# 7 INSTRUMENTATION AND CONTROL SYSTEMS

NUREG-1537 was originally written for heterogeneous non-power reactors. This ISG augments NUREG-1537, Part 1, to make it applicable to aqueous homogeneous non-power reactors and radioisotope production facilities. Additional sections have been added to this chapter as follows:

- Chapter 7a.1, "Heterogeneous Reactor Instrumentation and Control Systems"
- Chapter 7a.2, "Aqueous Homogeneous Reactor Instrumentation and Control Systems"
- Chapter 7b, "Radioisotope Production Facility Instrumentation and Control Systems"

Guidance for each of these options follows.

As of the date of this ISG, the NRC was preparing revised guidance concerning digital instrumentation and control (I&C) systems for non-power reactors (NPR). This ISG updates the original reference material so that NUREG-1537 reflects the most recent guidance at the time of ISG issuance. Applicants for licenses subsequent to the issuance of this ISG should check for any new guidance at the time of application, particularly in the area of NPR digital I&C.

## 7a.1 Heterogeneous Reactor Instrumentation and Control Systems

NUREG-1537, Part 1, Chapter 7, should be used for guidance in preparing this chapter.

## 7a.2 Aqueous Homogeneous Reactor Instrumentation and Control Systems

NUREG-1537, Part 1, Chapter 7, should be used for guidance in preparing this chapter.

## 7b Radioisotope Production Facility Instrumentation and Control Systems

NUREG-1537, Part 1, Chapter 7, applies to I&C systems for a reactor. It could also apply to I&C systems for a radioisotope production facility. Where the guidance specifically refers to the "reactor system," it should be interpreted to mean the "radioisotope production facility", as appropriate (i.e., radioisotope extraction and purification processes or the SNM preparation and handling processes outside of the reactor).

Applicants for radioisotope production facility licenses should also refer to NUREG-1537, Part 2, Chapter 7b, for specific information that should be included in the SAR.

## Bibliography

The current status of cited reference material is as follows:

- ANSI/ANS 10.4, "Verification and Validation of Non-Safety-Related Scientific and Engineering Computer Programs for the Nuclear Industry," was updated in 2008.

- ANSI/ANS 15.15, "Criteria for the Reactor Safety Systems of Research Reactors," was withdrawn in 1996.

- ANSI/ANS 15.20 (draft), "Criteria for the Reactor Control and Safety Systems of Research Reactors," was never issued.

- Institute for Electrical and Electronic Engineers (IEEE) Standard 7-4.3.2, “Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations,” was updated in 2010.

## Appendix 7.1

NRC Regulatory Guide 1.152, Revision 1, “Criteria for Use of Computers in Safety Systems of Nuclear Power Plants,” issued January 1996, should be replaced with the current version, Revision 3, issued July 2011.

# 8 ELECTRICAL POWER SYSTEMS

NUREG-1537 was originally written for heterogeneous non-power reactors. This ISG augments NUREG-1537, Part 1, to make it applicable to aqueous homogeneous non-power reactors and radioisotope production facilities. Additional sections have been added to this chapter as follows:

- Chapter 8a.1, "Heterogeneous Reactor Electrical Power Systems"
- Chapter 8a.2, "Aqueous Homogeneous Reactor Electrical Power Systems"
- Chapter 8b, Radioisotope Production Facility Electrical Power Systems"

Guidance for each of these options follows.

## 8a.1 Heterogeneous Reactor Electrical Power Systems

NUREG-1537, Part 1, Chapter 8, should be used for guidance in preparing this chapter.

## 8a.2 Aqueous Homogeneous Reactor Electrical Power Systems

NUREG-1537, Part 1, Chapter 8 should be used for guidance in preparing this chapter.

## 8b Radioisotope Production Facility Electrical Power Systems

NUREG-1537, Part 1, Chapter 8, should be used for guidance in preparing this chapter, provided that where there is a reference to the "reactor," it should be interpreted to mean the "radioisotope production facility," as appropriate. Where the reactor and production facility share a common electrical supply system, that fact should be noted, and it is not necessary to duplicate the information here.

## 8b.1 Normal Electrical Power Systems

This section of NUREG-1537 can apply to the radioisotope production facility. References to the "reactor" should be interpreted to mean the "production facility", as appropriate.

## 8b.2 Emergency Electrical Power Systems

This section can apply to any reactor system and the radioisotope production facility. Wherever the "power system" is applied to the reactor and auxiliary systems, it should be interpreted to include "safety-related radioisotope production equipment", as appropriate.

# 9 AUXILIARY SYSTEMS

NUREG-1537 was originally written for heterogeneous non-power reactors. This ISG augments NUREG-1537, Part 1, to make it applicable to aqueous homogeneous non-power reactors and radioisotope production facilities. Additional sections have been added to this chapter as follows:

- Chapter 9a.1, "Heterogeneous Reactor Auxiliary Systems"
- Chapter 9a.2, "Aqueous Homogeneous Reactor Auxiliary Systems"
- Chapter 9b, "Radioisotope Production Facility Auxiliary Systems"

Guidance is specified for each of these options as follows.

## 9a.1 Heterogeneous Reactor Auxiliary Systems

NUREG-1537, Part 1, Chapter 9, should be used for guidance in preparing this chapter.

## 9a.2 Aqueous Homogeneous Reactor Auxiliary Systems

NUREG-1537, Part 1, Chapter 9, should be used for guidance in preparing this chapter, provided that the differences between the heterogeneous and homogeneous designs are considered. For example, any reference to fuel cladding should, in the case of homogeneous reactors, be taken to mean the primary fission-product barrier.

## 9b Radioisotope Production Facility Auxiliary Systems

NUREG-1537, Part 1, Chapter 9, should be revised as follows.

The introduction to this chapter summarizes the typical auxiliary systems and components that should be included in the SAR. The introduction also describes the information that should be included in describing the design and function of each system. The current NUREG-1537 primarily addresses a heterogeneous reactor design. This introductory section should be interpreted to apply to auxiliary systems associated with the radioisotope and SNM processing that is conducted in a production facility. In general, wherever the term "reactor" appears, it should be interpreted to mean the "radioisotope production facility", as appropriate.

A section is added to the list of typical auxiliary systems as follows:

- The first bullet should read: "HVAC systems for normal operation of the fission-product (FP) radioisotope and irradiated SNM processing facilities. The applicant should…."

- The next-to-last bullet of the suggested auxiliary systems list should read: "Compressed air or gas systems and vacuum systems for the operation, control, or both of radioisotope production processes and processes with SNM outside of the reactor."

## 9b.1 Heating Ventilation and Air Conditioning Systems

This section, as it exists in the current version of NUREG-1537, is adequate to describe the heating, ventilation, and air conditioning (HVAC) systems, except that the wording applies to the reactor alone. Wherever there is reference to the "reactor," it should mean the "radioisotope production and SNM processing facility." The following changes and additions should be inserted in this section of NUREG-1537 to emphasize this.

The second sentence of the second paragraph of this section should be replaced with the following:

> The interactions among airflow patterns in the reactor and radioisotope and SNM processing areas should be discussed. The balance of supply and exhaust ventilation systems should be described. Design requirements for maintaining atmospheric pressure differences among the various structures and components should be discussed in this section. Air monitoring within controlled areas, ventilation components and exhaust stacks should be described. If the HVAC systems also are….

The last paragraph of this section should read as follows:

> The applicant should discuss the possible effects of malfunctions of the HVAC system on the operations of the reactor and radioisotope production facilities with particular attention to the potential for any release of airborne radioactive material during normal operation of the facility. The radiological effects of malfunctions should be discussed in Chapter 11.

## 9b.2 Handling and Storage of Reactor Fuel

Modifications to make this section more appropriate for a radioisotope production facility are as follows.

The last sentence of the first paragraph should read: "The discussion should include descriptions of apparatus that is employed in handling, processing, or storing the fuel. Particular attention should be paid to the design features and use of the equipment as well as administrative controls for the prevention of fuel mishandling or accidents."

The second paragraph, last sentence, should be: "The applicant must address the applicability of 10 CFR 70.24 concerning criticality monitoring, but any detailed discussion of any required system may be presented in Chapter 6 of the SAR."

The fourth paragraph should read as follows:

> The applicant should address the handling, storage, and shipment of new and irradiated fuel (or SNM) in either solid or liquid form. There should be a discussion of the design and operation of equipment or systems for loading and removing fuel (or SNM) into or out of the core or processing facilities and also the administrative controls that will be employed. The details should also include the

design and operation of all equipment that will be employed in the receipt, storage, chemical processing, and shipment of both unirradiated and irradiated fuel (or SNM). Discussions of procedures and systems employed in the handling and storage of irradiated fuel (or SNM) should include radiation shielding, protection from physical damage, change in chemical characteristics, security from diversion, and protection from overheating. Descriptions of facilities and procedures employed in operations with irradiated fuel may be addressed in Chapter 4b.1 of the SAR and therefore it need not be repeated here. Descriptions of irradiated fuel (or SNM) cooling systems and procedures may be included in Chapter 5 of the SAR if they are part of the primary cooling system.

The first sentences of the fifth paragraph should read as follows:

If any loss of fuel (or SNM) or fuel containment could result in the release of fission products, the applicant should discuss the mechanisms and analyze the consequences in Chapter 13, "Accident Analyses," of the SAR. Detailed discussions of radiological considerations during normal operations in handling and storing fuel should be discussed in Chapter 11, "Radiation Protection Program and Waste Management."

