

*** Note: This is a proposed revision to Chapter 7 of NUREG1520 ***

7. FIRE SAFETY

7.1 Purpose of Review

The purpose of this review is to determine with reasonable assurance that the applicant has designed a facility that provides adequate protection against fires and explosions that could affect the safety of licensed materials and thus present an increased radiological or chemical risk. The review should also establish that the applicant has considered the radiological and chemical consequences of the fires and will institute suitable safety controls to protect workers, the public, and the environment.

Fire safety issues are initially evaluated as part of the applicant's integrated safety analysis (ISA) summary. The ISA summary must evaluate credible accident sequences at the facility; identify items relied on for safety (IROFS) to prevent the occurrence or to mitigate the consequences of accidents; and include the management measures that provide reasonable assurance of the availability and reliability of IROFS, when needed. Reviewers assess the applicant's approach to protecting against fire and explosion hazards by examining the license application and the ISA summary to gain familiarity with the following:

- process information and accident sequences leading to conditions that could pose fire hazards
- IROFS and sole IROFS, used to prevent or mitigate such fire hazards
- management measures applied to ensure that IROFS will be available and reliable when required

7.2 Review Responsibilities

Primary: Fire Safety Specialist

Secondary: Criticality Safety Specialist
Environmental Specialist
Chemical Safety Specialist
Physical Security Specialist

Supporting: Regional, Resident, and Fuel Cycle Inspection Staff

7.3 Areas of Review

The regulation established in Title 10, Section 70.62(a), of the *Code of Federal Regulations* (10 CFR 70.62(a) requires an applicant to develop, implement, and maintain a safety program that will reasonably protect the health and safety of the public and the environment from the fire and explosive hazards associated with processing, handling, and storing licensed materials during normal operations, anticipated operational occurrences, and credible accidents. The fire protection program must address these process-specific risks, as well as general fire prevention, protection, and management issues. Although 10 CFR Part 70, "Domestic

Licensing of Special Nuclear Material,” does not require a separate fire safety program, an applicant should provide commitments pertaining to fire safety in the following areas:

- Fire safety management includes safety organization, engineering review, fire prevention; inspection, testing, and maintenance; prefire plans; and personnel qualifications, drills, and training.
- Fire risk identification includes the fire hazards analysis (FHA) and the ISA summary.
- Facility design includes information on building construction, fire areas, life safety, ventilation, and electrical system design. The facility design should also consider competing requirements among fire safety and security, criticality, and environmental concerns.
- Process fire safety involves design considerations to prevent an accident or to mitigate the consequences of an accident resulting from using process chemicals, combustible metals, flammable and combustible liquids and gases, high-temperature equipment, hot cells and glove boxes, and laboratories.
- Fire protection systems include fire detection, alarm, and suppression systems; portable extinguishers; water supplies; and emergency response organizations.

Review Interfaces

- Review information about the facility and process descriptions related to fire safety as required under Standard Review Plan (SRP) Chapter 1.
- Review information on safety program, ISA commitments, and ISA documentation applied to fire safety as required under SRP Chapter 3.
- Review information on controls applied to chemical processes for fire safety as required under SRP Chapter 6.
- Review information on configuration management, maintenance, training and qualifications, procedures, audits and assessments, incident investigations, record management, and other quality assurance elements as required under SRP Chapter 11 as related to fire safety.

7.4 Acceptance Criteria

An applicant that meets the acceptance criteria defined in this section, or that has provided an acceptable alternative, should be considered as having provided reasonable assurance of an acceptable fire protection program.

7.4.1 Regulatory Requirements

The regulatory basis for the fire safety review should be the requirements of 10 CFR 70.22, “Contents of Applications,” and 10 CFR 70.65, “Additional Content of Applications.” In addition, the fire safety review should focus on providing reasonable assurance of compliance with 10 CFR 70.61, “Performance Requirements”; 10 CFR 70.62, “Safety Program and Integrated Safety Analysis”; and 10 CFR 70.64, “Requirements for New Facilities or New Processes at Existing Facilities.”

