR § 1910.134, a full facepiece pressure demand SCBA certified by NIOSH for a minimum service life of thirty minutes, or a combination full facepiece pressure demand supplied-air respirator (SAR) with auxiliary self-contained air supply for unknown

⁸¹ 40 CFR Parts 264 and 265 and 29 CFR § 1926.250

⁸² 40 CFR § 262.34(c)(1)(ii)

3.10 Feedback and Improvement

Providing feedback and continuous improvement are core functions of DOE ISMS. This includes identifying performance measures that can be used to determine that the chemical management system is performing as intended and to identify methods to improve when it is not.

- 3.10.1 A CSMP shall report and investigate chemical incidents..⁸³
- 3.10.2 A CSMP should conduct independent assessments or self-assessments to identify improvement possibilities. It should ensure periodic program evaluations that include employee engagement and input, and integrate program and contractor self-assessments for quality and contractor assurance.
- 3.10.3 A CSMP should emphasize self-assessments to verify the chemical inventory is accurate, identify dangerous chemical conditions before events occur, and ensure hazard controls that are implemented are appropriate and working as intended.
- 3.10.4 A CSMP should use post-job briefings and other means of engagement to get worker input on hazard control implementation as well as potential issue resolution.
- 3.10.5 DOE sites and facilities should share lessons learned to prevent similar or repeat mishaps at other locations and facilities..⁸⁴

3.11 Program Management

The program management element of a CSMP encompasses the administrative and management requirements necessary for a complete and adequate program. A CSMP embraces the ISMS guiding principles, emphasizing clear roles and responsibilities and competencies commensurate with responsibilities..⁸⁵

- 3.11.1 An appointed program manager identifies, develops, and approves the chemical management program's scope, which includes any relevant regulatory requirements, techniques, and procedures for the site or facility. The manager is responsible for program execution and verifies the site chemical management program satisfies requirements. This includes escalating recurring issues through contract and government entities to secure resources and support. The program shall identify and follow DOE requirements for identifying and controlling hazardous chemicals.
- 3.11.2 Program management determines program roles, responsibilities, and resources. Program management ensures line managers know their role with respect to the chemical management system and protecting their workers. Each hazardous chemical shall have a custodian, who is accountable for the lifecycle of chemical at the facility which includes procurement, storage, transit, use and processing, and disposal..⁸⁶
- 3.11.3 Program management is responsible for detecting and communicating threats and hazard controls to personnel. Management should ensure that the workers are trained on the hazards and means of

⁸³ DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information*

⁸⁴ DOE O 210.2A, *Corporate Operating Experience Program*

⁸⁵ 10 CFR § 851.20

⁸⁶ 10 CFR § 851.25

immediate protection in case of an abnormal occurrence..⁸⁷

- 3.11.4 Line managers should ensure that workers (including federal staff) receive chemical safety training which should be activity or job specific..⁸⁸
- 3.11.5 A CSMP should include base training content and frequency on a needs analysis and regulatory requirements (such as DOT regulations), set training intervals, and ensure staff are trained and qualified to perform work.
- 3.11.6 A CSMP should describe information (e.g., SDS, approved technical procedures, hazard abatement strategies) for any operations in the work site where hazardous chemicals are present.
- 3.11.7 A CSMP should include training techniques and observations to recognize a dangerous chemical in the workplace.
- 3.11.8 A CSMP should train workers on physical and health hazards of chemicals, exposure symptoms, work practice controls (e.g., monitoring alarms, signs, labels), PPE, chemical storage requirements, and emergency procedures..⁸⁹
- 3.11.9 A CSMP should be integrated with other SMPs. Effective integration requires reporting, documenting, and exchanging SMP inputs and outputs.
- 3.11.10 Management should ensure all improvement actions are formally evaluated in a timely manner.
- 3.11.11 DOE sites and facilities should follow relevant codes and standards such as NFPA 400 Hazardous Material Code and ISMS for continuous improvement of the program in order to manage a CSMP.

⁸⁷ 10 CFR § 851.20(a)(2), (3); 29 CFR § 1910.1200(h)(1)

⁸⁸ 10 CFR § 851.20(a)(2), (3); 10 CFR § 851.25

⁸⁹ 29 CFR § 1910.1200(h)

APPENDIX A: APPLICABILITY OF THE CHEMICAL SAFETY MANAGEMENT PROGRAM TO NUCLEAR FACILITIES AND DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

Appendix A is intended to provide guidance for using a Chemical Safety Management Program (CSMP) at DOE Hazard Category (HC) 1, 2, and 3 nuclear facilities as a Safety Management Program (SMP) to comply with the requirements outlined in 10 CFR Part 830, Subpart B, *Safety Basis Requirements*.

A CSMP is one of the safety management programs that may be relied on in the DSA to ensure safe operation of HC-1, 2, and 3 nuclear facilities, and may provide a foundation for future integrations based upon the requirements of 10 CFR Part 830, Subpart B, the associated requirements documents, and methodologies used for DSA preparation as a recognized SMP. However, the DSA remains the controlling “documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment,” for HC-1, 2, and 3 nuclear facilities, as required by 10 CFR §830.204, *Documented safety analysis*. A CSMP does not relieve, and must not conflict with, any of these requirements.

The following requirements of 10 CFR § 830.204 are particularly germane while using a CSMP in preparing DSAs for HC-1, 2, and 3 nuclear facilities [emphasis added in ***bold italics***]:

§ 830.204

* * *

(b) The documented safety analysis for a Hazard Category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility:

* * *

(2) Provide a systematic ***identification of both natural and man-made hazards*** associated with the facility;

(3) Evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, ***identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials***, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility;

(4) Derive the hazard controls necessary to ensure adequate protection of workers, the public, and the environment, ***demonstrate the adequacy of these controls to eliminate, limit, or mitigate identified hazards***, and define the process for maintaining the hazard controls current at all times and controlling their use;

(5) *Define the characteristics of the safety management programs necessary to ensure the safe operation of the facility*, including (where applicable) quality assurance, procedures, maintenance, personnel training, conduct of operations, emergency preparedness, fire protection, waste management, and radiation protection;

* * *

APPENDIX B: REFERENCES

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