## 9b.3 Fire Protection Systems and Programs

The following should be added just before the last paragraph:

Radioisotope production facilities sometimes possess fairly large inventories of radioactive fission products, which are stored in containment vessels and filter systems. The potential risks and consequences of fire involving these containment vessels and filter systems should be addressed.

The potential for producing free $H_2$ or other combustible gases in an AHR should be considered. The reactor radiolytic gas management systems are designed to control and eliminate these gases. This system should be discussed in great detail in Chapter 4 of the SAR; however, the possibility of some failure of this system by which hydrogen could escape from the reactor containment should be evaluated and addressed. There may also be a possibility of $H_2$ accumulation in the irradiated fuel processing and storage systems. This potential hazard should be analyzed and addressed.

The last paragraph should be amended to read as follows:

The reviewer will use nationally recognized codes and standards to provide reasonable assurance of fire safety. These include, but are not limited to, the National Fire Protection Association (NFPA) National Fire Codes, Factory Mutual (FM) Data Sheets and Approval Guides, Underwriters Laboratories (UL) Standards and Building Material Directory, ANSI Standards, and American Society for Testing and Materials (ASTM) Standards. Commitments to specified standards will normally be considered an acceptable means of meeting the acceptance criteria. The staff recognizes NFPA 801, "Standard for Fire

Protection for Facilities Handling Radioactive Materials," as one standard that specifies acceptable facility fire safety design criteria; however, the applicant may use other nationally recognized codes and standards if appropriate.

### 9b.4 Communication Systems

NUREG-1537, Part 1, is applicable, as written, to a radioisotope production facility.

### 9b.5 Possession and Use of Byproduct, Source, and Special Nuclear Material

NUREG-1537, Part 1, is applicable, as written, to a radioisotope production facility.

Possession and use of byproduct material in an aqueous homogeneous reactor facility is authorized and regulated under a 10 CFR Part 50 license.

### 9b.6 Cover Gas Control in Closed Primary Coolant Systems

The cover gas system in any AHR facility, which could be associated with a production facility, is such an integral part of the reactor that it is described in detail in Chapter 4 of this ISG. There could be potential for radiolytic gas production in the radioisotope extraction and processing systems and also in any irradiated fuel storage and reconditioning systems or vessels. The need for a radiolytic gas management system associated with these operations should be analyzed and addressed.

### 9b.7 Other Auxiliary Systems

Radioisotope production facilities may have other auxiliary systems that are important to the safety of the worker, the public, and the environment. These systems should be described and analyzed for safety per the guidance in NUREG-1537, Part 1, provided that wherever the term "reactor" appears, it should be understood to mean a "non-power reactor", "radioisotope production facility," or both, as appropriate. Examples of these systems include process equipment decontamination or storage facilities; remote manipulator repair facilities; waste (liquid and solid) processing, storage, and disposal facilities; and any unique final-product packaging and shipment facilities.

### 9b.8 References

The following references should be added:


- U.S. Nuclear Regulatory Commission, SECY-09-0101, Policy Issue Notation Vote, "Licensing of a Babcock and Wilcox Medical Isotope Production System," July 9, 2009.

- National Fire Protection Association, NFPA 801, "Standard for Fire Protection for Facilities Handling Radioactive Materials," NFPA, Quincy, MA.

# 10 EXPERIMENTAL FACILITIES

Any type of non-power reactor could be designed for conducting experiments in and adjacent to the reactor core. The current guidance in NUREG-1537 should be used for addressing such operations in the SAR.

The experimental facilities referred to in the current version of NUREG-1537 may also apply to radioisotope production facility operations with byproduct material after it is separated from the target fuel. In the case of an AHR where the reactor fuel is the target, the radioisotope extraction and post-extraction process is an integral part of the reactor operation. The applicant should address some or all of the post-extraction radioisotope processing operations in this chapter; the current guidance in NUREG-1537 should be sufficient for this purpose. No additional NRC staff guidance is necessary in this ISG.

# 11 RADIATION PROTECTION AND WASTE MANAGEMENT

The introduction to Chapter 11, Part 1, is adequate as written, provided that wherever the term "reactor" appears, it should be understood to mean a "non-power reactor", "radioisotope production facility," or both, as appropriate. The description of radiation protection and waste management programs in NUREG-1537 should be extended to cover both non-power reactor and radioisotope production facilities.

## 11.1 Radiation Protection

NUREG-1537, Part 1, Section 11.1, and the ensuing subsections are adequate for radioisotope production facilities without modification in this ISG.

### 11.1.1 Radiation Sources

### 11.1.2 Radiation Protection Program

### 11.1.3 As Low As Is Reasonably Achievable Program

### 11.1.4 Radiation Monitoring and Surveying

### 11.1.5 Radiation Exposure Control and Dosimetry

A new section is added and reads as follows:

*11.1.5.1 Controlled Area*

Under 70.61(f) each licensee must establish a controlled area, as defined in 10 CFR 20.1003. This controlled area should be identified in the boundary and area maps provided in Chapter 2, Section 2.1.1.2, of the SAR. In addition, the licensee must retain the authority to exclude or remove personnel and property from the area. For the purpose of complying with the performance requirements of this section, individuals who are not workers, as defined in 10 CFR 70.4, may be permitted to perform ongoing activities (e.g., at a facility not related to the licensed activities) in the controlled area, if the licensee:

(1) Demonstrates and documents, in the integrated safety analysis, that the risk for those individuals at the location of their activities does not exceed the performance criteria of paragraphs (b)(2), (b)(3), (b)(4)(ii), (c)(2), and (c)(4)(ii) of 10 CFR 70.61; or

(2) Provides training that satisfies 10 CFR 19.12(a)(1)–(5) to these individuals and ensures that they are aware of the risks associated with accidents involving the licensed activities as determined by the integrated safety analysis, and conspicuously posts and maintains notices stating where the information in 10 CFR 19.11(a) may be examined by these individuals. Under these conditions, the performance criteria for workers specified in paragraphs (b) and (c) of 10 CFR 70.61 may be applied to these individuals.

NUREG-1537, Part 1, Chapter 11, should be used for guidance in preparing the SAR for the following subsections:

### 11.1.6 Contamination Control

### 11.1.7 Environmental Monitoring

## 11.2 Radioactive Waste Management

NUREG-1537, Part 1, Section 11.2, and the following subsections are adequate for radioisotope production facilities without modification in this ISG:

### 11.2.1 Radioactive Waste Management Program

### 11.2.2 Radioactive Waste Controls

### 11.2.3 Release of Radioactive Waste

## 11.3 Respiratory Protection Program

This section is added to address the requirements for a respiratory protection program.

The applicant must describe in detail how it plans to meet the requirements of 10 CFR Part 20, Subpart H, "Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas." This description must include the usage and maintenance of individual respiratory equipment via written procedures set forth in 10 CFR 20.1703(c)(4). Any further restrictions on the use of respiratory protective equipment to ensure that the program is adequate also should be mentioned.

Under 10 CFR 20.1703(c)(4), the applicant must describe the installation of the ventilation and containment systems and how these will protect personnel from inhaling airborne concentrations of radionuclides that are above the SLs. The applicant should also describe the surveillance requirements that will be imposed on the ventilation and containment systems and the respiratory protection equipment. This information should be sufficient to support an understanding of how the worker will be protected and how a safe working environment will be maintained.

Change the sequential number for the "References" section.

## 11.4 References

References in the current NUREG-1537, Part 1, Section 11.3, apply. The following has been updated:

U.S. Nuclear Regulatory Commission, Regulatory Guide 8.13, Revision 3, "Instruction Concerning Prenatal Radiation Exposure," June 1999.

# 12 CONDUCT OF OPERATIONS

The guidance provided in this chapter is broad in scope to the extent that it can be applied to non-power reactors, regardless of type, and also to radioisotope production facilities.

The applicant should describe and discuss the conduct of operations at any facility captured in the scope of this ISG. The conduct of operations involves the administrative aspects of facility operations, the facility emergency plan, the security plan, the quality assurance plan, the reactor operator requalification plan, the startup plan, and environmental reports as described in NUREG-1537. Wherever the document refers to "university, corporation, or facility," it should also include "processing facility."

Note that the guidance in Section 12.12, "Environmental Reports," has been expanded significantly in this ISG to reflect current National Energy Policy Act (NEPA) requirements.

Note that Section 12.13, "Material Control and Accounting," has been added in this ISG for compliance with 10 CFR Part 74, "Material Control and Accounting of Special Nuclear Material."

As written, the following sections of NUREG-1537, Part 1, are applicable to non-power reactors and radioisotope production facilities.

## 12.1 Organization

### 12.1.1 Structure

### 12.1.2 Responsibility

### 12.1.3 Staffing

### 12.1.4 Selection and Training of Personnel

The last sentence references ANSI/ANS 15.4-1988, which has been replaced with ANSI/ANS 15.4-2007, "Selection and Training of Personnel for Research Reactors."

### 12.1.5 Radiation Safety

The third and fourth sentences should read: "The radiation protection staff can be part of the reactor facility staff or may be provided as a service by a corporation-wide group or by an independent group. The radiation protection staff can report to either the managers of the facility or to the management chain above the facility."