7.4.2 Regulatory Guidance

The relevant regulatory guidance for fire safety includes the following U.S. Nuclear Regulatory Commission (NRC) and industrial standards:

- National Fire Protection Association (NFPA), “Standards for Facilities Handling Radioactive Material,” NFPA Standard 801, latest edition.
- U.S. Nuclear Regulatory Commission, “Integrated Safety Analysis Guidance Document,” NUREG-1513, May 2001.
- U.S. Nuclear Regulatory Commission, “Nuclear Fuel Cycle Facility Accident Analysis Handbook,” NUREG/CR-6410, March 1998.

7.4.3 Regulatory Acceptance Criteria

Partial acceptability of the application and the ISA summary will be contingent on the NRC staff’s review of the applicant’s commitments to control and mitigate fire hazards. The staff will focus on whether the application is risk informed, addresses the applicant’s procedures for maintaining an acceptable level of fire safety, and demonstrates that the applicant is prepared to react quickly and safely to extinguish fires. An applicant may use a graded approach to define fire safety but must provide sufficient documentation and commitments to ensure that workers, the public, and the environment will be adequately protected from fire events.

These acceptance criteria may be incorporated in the information supplied to satisfy SRP Section 3 (ISA) or other SRP sections, as long as clear cross-references are given (information need not be repeated). The staff’s fire safety specialist will review the application, ISA summary, and other documentation, as needed, regarding these acceptance criteria.

The reviewer(s) will use nationally recognized codes and standards, as appropriate, in evaluating a reasonable assurance of fire safety. These include, but are not limited to, the NFPA “National Fire Codes,” Factory Mutual Data Sheets and Approval Guide, Underwriters Laboratories Standards and Building Material Directory, American National Standards Institute standards, and American Society for Testing and Materials standards. Commitments to specified standards will normally be considered an acceptable means of meeting the acceptance criteria.

The NRC staff will review the application to ensure that it meets the acceptance criteria discussed below.

7.4.3.1 Fire Safety Management Measures

An adequate application documents how the applicant will administer and ensure fire safety at the licensed facility. The application should reflect a commitment to ensure that the IROFS, as identified in the ISA summary, are available and reliable, and the facility maintains fire safety awareness among employees, controls transient ignition sources and combustibles, and maintains a readiness to extinguish the fire or limit its consequences. These measures are unique to fire safety and, therefore, are not included in the acceptance criteria for SRP Section 11.

An adequate application identifies a senior-level manager who has the authority and staff to ensure that fire safety receives appropriate priority. A facility safety committee or fire safety review committee staffed by managers of different disciplines should integrate facility modifications. (The facility safety committee can do the work of a fire safety review committee.) As described in the application, an individual with sufficient practical fire safety experience in nuclear facilities should supervise day-to-day fire safety.

The “Standard for Fire Protection for Facilities Handling Radioactive Materials” (NFPA 801), specifies the following fire safety management measures: fire prevention; inspection, testing, and maintenance of fire protection systems; emergency response organization qualifications, drills, and training; and pre-fire plans. An adequate application documents the fire safety management measures in sufficient detail to identify their relationship to, and functions in, normal operations, anticipated (off-normal) events, and accident safety (i.e., IROFS). The staff recognizes NFPA 801 as one acceptable standard for fire safety management measures; however, the applicant may use other nationally recognized codes and standards if appropriate.

7.4.3.2 Fire Hazards Analysis

Knowing the fire risk allows an applicant to apply the appropriate level of fire protection to ensure the safety of workers, the public, and the environment from fire-induced radiological or chemical hazards. To be risk informed, a licensee should conduct an FHA for each facility, or part thereof, that, if totally consumed by fire, could release special nuclear material (SNM) in quantity and form that could cause at least an intermediate consequence, as defined in 10 CFR 70.61. The FHA should develop bounding credible fire scenarios for each fire area containing significant fire loading and then assess the consequences of an unmitigated fire. The staff recognizes NFPA 801 as one standard that provides guidance for conducting FHAs; however, the applicant may use other nationally recognized codes and standards if appropriate. The FHA should include a description, by fire area, of the fuel loading, fire scenarios, methods of consequence analysis, the potential consequences, and a description of the mitigative and/or preventive controls.