The last sentence references ANSI/ANS 15.11-1993, which has been replaced with ANSI/ANS 15.11-2009, "Radiation Protection at Research Reactor Facilities."

### 12.1.6 Production Facility Safety Program

The radioisotope production facility must have an established safety program, as required by 10 CFR 70.61, "Performance Requirements" and 10 CFR 70.62, "Safety Program and Integrated Safety Analysis." This program may be integrated with a similar program established for other functions on site such as the reactor, but as a minimum the following requirements must be satisfied:

**(a)** As required by 10 CFR 70.62(a), the application shall include a description of a safety program that contains the following information:

(1) Each licensee or applicant shall establish and maintain a safety program that demonstrates compliance with the performance criteria in 10 CFR 70.61(b), (c), and (d). The safety program may be graded such that the management measures applied are graded commensurate with the magnitude of the risks involved. Three elements of this safety program (process safety information, accident analysis, and management measures) are described in paragraphs (b) through (d) of this section.

(2) Each licensee or applicant shall establish and maintain records that demonstrate compliance with the requirements of paragraphs (b) through (d) of this section.

(3) Each licensee or applicant shall maintain records of failures readily retrievable and available for NRC inspection, documenting each discovery that an IROFS or management measure has failed to perform its function upon demand or has degraded such that the performance requirements of 10 CFR 70.61 referenced above are not satisfied. These records must identify the IROFS or management measure that has failed and the safety function affected, the date of discovery, date (or estimated date) of the failure, duration (or estimated duration) of the time that the IROFS was unable to perform its function, any other IROFS or management measures and their safety function, affected processes, cause of the failure, whether the failure was in the context of the performance criteria or upon demand or both, and any corrective or compensatory action that was taken. A failure must be recorded at the time of discovery and the record of that failure updated promptly upon the conclusion of each failure investigation of an IROFS or management measure.

(b) *Process safety information.* Under 10 CFR 70.62(b), each licensee or applicant shall maintain process safety information to enable the performance and maintenance of an accident analysis. This process safety information must include information pertaining to the hazards of the materials used or produced in the process, information pertaining to the technology of the process, and information pertaining to the equipment in the process.

(c) *Accident analysis.*

(1) Under 10 CFR 70.62(c)(1), each licensee or applicant shall conduct and maintain an integrated safety analysis that is of appropriate detail for the complexity of the process that identifies:

(i) Radiological hazards related to possessing or processing licensed material at its facility;

(ii) Chemical hazards of licensed material and hazardous chemicals produced from licensed material;

(iii) Facility hazards that could affect the safety of licensed materials and thus present an increased radiological risk;

(iv) Potential accident sequences caused by process deviations or other events internal to the facility and credible external events, including natural phenomena;

(v) The consequence and the likelihood of occurrence of each potential accident sequence identified pursuant to paragraph (c)(1)(iv) above, and the methods used to determine the consequences and likelihoods; and

(vi) Each IROFS identified in the required accident analyses pursuant to 10 CFR 70.61(e), the characteristics of its preventive, mitigative, or other safety function, and the assumptions and conditions under which the IROFS is relied on to support compliance with the performance criteria.

(2) Integrated safety analysis team qualifications. Under 10 CFR 70.62(c)(2) the analysis must be performed by a team with expertise in engineering and process operations to ensure the adequacy of the integrated safety analysis. The team shall include at least one person who has experience and knowledge specific to each process being evaluated and persons who have experience in nuclear criticality safety, radiation safety, fire safety, and chemical process safety. One member of the team must be knowledgeable in the specific accident analysis methodology being used.

(d) *Management measures.* Under 10 CFR 70.62(d), each applicant or licensee shall establish management measures to ensure compliance with the performance criteria in 10 CFR 70.61. The measures applied to a particular engineered or administrative control or control system may be graded commensurate with the reduction of the risk attributable to that control or control system. The management measures shall ensure that engineered and administrative controls and control systems that are identified as IROFS are designed, implemented, and maintained, as necessary, to ensure that they are available and reliable to perform their function when needed, to comply with the performance requirements of 10 CFR 70.61.

## 12.2 Review and Audit Activities

As written, this section is applicable to a non-power reactor and radioisotope production facility.

### 12.2.1 Composition and Qualifications

The last two sentences should read: "The applicant should discuss the use of committee members from outside the reactor and production facility organization. It is desirable to have some members on the committee from outside the facility management to increase the independence of the committee."

### 12.2.2–12.2.4

As written, these subsections are applicable to non-power reactor and radioisotope production facilities.

## 12.3 Procedures

The sixth sentence references ANSI/ANS 15.1-1990, which has been replaced with ANSI/ANS 15.1-2007, "The Development of Technical Specifications for Research Reactors."

## 12.4–12.6

These sections are applicable as written in NUREG-1537.

## 12.7 Emergency Planning

In this section of the SAR, the applicant should give a brief overview of the overall emergency plan for the combined reactor and production facility.

For the reactor and production facility, the applicant should follow the guidance of ANSI/ANS 15.16-2008, "Emergency Planning for Research Reactors," which is endorsed and amplified by Regulatory Guide 2.6, Revision 1, "Emergency Planning for Research and Test Reactors," issued March 1983. The applicant should also review NUREG-0849, "Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors," issued October 1983.

In addition, NUREG-1520 describes the details about the production facility that should be included. Section 12.7 of Part 2 of this ISG specifies the portions of NUREG-1520 that should be addressed.

The applicant must ensure that the terminology for releases discussed in the emergency plan matches that used in the revision of 10 CFR Part 20 that became mandatory on January 1, 1994. Specifically, effluent concentrations have replaced maximum permissible concentrations, although use of dose values in millisieverts (mSv) (millirem (mrem)) would be a more appropriate protective action guideline because dose is the ultimate criterion specified. The applicant should ensure that the action levels discussed in the emergency plan for each emergency class follow the guidance. If it is impossible for an event at a particular facility to reach a given action level, that emergency class is not possible, and the plan should state that fact.

## 12.8 Security Planning

In this section of the SAR, the applicant should briefly discuss security planning for the entire facility. The information in the SAR must be public and must not contain proprietary information

(10 CFR 2.390), Safeguards Information -Modified Handling (10 CFR 73.21 and 10 CFR 73.23) or Safeguards Information (SGI) (10 CFR 73.21 and 10 CFR 73.22). The proprietary or SGI version of the security plan is protected from disclosure by the regulations referenced above. The applicant should refer to the guidance in Regulatory Guide 5.59, "Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance" (appears in NUREG-1537, Part 1, Appendix 12.3), when developing the combined security plan for the facility, including for the processing facility. New facilities may be subject to additional security requirements in the form of orders and may be subject to a security assessment conducted by the NRC staff.

## 12.9 Quality Assurance

The third sentence references ANSI/ANS 15.8-1976, which has been replaced with ANSI/ANS 15.8-2005, "Quality Assurance Program Requirements for Research Reactors."

## 12.10 Operator Training and Requalification

The current wording of this section predominantly addresses training requirements for the non-power reactor staff. The section should be titled:

## 12.10a Reactor Operator Training and Requalification

NUREG-1537 is applicable to a non-power reactor facility without requiring changes in this ISG.

A new section should be added pertaining to training in the radioisotope production facility as follows:

## 12.10b Production Facility Operator Training and Requalification

The Atomic Energy Act of 1954, Section 107, states, "The Commission shall prescribe uniform conditions for licensing individuals as operators of any of the various classes of production and utilization facilities licensed in this Act." As set out in 10 CFR 50.54(h) and (i) the license is subject to the provisions of the Act, and prohibits the manipulation of the controls of any facility by anyone who is not a licensed operator or senior operator under the regulations in 10 CFR Part 55, "Operators' Licenses." Although, 10 CFR Part 55 only specifies the licensing requirements for utilization facility operators without specifically addressing production facilities, the NRC will be imposing applicable Part 55 requirements to production facility operators as a license condition.

In addition to stating the general and specific training requirements for licensing utilization facility operators and senior operators contained in10 CFR Part 55, the applicant should prepare basic topics to be part of a training program to be made a license condition that define the knowledge and skills of the staff of a radioisotope production facility conducting safety-related operations with SNM outside of the reactor such as:

- theory and principles of the radioisotope production processes involving SNM
- theory and principles of radioisotope extraction and purification processes
- facility design and operating characteristics
- instrumentation and control systems
- ESFs

- TS
- criticality control features and management measures required for each process involving SNM
- normal and emergency operating procedures

ANSI/ANS 15.4-2007 may contain additional guidance on training and qualification of personnel applicable to production facilities.

In 10 CFR 50.54(i-1), the NRC requires that within 3 months after an operating license is issued, the licensee have in effect an operator requalification program, which at a minimum meets the requirements of 10 CFR 55.59(c). The regulations in 10 CFR Part 55 apply specifically to reactor operating licenses. With regard to production facilities, the proposed operator training license conditions should comply with the same requirements of 10 CFR 50.54(i) and (i-1).

NUREG-1537, Part 2, Section 12.10b, of this ISG presents specific information about the content of a radioisotope production facility training and qualification program.

## 12.11 Startup Plan

In this section, startup operations involving fuel should be described as processes with fuel in liquid or solid form, as appropriate.

Certain operations with the fuel or SNM that are conducted outside of the reactor will be subject to the requirements of 10 CFR Part 70. All operations with SNM outside the reactor also must be conducted according to the requirements of 10 CFR Part 70. Guidance for an NCS program is discussed in NUREG-1537, Part 1, Chapter 6, Section 6b.3, of this ISG. Examples of such operations include the following:

- receipt, unpacking, and internal transfer and storage of new fuel or SNM
- preparation of fuel for use in the reactor
- preparation of SNM for use as irradiation targets or experiments
- processing of fuel for reuse in the reactor or for disposal
- packing of spent fuel or SNM for transport to a reprocessing facility

## 12.12 Environmental Report (Previously published for comment in the FR, no need to review, however there will be additional edits before the final is published.)

NEPA, as amended, requires Federal agencies to disclose and consider environmental impacts for major Federal actions. The NRC's environmental protection regulations in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," implement these requirements. These regulations describe the type of actions for which the NRC must conduct environmental reviews in order to disclose and consider the environmental impacts of a proposed action under NRC regulatory purview.

Environmental reviews for licensing actions fall into one of three categories: those identified as categorical exclusions, those requiring the preparation of an environmental assessment (EA), and those requiring the preparation of an environmental impact statement (EIS). The regulation

in 10 CFR 51.20, “Criteria for and Identification of Licensing and Regulatory Actions Requiring Environmental Impact Statements,” describes several types of actions that would require an EIS. While an EIS or supplement to an EIS is required for construction permits and operating licenses for testing facilities, 10 CFR 51.20 does not currently include a similar requirement for medical isotope production facilities. Such activities may require an EA or an EIS, depending on the action’s potential for significant impacts that may affect the quality of the natural and human environment. An EA is used to determine if the impacts from the proposed action may be significant and whether a finding of no significant impact can be made. If an EA concludes that the proposed action could result in significant impacts to the natural or human environment, then the NRC should prepare an EIS. In some cases, the NRC may decide to prepare an EIS, rather than an EA, if there is the potential for significant impacts to the natural or human environment or the proposed action involves a matter that the Commission, in the exercise of its discretion, has determined should be covered by an EIS.

The applicant or licensee shall submit an environmental report (ER) to assist the NRC in conducting an expeditious environmental review. The regulatory requirements for preparing an ER are provided in 10 CFR 51.41, 51.45, 51.49, and 51.50.

The applicant or licensee may benefit from a preapplication meeting with the NRC licensing and environmental project managers to discuss the information needed to support the environmental review. The goal of such a meeting is to define the scope and detail of information that the applicant or licensee should provide in the ER. NUREG-1537, Part 2, Section 12.12, describes how the NRC staff uses the information in the ER to prepare an EA or EIS.

The information provided in the ER should address the likelihood of significant impacts to the natural and human environment posed by the proposed action. Likewise, the level of detail should be commensurate with the likelihood of significant impacts. For example, construction and operation of a new facility at a previously undisturbed site near sensitive environmental resources would require more detail than construction and/or modification and operation of a facility within an existing building at an industrial site. The ER should present a thorough description of each affected resource area for the evaluation of potential impacts to the environment. Every resource may not need the same level of detailed review, and every action may not require all the information discussed in this section. Likewise, the proposed action may present unique issues and may require additional information. This is consistent with some of the goals of NEPA, which are to concentrate on issues significant to the proposed action and their potential environmental impacts, as well as to ensure that affected resources are analyzed in proportion to their importance and the expected level of impact on them. The following sections describe the information that applicants or licensees should provide in each section of the ER.

### 12.12.1 Introduction of the Environmental Report

The introduction should briefly describe the proposed action, location of the proposed action, and relevant background information. Key dates and deadlines should also be identified to establish the timeframe for the proposed action.

#### *12.12.1.1 Purpose and Need for the Proposed Action*

This section should explain the purpose and need for the proposed action and should not be written merely as a justification of the proposed action. Examples of purpose and need include

a benefit provided if the proposed action is licensed and implemented or descriptions of the disadvantages that would be experienced without the proposed action. For instance, a description of how implementing the proposed action would satisfy global, national, or regional projected demands for isotope production, including, as appropriate, quantifying the benefit in terms of the proposed production volume relative to the projected demand, could support the purpose and need section.

*12.12.1.2 Applicable Regulatory Requirements, Permits, and Required Consultations*

As described in 10 CFR 51.45(d), this section should list and summarize the status of all applicable Federal, State, local, and other regulatory requirements, permits, and consultations that would be required for the proposed facility to be constructed and operated. The applicant or the licensee should provide the following information in the ER, as applicable:

- name of each regulatory agency involved in a consultation, review, approval, and authorization, and the applicable law, ordinance, or regulation
- activity to be covered by the consultation, review, approval, or authorization
- current status of each consultation, review, approval, and authorization
- potential administrative delays or other problems preventing agency consultation, review, approval, or authorization
- summary of any surveys required to complete consultation (such as threatened and endangered species or archaeological surveys) and the status of such surveys

### 12.12.2 Proposed Action

The applicant or licensee should describe the proposed action and briefly summarize the information provided in the ER, referring the reader to other sections for more detail. Depending on the scope of the proposed action and immediate environs, all the information listed below may not be necessary for the evaluation of potential impacts from the proposed action:

- detailed description of the proposed action, the general progression of the project, and preoperational, operational, and postoperational activities, as appropriate
- schedule of the major steps in the proposed action, such as start and completion dates of major construction, modifications, and operational activities
- full names of all organizations sharing ownership of the proposed action

Site Location and Layout

- site location, including distance and direction from the nearest major city, nearby towns, nearby inhabitants, sensitive populations (e.g., schools, daycare facilities, retirement homes), and landmarks, including highways, rivers, or other bodies of water within 50 miles (mi) (80 kilometers (km)) of the facility

- facility latitude and longitude coordinates
- areal extent of the site and facility layout, including the site boundary
- list of current or proposed buildings or areas used for chemical, oil, diesel fuel, and other hazardous material storage; waste management (radioactive and nonradioactive); vehicle cleaning; administration; operations and maintenance; shipping and receiving; generating electricity; health and security; parking; and other areas
- underground storage tanks, wells, pipelines, water supply, sewage and storm water systems
- identification of the type and quantity of radionuclides and hazardous materials associated with the facility or in the vicinity
- summary of how materials would be stored, handled, used, and disposed of
- air, ground water, surface water, meteorological, and/or ecological monitoring stations or proposed monitoring stations

Non-power Reactor and Utilization Facility

*Non-power Reactor*

- the number of units and a description of each reactor
- fuel description, total quantities of uranium, and percentage U-235 enrichment, and the planned average irradiation level of spent fuel
- a simplified flow diagram for the reactor power conversion system

*Medical Isotope Production Facility*

- a description of the medical isotope production system, including any relevant flow diagrams

*Other Systems*

- a description of any other relevant production system, including any relevant flow diagrams

Water Consumption and Treatment

- a narrative description and water use diagram of the various facility water use systems, their interconnections, and their operational interdependence and coordination, including water sources and discharge locations

- for water sources independent of a municipal or commercial supply, the data and narrative description for maximum water consumption, water consumption during periods of minimum water availability (e.g., low-flow conditions), and average operation by month and by facility operating status

- a description of water treatment systems used in the facility
  - identification, quantities, and points of addition of chemicals and additives to be used by each system
  - operating cycles for each water treatment system for normal modes of facility operation (e.g., full-power operation, shutdown/refueling, and startup)

Cooling and Heating Dissipation Systems

- system descriptions

- descriptions of anticipated operational modes and the estimated periods of time that the systems would operate in each mode
  - for each anticipated operational mode, quantities of heat generated, dissipated to the atmosphere, and released in liquid or gaseous discharges
  - for each anticipated operational mode, water source and quantities of water or gases withdrawn, consumed, and discharged for heating or cooling

- for proposed water intake and discharge systems:
  - a drawing of the intake and discharge lines and structures showing the relationship of the inlets and outlets to the water surface, bottom geometry, and shoreline
  - a description of any cooling water pumping facility
  - a description of any trash racks, traveling screens, trash baskets, and fish return devices
  - performance characteristics (e.g., flow rates, intake and discharge velocities, and discharge temperature and temperature differential) for all operational modes
  - the location and description of components for the addition of chemicals (e.g., corrosion inhibitors, antifouling agents) to the intake system

- for heat dissipation systems:
  - the location of heat dissipation system components relative to other site features
  - the design details of heat dissipation system components affecting system performance

- heat dissipation system performance characteristics for all operational modes, including abnormal conditions (e.g., accidents)

Waste Systems

- descriptions of all (i.e., nonradioactive, radioactive, mixed, and hazardous waste materials) proposed and/or current waste systems, including quantities, composition, and frequency of waste generation [Effluent discharges need not be discussed here if they will be covered in other parts of Section 12.12.3 (i.e., air effluents in Section 12.12.3.2, "Air Quality," and liquid effluents in Section 12.12.3.4, "Water Quality."]