The FHA is used to identify possible fire initiators and accident sequences leading to radiological consequences or toxic chemical consequences resulting from interaction with SNM. In developing accident sequences that will be reported in the ISA summary, the ISA team will

consider the FHA results and assign likelihoods to the various events in the accident sequences. With respect to fire safety, the ISA summary is acceptable if the credible fire hazards (e.g., from the FHA) are identified for each process fire, and details are given as to how each fire hazard was considered and addressed (i.e., the management measures and/or IROFS) for each process accident sequence whose consequence could exceed the performance requirements in 10 CFR 70.61. Thus, the FHA is a fundamental tool for evaluating fire hazards as input to the ISA evaluation.

Deviations from NFPA Codes and Standards

When the applicant/licensee states that its design “meets the NFPA code(s)” or “meets the intent of the NFPA codes” and does not identify any deviations from such codes, the NRC expects that the design conforms to the codes and is subject to inspection against the NFPA code of record. A licensee may apply the equivalency concept in meeting the provisions of the NFPA codes or standards. Nothing in the NFPA codes or standards is intended to prevent the use of methods, systems or devices of equivalent or superior quality, strength, fire resistance, durability, and safety as alternatives to those prescribed by the codes or standards, provided technical documentation demonstrates equivalency and the method, system, or device is listed or approved for the intended purpose. Recent editions of the NFPA codes require submittal of technical documentation to the “authority having jurisdiction” (AHJ) to demonstrate equivalency of an alternative system, method or device. The NRC does not require review and approval of equivalency evaluations. However, the licensee should document these evaluations and make them available for NRC inspection. The AHJ (as described in NFPA documents) refers to the Director of the NRC’s Office of Nuclear Material Safety and Safeguards, or designee.

7.4.3.3 Facility Design

Building construction, fire area determination, electrical installation, life safety, ventilation, drainage, and lightning protection are all facility design features that affect fire safety. The staff recognizes NFPA 801 as one standard that specifies acceptable facility fire safety design criteria; however, the applicant may use other nationally recognized codes and standards, if appropriate. An adequate application documents the fire safety considerations used in the general design of fuel cycle facilities. The following is a list of fire safety related design information normally reviewed by the NRC staff in a license review:

- Type of construction (as per NFPA 220 “Standard on Types of Building Construction,” if a new building), applicable building codes (if existing building) with comparison to NFPA 220 building types
- Identification of building material, fire duration rating (if known), description of exterior openings
- Overall description of fire detection system, including degree of compliance with NFPA 72 “National Fire Alarm Code” for design, installation, surveillance, testing, and maintenance.

- Overall description of automatic fire suppression system, applicable design standards, system design basis, identification of standards for surveillance, testing, and maintenance procedures.
- Description of water distribution system including descriptions of fire pumps, fire mains including location of sectionalizing valves, maximum fire demand and compliance with applicable NFPA standards.

In addition to standard industrial fire safety concerns, the application should also address the following nuclear safety, environmental protection, and physical security issues:

- Criticality concerns may exclude water extinguishing systems from process areas. However, during major fire events, the fire may easily overcome the extinguishing capability of portable extinguishers, and hose lines may be needed to extinguish the fire. Consequently, applicants should consider using total flooding gaseous systems in water-exclusion areas with significant fire risks. An adequate application addresses the methodology for extinguishing fires in water-exclusion areas.
- Environmental concerns include the potential for thousands of gallons of fire water to be contaminated with nuclear material during a fire event. Consequently, diked areas and drainage of process facilities may be needed. NFPA 801 provides guidance on how to calculate the potential amount of runoff to properly size drainage and containment systems. An adequate application documents any measures used to control fire water runoff.
- Physical security concerns include the need to design buildings and facilities to provide safe egress in case of fire. Physical security requirements for SNM may inadvertently delay worker egress and firefighter access. Physical security procedures should allow offsite fire departments quick and efficient access to fire emergencies. An adequate application documents the design criteria used for worker egress and procedures for firefighter access. The staff recognizes NFPA 801 as one standard that specifies acceptable worker egress design criteria; however, the applicant may use other nationally recognized codes and standards, if appropriate.

Design and construction of new facilities must comply with the baseline design criteria (BDC) specified in 10 CFR 70.64(a) and comply with the defense-in-depth requirements of 10 CFR 70.64(b). The design and construction should be consistent with the guidance provided in NFPA 801 or other appropriate nationally recognized fire protection codes and standards.

7.4.3.4 Process Fire Safety

Many hazardous chemicals and processes used by fuel cycle facilities contribute to the fire hazards. In areas that have fire hazards that may threaten licensed material, the application should identify the hazardous chemicals, processes, and design standards used to ensure fire safety. The staff recognizes NFPA 801 as one standard that provides acceptable design criteria

for radiological process areas that may contain hazardous material, laboratories, high-temperature equipment, hot cells, and/or glove boxes. However, the applicant may use other nationally recognized codes and standards, if appropriate.

The following are a few of the more common hazardous materials used at fuel cycle facilities:

- Anhydrous ammonia is an explosive, flammable, and toxic gas used to make hydrogen.
- Fluorine reacts violently with organic material or metal powders and water vapor.
- Hydrogen is an explosive and flammable gas used in reduction processes.
- Hydrogen peroxide off-gases hydrogen and oxygen and is incompatible with some extinguishers.
- Nitric acid nitrates organic material, which lowers the ignition temperature of combustibles.
- Sulfuric acid absorbs water from organic material in an exothermic reaction, thereby causing ignition.
- Zirconium is a combustible metal that burns at elevated temperatures.
- Calciners and incinerators are sources of heat that have initiated fires at fuel cycle facilities.

The applicant should identify fire and explosion hazards, fire and/or explosion parameters of hazardous materials and degree of compliance with applicable codes (e.g., NFPA 30 “Flammable and Combustible Liquids Code”, NFPA 69 “Standard on Explosion Prevention Systems”, NFPA 86 “Standard for Industrial Furnaces”).

In addition to participating in the integrated review of the ISA summary performed in accordance with Chapter 3 of the SRP, the reviewer should also examine in detail the fire-initiated release scenarios provided in the ISA summary to demonstrate compliance with 10 CFR 70.61. This review should follow the guidance provided in applicable subsections of Chapter 3 of the SRP to include a detailed evaluation of these scenarios including review of fire initiators, fire-induced consequences, the likelihoods of such consequences, and IROFS chosen to prevent or mitigate those consequences.

7.4.3.4.1 Fire-Initiated Accident Sequences

The following factors should be considered in determining the acceptability of the applicant’s descriptions of fire-initiated accident sequences:

- Fire hazard descriptions are detailed enough to permit an understanding of the fire hazards sufficient to allow evaluation of potential accident sequences.

- The applicant adequately describes the consequences and likelihoods of accident sequences identified in the ISA summary involving fire, including risks from hazardous chemicals produced from licensed material, as well as risks from radioactive materials.
- A justification of the initiation probability is provided with enough detail for the reviewer to make an independent verification for those scenarios where the initiation probability appears to be unconservative. If controls are relied on to achieve this initiation probability, they should be identified as IROFS as appropriate.
- Controls that are used to mitigate or prevent the scenario are identified as IROFS or as defense-in-depth measures. For those controls that are IROFS, reliability and associated management measures must be indicated.
- Analyses that the applicant has performed as part of the evaluation are part of the ISA and referenced.

7.4.3.4.2 IROFS and Associated Management Measures

Based on a comparison of the unmitigated fire protection accident sequence consequences with the performance criteria of 10 CFR 70.61, the applicant should identify (in the ISA summary) fire protection safety controls suitable to prevent or mitigate potential accidents. If the applicant takes a graded approach to safety in accordance with 10 CFR 70.62(a), the reviewer should establish that the grading of IROFS and associated management measures are appropriate and sufficient to protect against fire-related risks.