- information on proposed or current disposal activities including transportation and size and location of hazardous material disposal sites both on and off site

- identification of all sources of radioactive liquid, solid, and gaseous waste material within the facility and nearby operating facilities

- identification of direct radiation sources stored on site or near the site (e.g., independent fuel storage, low-level radioactive waste storage, or storage of radiation equipment)

- a description of any pollution prevention and waste minimization program

Storage, Treatment, and Transportation of Radioactive and Nonradioactive Materials, Including Fuel, Waste, Medical Isotopes, and Any Other Materials

- the capacity of the onsite storage facilities to store target or reactor fuel materials, irradiated fuel, and medical isotope products, as applicable, and the storage time between removal from the reactor and transportation off site

- identification of treatment and packaging procedures for radioactive and nonradioactive wastes and medical isotope products

- transportation packaging systems to be used for fresh fuel and targets, spent fuel, and other wastes and medical isotopes

- the location and the estimated transportation distance from the fuel fabrication facility to the reactor and from the reactor to the facilities to which irradiated targets, fuel, radioactive and nonradioactive wastes, and medical isotopes would most likely be sent

- estimated transportation destination and distance, number of shipments, and mode of transportation that would be used to transport medical isotopes from the proposed facility to other purification and processing facilities

### 12.12.3 Description of the Affected Environment

The affected environment describes baseline (existing) conditions at the site of the proposed action. Baseline conditions are used to measure changes in the affected environment caused by the proposed action, the impacts of which are discussed in Section 12.12.4. The applicant or licensee should describe the affected resources in sufficient detail to permit the evaluation of changes from baseline conditions because of the proposed action.

Depending on the scope of the proposed action and immediate environs, all the information listed below may not be necessary for the evaluation of potential impacts from the proposed action.

*12.12.3.1 Land Use and Visual Resources*

The applicant or licensee should describe land use conditions on and in the vicinity of site. The applicant or licensee should provide the following information in the ER:

- land uses, both on and off site, that could be affected by the proposed action
- maps of the site showing current and proposed site boundaries, exclusion areas, site structures, restricted areas, and current and proposed facilities
- maps showing major land uses in the region, such as U.S. Geological Survey land use categories within 50 mi (80 km) of the facility
- special land use classifications (e.g., American Indian or military reservations, wild and scenic rivers, parks, forests, designated coastal zone areas, wildlife and wilderness areas, and prime and important farmland soils as designated by the U.S. Department of Agriculture Natural Resources Conservation Service) within 50 mi (80 km) of the facility
- Federal facilities, including national parks, national forests, national wildlife refuges and wilderness areas, American Indian and/or Bureau of Indian Affairs lands held in trust for American Indians, and Indian Tribes' lands within 50 mi (80 km) of the proposed site
- information from the Natural Resources Conservation Service on the relative value of the land acquired for the new facility if it involves farmland
- principal agricultural products within the area, facilities, agricultural practices, game harvests, or food processing operations
- mineral resources within the area
- description of the regional setting, transportation corridors, residential areas, airports, industrial and commercial facilities, and railroads
- current, future, and proposed land use plans

<u>Visual Resources</u>

- description of the visual setting (i.e., view shed) of the area being affected

- identification and description of the height, color, shape, and visibility of the tallest proposed structures, as well as direction and distances from which these structures would be visible

- identification of residents and visitors to the area who might be affected by the aesthetic impact of the proposed new facility, including any associated tourist or scenic areas of interest

- rating of the aesthetic and scenic quality of the site in accordance with the U.S. Bureau of Land Management Visual Resource Management System

*12.12.3.2 Meteorology, Climatology, and Air Quality*

The applicant or licensee should characterize atmospheric transport and diffusion processes at and near the site of the proposed action. The applicant or licensee should provide the following information in the ER:

- description of the general climate of the region (e.g., climatological averages of parameters such as temperature, precipitation, and windspeed and direction)

- summarized monthly and annual meteorological data (including averages, measured extremes, and diurnal range) as near as possible to the site for the most recent 5-year period

- summary of wind flow data on site and in the region

- discussion of severe weather phenomena (e.g., tornadoes, hurricanes, thunderstorms, atmospheric stagnation episodes) experienced in the region with expected frequencies of occurrence and measured extremes of parameters such as temperature, precipitation, and windspeed

- description of regional air quality, including the locations of mandatory Federal Class I areas and identification of pollutants that are in nonattainment or maintenance areas and the relationship of the site to these areas

- discussion and/or map of the region within a 50 mi (80 km) radius of the nonattainment and maintenance areas near the site

- description of programs or policies to reduce greenhouse gas emissions

If appropriate meteorological data are not available specifically for the site, applicable data from nearby sources (e.g., airport or federally or state-maintained ambient air quality station) may be used.

*12.12.3.3 Geology, Soils, and Seismology*

The applicant or licensee should identify the geological, seismological, and geotechnical characteristics of the site and vicinity. The applicant or licensee should provide the following information in the ER, as applicable:

- stratigraphy and structures, including descriptions of geologic units, major structural and tectonic features (e.g., faults), and any other significant geological conditions
- geotechnical investigations conducted to characterize the site
- characteristics of soil, including a physical description of the soil units and descriptions of features related to soils at the site and nearby
- identification of soils that are prime, unique, or farmland of Statewide or local importance on or in the vicinity of the site
- description of erosion potential at the site and current onsite erosion control and runoff best management practices
- description of seismic potential at the site and seismic history
- identification of largest known historical regional earthquake and description of safe shutdown for the facility
- analysis and evaluation of the local and regional seismicity data, volcanism, or any information that may indicate a geologic hazard at the site (e.g., earthquakes or tsunamis), including whether any identified geologic faults are "capable" (potentially active) per 10 CFR Part 100, "Reactor Site Criteria," Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants"
- other geologic hazards such as nearby landslide areas, areas of land subsidence, karst features, and/or soils with a high shrink-swell potential

*12.12.3.4 Water Resources*

The applicant or licensee should describe site-specific and regional data on the physical and hydrological characteristics of surface water and ground water in sufficient detail to provide the basic data for the evaluation of impacts on water bodies and aquifers in the area. The applicant or licensee should provide the following information in the ER:

- a water use diagram for the reactor and processing facility showing flow rates to and from the various water systems (e.g., circulating water system, sanitary system, radwaste and chemical waste systems, service water systems), points of consumption, and source and discharge locations
- for fresh water streams potentially affected by the proposed action:
  - historic monthly flow information, including maximum, average-maximum, average, average-minimum, and minimum flow

  - historical drought stages and discharges by month and the 7-day once-in-10-year low flow

- for lakes and impoundments potentially affected by the proposed action:
  - elevation-area-capacity curves
  - reservoir operating rules, if applicable
  - annual yield and dependability

- for estuaries and oceans potentially affected by the proposed action:
  - shoreline and bottom descriptions, including seasonal variations due to sediment transport
  - monthly river discharge including maximum and minimum discharge and, for estuaries, flushing characteristics

- ground water characteristics for features that could be affected by the construction, modification, operation, and decommissioning of proposed facilities:
  - historical and seasonal trends in ground water elevation or piezometric levels
  - piezometric contour maps, water table contour maps, and hydraulic gradients (historical, if available, and current)
  - depth to water table for unconfined aquifer systems
  - historical and current data from site wells (e.g., monitoring, background, corrective action, or other uses)
  - hydrostratigraphy of the site, including cross sections and hydrostratigraphic unit descriptions
  - qualitative description of ground water aquifers, including identification of sole source aquifers designated by the U.S. Environmental Protection Agency

- a description of present and reasonably foreseeable future surface water uses (withdrawals, consumption, and returns, including, but not limited to, domestic, municipal, agricultural, industrial, mining, recreation, navigation, and hydroelectric power); ground water withdrawals; and nonconsumptive water uses (e.g., recreational, navigational, instream) that may affect or be affected by construction, facility modifications, operations, and/or decommissioning of the reactor and processing facility, including any bodies of water or aquifers at distances close enough to affect or be adversely affected by the facilities

- descriptions of past, present, and reasonably foreseeable pollutant sources with discharges to water that may interact with the facility, including locations relative to the site and the affected water bodies, and the magnitude and nature of the pollutant discharges, including temporal variations

*12.12.3.5 Ecological Resources*

The applicant or licensee should describe the ecological resources potentially affected by construction, modification, operation, and/or decommissioning. Ecological resources include members and attributes of aquatic, terrestrial, riparian, and wetland plant and animal communities. Wetlands and riparian habitats are the interface between aquatic and terrestrial habitats and were defined by the U.S. Environmental Protection Agency in 1993 as follows:

> [Wetlands are] those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
>
> [Riparian areas are] vegetated ecosystems along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two land forms; they do not in all cases have all of the characteristics necessary for them to be classified as wetlands.

The applicant or licensee should provide the following information in the ER:

Region

The ER should describe the ecoregion (large areas of similar climate where ecosystems recur in predictable patterns), ecosystems, and habitats surrounding the site; the geomorphic or physiographic province; characteristic vegetation and animal species, including climax vegetation and typical succession in the area of the site; the ecological province of the ocean if the facility is located near an ocean or estuary; and the watersheds potentially affected by the proposed action.

Site and Vicinity

The ER should describe the local environment of the site; vegetation and animal communities; quantification and a description of physiographic habitats (such as upland forest, swamp marshes, wetlands, rivers, streams) on site; and quantification of the extent of habitats to be directly affected by proposed construction, modifications, operation, and decommissioning, and the like. The ER should also include topographic maps and descriptions, as appropriate.