The NRC staff should also review management measures to ensure the availability and reliability of such IROFS when they are required to perform safety functions. The ISA summary should demonstrate that the management measures proposed to ensure that IROFS are available and reliable when required by briefly describing the following:

- measures to ensure the reliable operation of engineered controls (e.g., inspection and testing procedures and frequencies, calibration programs, functional tests, corrective and preventive maintenance programs, and criteria for acceptable test results)
- measures to ensure that administrative controls will be correctly implemented when required (e.g., employee training and qualification in operating procedures, refresher training, safe work practices, development of standard operating procedures, and training program evaluations)
- compliance of IROFS with all applicable NFPA or industry consensus fire codes and standards, as a minimum, IROFS should comply with those sections of the codes or standards affecting the reliability and effectiveness of the IROFS

7.4.3.5 Fire Protection and Emergency Response

The application should document the fire protection systems and fire emergency response organizations provided for licensed facilities. The ISA summary should identify the fire protection IROFS. An adequate application describes the fire protection for areas in which licensed material is present. The application should describe which standards the fire protection systems and equipment meet. The staff recognizes the NFPA's national fire codes as acceptable standards for the design, installation, testing, and maintenance of the fire protection systems and equipment. However, the applicant may use other nationally recognized codes and standards, if appropriate.

Facilities with the potential for rapidly developing fires that do not have an adequate nearby emergency responder may need an onsite fire emergency response team. One acceptable standard is NFPA 600, "Industrial Fire Brigades." However, the applicant may use other nationally recognized codes and standards, if appropriate. If offsite fire departments are needed for facility fire safety, periodic training with the fire departments is necessary so that offsite departments will become familiar with facility access procedures, facility layout, and prefire plans. A memorandum of understanding between the applicant and the fire departments is recommended to define the required protection. The staff's fire safety specialist will review the adequacy of the applicant's fire protection and emergency response commitments.

7.4.3.6 Requirements for New Facilities or New Processes at Existing Facilities

The application and/or ISA summary should address the BDC as required under 10 CFR 70.64 for new facilities or new processes at existing facilities that require a license amendment under 10 CFR 70.72, "Facility Changes and Change Process." With respect to fire safety, the application should be considered acceptable if it includes the information listed below (or references other sections of the application that include this information):

- The application should briefly describe how the ISA was performed for the new process, including its use and relationship to the performance requirements in 10 CFR 70.61, the BDC, and a defense-in-depth strategy for higher risk accident sequences. Acceptable principles for defense-in-depth of the fire safety design would be those that support hierarchy of controls with preference for prevention of releases (over mitigation of consequences) and engineered controls over administrative controls.
- The ISA summary should describe how BDC(3), "Fire Protection," was applied in establishing the design principles, features, and control systems of the new process. This will normally involve a commitment to follow appropriate codes and standards for design, testing, surveillance, and maintenance of fire protection systems including those that are not IROFS but may involve nuclear processes or buildings housing nuclear material.

7.5 Review Procedures

7.5.1 Acceptance Review

During the acceptance review, the primary reviewer evaluates the application for completeness as required by 10 CFR Part 70 and determines whether the application addresses the criteria discussed in SRP Section 7.3. If significant deficiencies in the application are identified, the primary reviewer should recommend the return of the application or request additional information before the start of the safety evaluation.

7.5.2 Safety Evaluation

During the safety evaluation, the primary and secondary reviewers determine whether the application comprehensively describes the fire safety of the licensed activity as identified in SRP Section 7.3 and assess the commitments made in response to the criteria specified in Section 7.4. The staff may ask the applicant or licensee to provide additional information or modify the submittal to meet the acceptance criteria.

Reviewers should note that NFPA 801 uses “administrative control” in a different sense than the term is used in 10 CFR Part 70 and elsewhere in this SRP. In 10 CFR Part 70, an administrative control is an IROFS if it is the human action necessary to meet safety performance requirements, and it is supported by management measures (training, quality assurance, procedures, etc.) that ensure that the action will be taken if needed. In NFPA 801, “administrative controls” refer to the training, qualifications, and procedures behind the human action; however, these elements are referred to as “management measures” in 10 CFR Part 70, and in this SRP.

For an existing facility, the reviewer may consult cognizant NRC inspectors to identify and resolve any issues related to the licensing review. For a planned facility, the reviewers may wish to consult with the facility design team to gain a better understanding of the process, its potential hazards, and safety approaches.