History

The ER should provide a short historical description of the ecological environment. This description should include major changes or modifications to the land and/or water bodies (e.g., channelization, navigation, pollution, habitat degradation or fragmentation, urbanization, development, and pond or reservoir creation). The ER should briefly describe major wildlife species and populations currently and historically living in the vicinity of the facility.

Places and Entities of Special Interest

The ER should provide the occurrence, location, and description of communities and habitats of special interest in the vicinity of the facility, such as wetlands, natural heritage areas, and other areas of public or scientific interest; other areas that may be particularly sensitive or susceptible either directly or indirectly to the effects of the proposed construction, modification, operations, or decommissioning; important ecological systems that are especially vulnerable to change or that contain important species habitats, such as areas used for breeding (nesting and nursery areas), feeding, resting, overwintering; or other areas containing seasonally high concentrations of individuals of important species.

Aquatic Communities and Potentially Affected Water Bodies

The ER should briefly describe the aquatic communities based on available information (e.g., present and past studies, Federal and State sources). This description should focus on a subset of representative and important species, such as those with the following characteristics: potential or reported susceptibility to construction or operational impacts; dominance, commonness, or rarity in numbers or biomass; importance to the structure and function of the ecosystem, such as keystone species (a species with a disproportionate effect on the ecosystem relative to the species' abundance or biomass), important trophic links (predator-prey or herbivore relationships), potential for trophic cascade, or habitat formers (a species that constitutes the basis of a habitat type) or modifiers; indicators of water quality or "ecosystem health"; important recreational or commercial fishing and shellfishing; fish consumption advisories; and ecosystem services. The ER should describe the relative significance of various aquatic habitats in a regional context.

The ER should describe the location of the site with respect to the principal nearby water bodies that the site affects. The ER should also describe water bodies potentially affected by the proposed action. This section should describe any water body uses (e.g., withdrawal or discharges for cooling water).

Terrestrial Communities

The ER should briefly describe the terrestrial communities, using available information (e.g., present and past studies, Federal and State sources), and include representative species of plants, mammals, birds, reptiles, amphibians, and insects. This description should note any endemic species, sensitive or indicator species, keystone species, or important recreationally hunted species. The ER should also describe bird species that nest within the area, migratory species, known migratory bird rookeries, and, if applicable, the location of the site in relation to any nearby flyways. Additionally, the ER should describe the types of vegetative communities found on and in the vicinity of the site, especially any delineated wetlands or potential wetland habitat. The ER should include any applicable correspondence with the U.S. Army Corps of Engineers or other Federal or State agencies regarding any applicable Clean Water Act 404 or other wetland-related permits. This section should summarize any available botanical surveys conducted on or in the vicinity of the site. The ER should describe the relative significance of various terrestrial habitats in a regional context.

Invasive Species

The ER should provide occurrences of aquatic and terrestrial invasive species in the vicinity of the facility and document any management activities undertaken by the facility to control such species.

Procedures and Protocols

The ER should describe management plans for aquatic and terrestrial ecosystems and best management practices (if applicable), including pesticides and herbicides used and ground-disturbing activities performed routinely to maintain the site.

Studies and Monitoring

The ER should briefly summarize any aquatic or terrestrial studies or monitoring programs on or in the vicinity of the site and include the location, dates, objectives, methods, and results applicable to the application. The ER should also identify any data or data summaries that might be available for NRC review.

Cumulative Impacts

The ER should describe other current and reasonable foreseeable actions (Federal or non-Federal) that would have overlapping aquatic and terrestrial ecological impacts with the proposed action.

Threatened, Endangered, and Protected Species and Essential Fish Habitat

This section of the ER should include information on federally or State-listed threatened and endangered species and essential fish habitat (EFH), as well as any species that are protected under other legislation, including the Marine Mammal Protection Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act, as outlined below:

- The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) was enacted to protect threatened and endangered species and the ecosystems on which they depend. In accordance with Section 7 of the Endangered Species Act, Federal agencies must review actions they undertake or support (such as issuing permits and licenses) to determine whether these actions may jeopardize the continued existence of any listed endangered or threatened species or their habitats.

  If such review reveals the potential to adversely affect listed or candidate species, the Federal agency must consult with the U.S. Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (collectively, the Services), as appropriate. The Services implement the interagency cooperation provisions of Section 7 at 50 CFR Part 402, “Interagency Cooperation—Endangered Species Act of 1973, As Amended.”

  The applicant should determine if federally listed threatened, endangered, or candidate species, critical habitat, and/or State-listed species and habitat have the potential to occur on the site or in the vicinity of the site. For such species, the ER should provide sufficient information on historical occurrences, population size and trends, critical habitat, and potential habitat to aid the NRC in its biological assessment. The ER should discuss any activities, including construction, modification, operations, maintenance, transportation, or decommissioning activities, that may affect such species and habitats.

- Several Federal laws, including the Magnuson-Stevens Fishery Conservation and Management Act, the Marine Mammal Protection Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act, also mandate the protection of certain habitats and species. In the ER, the applicant or licensee should discuss protected species that have the potential to occur on or in the vicinity of the site. The applicant or licensee should include in the ER documentation of related correspondence with the appropriate Federal and State agencies (e.g., as required by the Fish and Wildlife Coordination Act) and affected American Indian Tribes.

*12.12.3.6 Historic and Cultural Resources*

The applicant or licensee should identify and describe all historic properties, including archaeological and cultural resources, located on or near the site of the proposed action. "Historic properties" means any prehistoric or historic districts, sites, buildings, structures, or objects included in, or eligible for inclusion (e.g., more than 50 years old) on the National Register of Historic Places (36 CFR Part 60, "National Register of Historic Places"). Archaeological resources include artifacts, records, and remains that are related to and located in prehistoric or historic districts, sites, buildings, or structures. Properties of traditional, religious, and cultural importance to an American Indian Tribe that meet the National Register criteria are also included.

Descriptions of historic properties and archaeological and cultural resources should be of sufficient detail to permit the assessment and evaluation of impacts from the proposed action. The applicant or licensee should provide the following information in the ER:

- description of known archaeological and cultural resources in the vicinity of the proposed action and an overview of the area's cultural history, including summaries of historical and cultural resource surveys conducted in the area and the types of resources discovered

- summarized results of archaeological or historical surveys conducted at the proposed site, including the following:
  - map and description of the physical extent of the survey, and/or the area of potential effect (APE) (If the entire site was not surveyed, the basis for the limited survey is needed.)
  - brief description of the techniques used to conduct the survey
  - qualifications of the surveyors
  - survey findings in sufficient detail to permit an assessment of the potential impact of the proposed action on archaeological and historic resources

- description of any reconnaissance or pedestrian surveys of the proposed site and consultation efforts with the State Historic Preservation Office (SHPO), American Indian Tribe(s), and/or members of the public used to assess the presence of historic and cultural resources within the APE

- a list of cultural and historic properties located within the proposed site or within the APE (These properties are included in State or local registers or inventories of historic and archaeological resources. Guidance can be found on the U.S. National Park Service Web site at http://www.cr.nps.gov/nr/publications.)

- a statement of the significance or importance of each cultural resource potentially affected

- comments from SHPO, Tribal Historic Preservation Office, or any organizations and individuals contacted by the applicant/licensee that provided significant information concerning the location of cultural and historic properties

*12.12.3.7 Socioeconomics*

The applicant or licensee should briefly describe socioeconomic conditions in the region (affected counties) around the proposed site including population, demographics (e.g., race and ethnicity), the economy (e.g., median and per capita income, civilian labor force, unemployment, and individuals and families living in poverty), housing availability, public services (e.g., public water supplies and public school enrollments), offsite land use, local transportation, and noise. Socioeconomic information should be of sufficient detail to permit the assessment and evaluation of impacts from the proposed action. The applicant or licensee should provide the following information in the ER:

General Socioeconomics

- U.S. Bureau of Census information and data on the affected counties, including the following:
  - population and demographic information by race and ethnicity and historic and projected population growth rates by county
  - median household and per capita income
  - civilian labor force by county
  - unemployment
  - percent of individuals and families living below the census poverty threshold
  - housing: total number of units, number of occupied units, number of vacant units, vacancy rate, and median value
  - transient (seasonal) population, including students attending colleges and universities within 50 mi (80 km) of the facility

- public water supply system information, including source (ground water or surface water, average daily production, system design capacity, and population served)

- information about local public schools, such as school district(s) and total enrollment

- map identifying places of significant population grouping, such as cities and towns
- information (including general condition of site access roads, average annual daily traffic volume, and road capacity, if available) on local road networks used to access the proposed site and major regional transportation systems used for the transport of construction materials, production materials, and waste
- tax payment information, including information about local tax authorities (i.e., county, municipality, and public school district) that would be directly affected by the proposed action
- brief description of public recreational facilities (e.g., distance from proposed facility, purpose of the recreational facility)

Noise

- brief discussion of any current or past noise studies and analyses conducted in the vicinity of the proposed site
- list of the loudest noise-generating facilities and activities in the vicinity of the proposed site
- distribution of sensitive noise receptors that could be affected by the proposed action

*12.12.3.8 Human Health*

The applicant or licensee should describe existing public and occupational health issues. The applicant or licensee should provide the following information in the ER, as applicable:

- maps, in an appropriate scale, showing the distances from the proposed action to the following points or areas for radial sectors centered on the cardinal compass directions:
  - nearest site boundary
  - nearest full-time resident
  - nearest drinking water intake (see Section 12.12.3.4, “Water Resources”)
  - nearest sensitive receptors (e.g., schools and hospitals)
- major sources and levels of background radiation exposure, including natural and manmade sources, with levels expressed in mSv per year (mrem per year)
- description of the radioactive and nonradioactive hazardous liquid, gaseous, and solid waste management and effluent control systems
- information on radioactive and nonradioactive effluents released into the environment
- radioactive and nonradioactive hazardous material stored on site or in the vicinity

- current onsite or nearby sources of radioactive materials and levels of exposure to members of the public and workers from these sources

- major onsite or nearby sources of chemicals and levels of exposure to members of the public and workers from these sources

- historical exposures to radioactive materials of both workers and members of the public

- for facilities located near operating facilities:
  - a description of the radiological environmental monitoring program and environmental data (from the operating facility's annual radiological environmental monitoring reports)

  - historical maximum individual doses to members of the public (from the operating facility's annual radioactive effluent release reports)

- relevant occupational injury rates and occupational fatality rates

- summary of relevant health effects studies applicable to the proposed action

### 12.12.4 Impacts of Proposed Construction, Facility Modifications, Operations, and Decommissioning

The applicant or licensee should describe the potential impacts of the proposed action for each resource area described in Section 12.12.3, "Description of the Affected Environment." These impacts include the direct and indirect impacts of the proposed action and alternatives, as well as the cumulative impacts of other past, present, and reasonably foreseeable future actions. When analyzing impacts, the applicant or licensee should consider resources separately, and if necessary, in combination with other resources or conditions (e.g., noise impacts on wildlife or transportation impacts on land use).

The applicant or licensee should evaluate construction, modification, operation, and decommissioning activities under the proposed action in sufficient detail to determine the significance of potential impacts. In addition, the ER should summarize any mitigation measures that the applicant could take to reduce adverse impacts and describe the anticipated cost-effectiveness of such mitigation measures in reducing adverse impacts.

In general, data needs that are described in Section 12.12.3 are not repeated below. Data provided in Section 12.12.3 should be included in Section 12.12.4 to the extent necessary to describe impacts from the proposed action. All the information listed below may not be necessary for the evaluation of potential impacts from the proposed action and alternatives.

#### *12.12.4.1 Land Use and Visual Resources*

This section describes land use and visual resources/aesthetic impacts caused by the proposed action. The applicant or licensee should provide the following information in the ER:

Land Use

- description of onsite and offsite land use changes, including the number of acres and location of each land use type that would be disturbed and/or occupied on a short- and long-term basis during construction, modification, operation, and decommissioning

- impacts on any special land use categories, Federal facilities, or prime or other important farmland

- potential mitigation measures

- cumulative impacts from other past, present, or reasonably foreseeable Federal or non-Federal projects in the area

Visual Resources/Aesthetics

- photos of the site with the proposed action superimposed

- discussion of any significant visual impacts from the proposed action
  - physical facilities that are out of character with overall existing architectural features
  - structures that may partially or completely obstruct views of existing landscape
  - structures that create visual intrusions in the existing landscape character (e.g., radar towers, cooling towers, effluent stacks)
  - structures that may require the removal of natural or built barriers, screens or buffers, thus enabling lower quality viewscapes to be seen
  - altering historical, archaeological, or cultural properties, other areas of a special land use category, or the character of the property's setting when that character contributes to the property's significance
  - structures that create visual, audible, or atmospheric elements that are out of character with the site or alter its setting

- a determination of whether the visual impact is compatible or in compliance with regulations, ordinances, and requirements

- potential mitigation measures

- description of cumulative impacts on visual or scenic quality from other past, present, and reasonably foreseeable Federal and non-Federal projects

*12.12.4.2 Meteorology, Climatology, and Air Quality*

This section presents key factors and guidance for evaluating meteorological conditions and air quality impacts. The applicant or licensee should provide the following information in the ER:

- description of gaseous effluents (i.e., type, quantity, and origin), permits needed, and the status of those permits
- table comparing effluent (or emission) concentrations to regional air quality parameters (effluent or emission concentrations for both short- and long-term impacts)
- release point characteristics (i.e., elevation above grade, inside vent or stack diameter, physical shape, flow rate, effluent temperature, exit velocity, release frequency, or other appropriate information to allow calculation of transport and diffusion)
- description of gaseous effluent control systems
- detailed descriptions of the models and assumptions used to determine normalized concentration and/or relative deposition
- normalized concentration and/or relative deposition at points of potential maximum concentration outside the site boundary, at points of maximum individual exposure, and at points within a reasonable area that could be impacted
- description of visibility impacts (e.g., plume)
- description of mitigative measures for air quality impacts
- description of design considerations for severe weather events
- greenhouse gas emissions, including both direct emission from construction, operation, and decommissioning of the proposed facilities and indirect emissions from activities such as commuting
- description of cumulative air quality impacts from other past, present, and reasonably foreseeable Federal and non-Federal projects

*12.12.4.3 Geology, Soils, and Seismology*

This section presents key factors and guidance for evaluating site geologic and soils conditions and geologic resource impacts. The applicant or licensee should consider those geologic and soil resources and conditions that could be affected by construction, modification, operation, and decommissioning activities, as well as those geologic conditions and hazards that could affect the proposed action and alternatives. Conditions that could affect the proposed action and specific facilities include large-scale geologic hazards (e.g., earthquakes, volcanic activity, landslides, land subsidence, and erosional processes) and local hazards associated with the site-specific attributes of the soil and bedrock beneath facility sites. The major analysis for seismic and other geologic hazards can usually be found in the preliminary safety analysis report or similar documentation and needs only to be summarized in this section of the ER. The applicant or licensee should provide a summary of management practices, design considerations, or policies that would minimize these impacts.

The applicant or licensee should provide the following information in the ER:

- depth of excavation for below-grade portions of facilities and for activities such as trenching for utilities and piping, roadway construction, and others
- depth of bedrock and whether blasting may be required
- estimate of the volume of geologic resources required for project activities (e.g., borrow for backfill, sand and gravel aggregate for construction)
- impacts on any rare or unique geologic resources or on rock, mineral, or energy rights and assets (also see Section 12.12.4.1, "Land Use and Visual Resources")
- potential mitigation measures
- cumulative impacts with other past, present, or reasonably foreseeable Federal or non-Federal projects in the area

*12.12.4.4 Water Resources*

This section presents key factors and guidance for evaluating impacts on water use and water quality for each alternative to include the impacts of both radiological and nonradiological effluents.

The applicant or licensee should consider surface water and ground water uses that could affect or be affected by the construction, modification, operation, and/or decommissioning of the proposed facility. Other water uses may include, but are not limited to, domestic, municipal, agricultural, industrial, mining, recreation, navigation, and hydroelectric power. The applicant or licensee should also consider impacts on the physical, chemical, and biological water quality characteristics of surface water and ground water. Because water quality and water supply are interdependent, the applicant or licensee should consider changes in water quality simultaneously with changes in water supply. The applicant or licensee should provide the following information in the ER:

<u>General Water Resources</u>

- identification of potentially impacted ground and surface waters, including those receiving effluents and the expected average and maximum flow rates, physical characteristics (e.g., temperature, sediment load, velocities), and composition of radiological and nonradiological pollutants in these effluents
- impacts on surface water and ground water quality including comparison of predicted effluent and receiving-water quality with applicable effluent limitations and water quality standards for both radiological and nonradiological constituents (including conclusions regarding project compliance with these standards, the physical impacts of consumptive water uses (e.g., ground water depletion) on other water users, and adverse impacts on surface-oriented water users (e.g., fishing, navigation) resulting from facility activities)

- identification of onsite and offsite hydrological system impacts (e.g., water quantity and availability, water flow, and movement patterns); erosion, deposition, and sediment transport; water drainage characteristics; the flood-handling capability of the floodplains; flow and circulation patterns; subsidence resulting from ground water withdrawal, and erosion and sediment transport

- withdrawals and returns of surface and ground water during construction, modification, operation, and decommissioning

- descriptions of any proposed best management practices and measures to control impacts on water quality and/or quantity (e.g., protection of natural drainage channels and water bodies; protection of shorelines and beaches; restrictions on access to and use of surface water; protection against saltwater intrusion; and handling of fuels, lubricants, oily wastes, chemical wastes, sanitary wastes, herbicides, and pesticides)

- identification of cumulative effects on water resources from other past, present, and reasonably foreseeable Federal and non-Federal projects

Monitoring

For water quality monitoring, the applicable monitoring plans should be described, including the following:

- chemical and physical parameters to be measured

- number and location of sample collection points, measuring devices used, and pathway sampled or measured

- sample size, sample collection frequency, and sampling duration

- method and frequency of analysis including lower limits of detection

- quality assurance procedures

*12.12.4.5 Ecological Resources*

This section presents key factors and guidance for evaluating terrestrial and aquatic ecological impacts from the proposed action. The applicant or licensee should provide the following information in the ER:

General Ecological Resources

- site map showing proposed buildings, land to be cleared, areas to be cleared along stream banks, areas proposed for dredge material, areas to be dredged, and waste disposal areas

- total area of temporary and permanent impacts for each habitat type and an estimate of the amount of these habitats that would be impacted relative to the total amount present

in the region

- area to be used on a short-term basis during construction or facility modification and plans for restoration of this land
- maintenance practices such as use of chemical herbicides, roadway maintenance, and mechanical clearing that are anticipated to affect biota
- estimate of the potential impacts of elevated construction equipment or structures on species (e.g., bird collisions, nesting)
- tolerances and/or susceptibilities of important biota to physical and chemical pollutants
- clearing methods, erosion, runoff, and siltation control methods (both temporary and permanent), dust suppression methods, and other construction practices to control or minimize adverse impacts to ecological resources
- special maintenance practices used in important habitats (e.g., marshes, natural areas, bogs), including those that result in unique beneficial effects for specific biota
- wildlife management practices
- practices and procedures or alternative designs to minimize adverse impacts
- identification of cumulative effects on ecological resources from other past, present, and reasonably foreseeable Federal and non-Federal projects

Special Status Species

Special status species include those designated by a State or Federal agency as threatened, endangered, proposed, or candidate species, or a species of special concern, as defined by the Federal or State agency. Fish and shellfish with EFH near the facility are also considered special status species.