The primary reviewer will prepare a safety evaluation report (SER) for the licensing project manager in support of the licensing action.

7.5.2.1 Fire-Related Risks and Accident Sequences

The results of the ISA are the basis for the fire safety evaluation. The reviewer should assess the fire risks identified in the ISA summary and ensure that the level of safety is reflected in the design and the operational plans for the facility. The reviewer should establish that the applicant’s facility design, operations, and IROFS for fire and explosion safety provide reasonable assurance that they will function as intended and provide for the safe handling of licensed material at the facility.

7.5.2.2 *IROFS and Management Measures*

The staff reviews the fire and explosion IROFS to ensure their adequacy in protecting against all unmitigated sequences identified in the ISA summary.

If the applicant has applied a graded approach to safety, the reviewer should establish that the grading of IROFS or management measures is appropriate and sufficient to protect against fire and explosion risks.

7.5.2.3 *Requirements for New Facilities or New Processes at Existing Facilities*

The staff reviews the applicant's commitments as required to satisfy the BDC, given in 10 CFR 70.64(a), for the design of new facilities or new processes at an existing facility that require a license amendment under 10 CFR 70.72.

7.6 **Evaluation Findings**

The staff's review should verify that the applicant (1) provides sufficient information to satisfy the intent of 10 CFR Part 70 requirements related to the overall safety program and (2) is consistent with the fire safety criteria in this SRP. On the basis of this information, the staff should be able to evaluate whether the application meets the appropriate criteria. As an example, the staff might document the fire safety review in an SER in the following manner:

The applicant has established a fire protection function meeting the acceptance criteria in Chapter 7 of the "SRP for the Review of a License Application for a Fuel Cycle Facility." The function includes a facility safety review committee responsible for integrating modifications to the facility and a Fire Safety Manager responsible for day-to-day program implementation. Fire prevention, inspection, testing, and maintenance of fire protection systems, and the qualification, drills, and training of facility personnel are in accordance with applicable NFPA codes and standards. (Note that fire protection training requirements are described in SER Section 11.3.)

The applicant has conducted risk analyses in accordance with NFPA 801, "Standard for Fire Protection for Facilities Handling Radioactive Material." The FHAs identified credible fire scenarios that bound the fire risk. The ISA used these scenarios and identified fire protection IROFS (in particular, wet pipe sprinkling in the process areas, isolation of the high-temperature equipment within fire barriers, and a fire brigade meeting NFPA 600, "Industrial Fire Brigades"). An MOU with the fire department documents the required assistance and the annual exercises. Procedures are in place to allow the fire department efficient access to process areas during fire emergencies. Worker egress is designed and maintained in accordance with NFPA 101, "Life Safety Code."

The applicant has demonstrated that appropriate fire safety considerations were incorporated in the design of its facilities. The applicant has also demonstrated that the facility has appropriate active fire protection systems.

The staff concludes that the applicant's submittals provide sufficient information in accordance with requirements of 10 CFR 30.33, 40.32, 70.22, and 70.65 regarding potential fire hazards, consequences, and required controls for the proposed ACP processes. The NRC staff determined that the applicant demonstrated compliance with the performance requirements of 10 CFR 70.61 for fire protection related to postulated accident scenarios. The design the applicant proposes also satisfies the requirements of 10 CFR 70.64(a) Baseline Design Criteria (3) "Fire protection" as well as 10 CFR Part 70.64(b), defense in depth (as required).

7.7 References

U.S. Code of Federal Regulations, Chapter I, Title 10, "Energy," Part 70, "Domestic Licensing of Special Nuclear Material," as revised.

National Fire Protection Association, "National Fire Codes," latest edition.

U.S. Nuclear Regulatory Commission, "Uranium Oxide Fires at Fuel Cycle Facilities," Information Notice No. 92-14, February 21, 1992.

U.S. Nuclear Regulatory Commission, "Integrated Safety Analysis Guidance Document," NUREG-1513, May 2001.

U.S. Nuclear Regulatory Commission, "Nuclear Fuel Cycle Facility Accident Analysis Handbook," NUREG/CR-6410, March 1998.