In addition to the information described above that would be relevant to special status species, the applicant or licensee should provide the following:

- documentation of consultations with the FWS and National Oceanic and Atmospheric Administration on the impact of the proposed action on endangered and threatened species and critical habitat
- documentation of consultations with State and local agencies and Tribes regarding the impact of the proposed action on important species
- any proposed activities expected to impact communities or habitats that have been defined as rare or unique or that support threatened and endangered species

Monitoring

For ecological monitoring, the applicant or licensee should provide a description of the applicable monitoring plans, including the following:

- maps showing major ecological communities, important habitats, and sampling stations and monitoring locations
- list of monitoring program elements or parameters including action or reporting levels for each element
- sampling design, such as the type, frequency, and duration of observations or samples to be taken at each location
- sampling equipment to be used
- method of chemical analyses, as applicable
- data analysis, statistics, or other biological indices that would be calculated as part of the proposed sampling program, and reporting procedures
- summary of the quality assurance procedures
- documentation of applicant consultations with FWS, appropriate State agencies (e.g., fish and wildlife agency), and American Indian Tribal agencies
- documentation of the environmental monitoring programs in policy directives designating a person or organizational unit responsible for reviewing the program on an ongoing basis

*12.12.4.6 Historic and Cultural Resources*

This section presents key factors and guidance for evaluating impacts on historic properties and cultural resources. Adverse effects occur when a proposed action's effect on a cultural resource diminishes the integrity of its location, design, setting, materials, workmanship, feeling, or association. Adverse effects include, but are not limited to, (1) physical destruction, damage, or alteration of all or part of the historic property, (2) isolation of the property from or alteration of the character of the historic property's setting when that character contributes to the historic property's qualification for listing on the National Register of Historic Places, (3) introduction of visual, audible, or atmospheric elements that are out of character with the historic property or alter its setting, (4) neglect of a historic property resulting in its deterioration or destruction, and (5) transfer, lease, or sale of the historic property.

The applicant or licensee should provide the following information in the ER:

- map showing historic and archaeological sites that could be impacted by the proposed action

- discussion of impacts on historic and cultural resources during construction, modification, operation, or decommissioning, including impacts resulting from land use and visual changes or denial of access

- documentation of consultations with the SHPO and/or Tribal Historic Preservation Office, as appropriate, concerning the impact of the proposed action on historic properties and other cultural resources and any conclusions resulting from the consultations

- discussion of any State laws and plans for historic preservation, if available

- discussion of the potential for and the process to be followed upon the discovery of human remains at the proposed site

- practices and procedures or alternative designs that could be used to minimize adverse impacts, including mitigation measures such as (1) limiting the scale of the project, (2) modifying the project through redesign, reorientation, or construction on the proposed action, (3) repair, rehabilitation, or restoration of an affected historic property as opposed to demolition, (4) preservation and maintenance operations involving historic properties, (5) documentation (e.g., drawings, photos, histories) of building or structures that would be destroyed or substantially altered, (6) relocation of historic properties, and (7) salvage of archaeological or architectural information and materials

- description of cumulative impacts on historic and cultural resources from other past, present, and reasonably foreseeable Federal and non-Federal projects

*12.12.4.7 Socioeconomics*

This section describes impacts to regional socioeconomic conditions, such as changes in the population, the economy, housing availability, public services, offsite land use, and noise from the proposed action. The applicant or licensee should provide the following information in the ER:

Socioeconomics

- estimated number of construction, operations, and decommissioning workers

- impacts to housing, public services (i.e., water supply), public education, and local transportation

- tax impacts

- discussion of methodology used to determine impacts

- description of cumulative impacts to socioeconomic factors from other past, present, and reasonably foreseeable Federal and non-Federal projects

Transportation

- description of construction or modification of any access roads, railroads, or other transportation infrastructure that would be used to support construction, operations, and decommissioning (see Section 12.12.4.1)
- transportation route and mode for conveying materials for construction and operations, equipment, and workers to the proposed site
- traffic pattern impacts (e.g., impacts from any increase in traffic during construction or operations)
- impacts from transportation associated with construction such as fugitive dust, scenic quality, and noise
- mitigation measures and consultations with Federal, State, and local agencies
- description of transportation-related cumulative impacts from other past, present, and reasonably foreseeable Federal and non-Federal projects

Noise

- predicted noise levels using the dBA (decibels acoustic) scale
- potential impacts to sensitive receptors (i.e., hospitals, schools, residences, wildlife)
- mitigation measures to reduce impacts of noise
- description of noise-related cumulative impacts from other past, present, and reasonably foreseeable Federal and non-Federal projects.

*12.12.4.8 Human Health*

This section describes public and occupational health impacts from both nonradiological and radiological sources.

Nonradiological Impacts

The applicant or licensee should provide the following information in the ER. All the information listed below may not be necessary for the evaluation of potential impacts of the proposed action:

- description of nonradioactive chemical sources (location, type, strength)
- description of the nonradioactive liquid, gaseous, and solid waste management and effluent control systems
- information on nonradioactive effluents released into the onsite and offsite environment

- calculated chemical exposure to the public or calculated average annual concentration of nonradioactive releases to air and water, including all models, assumptions, and input data in order to determine compliance (e.g., with 40 CFR Parts 50, 59, 60, 61, 122, 129, and 131)

- assessment of the physical occupational hazards

- the calculated exposure to the workforce, including all models, assumptions, and input data needed to determine compliance with 29 CFR Part 1910, "Occupational Safety and Health Standards"

- description of the environmental monitoring program

- discussion of mitigation measures

- description of nonradiological cumulative health impacts to the public and workers from other past, present, and reasonably foreseeable projects in the local area
  - for facilities located near operating industrial facilities, description of the nonradiological environmental monitoring program and environmental data (from the applicant's environmental monitoring reports or other sources)

Radiological Impacts

This section describes the public and occupational health impacts from radioactive material. The applicant or licensee should provide the following information in the ER. All the information listed below may not be necessary for the evaluation of potential impacts from the proposed action:

- physical layout of the site, including the location of radioactive materials expected to be present

- characteristics of radiation sources and expected radioactive effluents (i.e., radioactive liquid, gaseous, and solid wastes)

- baseline radiation of the site, including measured radiation dose rates, airborne radioactivity concentrations, and waterborne radioactivity concentrations at specific current locations where environmental radiological monitoring data exist

- compliance with 10 CFR 20.1301 by applying one of the following methods:
  - calculated radiation dose rates, annual averaged airborne radioactivity concentrations, and annual averaged waterborne radioactivity concentrations at the site boundary, including a description of the methodology and assumptions

  - calculated annual total effective dose equivalent (TEDE) to a maximally exposed member of the public in the unrestricted area, including a description of the methodology and assumptions

- calculated annual dose to the maximally exposed worker, including a description of the methodology and assumption

- description of any mitigation measures to minimize public and occupational exposures to radioactive material

- description of the cumulative impacts to public and occupational radiological exposure from other past, present, and reasonably foreseeable sources (i.e., hospitals and other licensed users of radioactive material) in the vicinity of the proposed facility

Radiological Monitoring

This section describes the programs used to monitor radioactive effluents released from the proposed facility and to obtain data on measurable levels of radiation and radioactive materials in the environment.

The applicant or licensee should provide the following information in the ER. All the information listed below may not be necessary for the evaluation of potential impacts from the proposed action:

- for radiological effluent monitoring, a general description of the in-facility monitoring plan, including number and location of sample points, type of measuring devices, and pathways sampled or measured

- for radiological environmental monitoring, a general description of the onsite and offsite monitoring plan, including number and location of sample collection points, type of measuring devices, and pathways sampled or measured

Note: For additional guidance regarding acceptable radiological environmental monitoring programs, refer to the Branch Technical Position, "An Acceptable Radiological Environmental Monitoring Program," Revision 1, issued November 1979 (ADAMS Accession No. ML010710060), and NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," issued April 1991.

*12.12.4.9 Waste Management*

This section describes the types of radiological and nonradiological waste expected to be generated and the management program used to safely handle, process, store, and dispose of the waste.

The applicant or licensee should present the following information in the ER. All the information listed below may not be necessary for the evaluation of potential impacts from the proposed action:

- description of the sources, types, and approximate quantities of solid, hazardous, radioactive, and mixed wastes expected from the proposed action

- description of proposed waste management systems designed to collect, store, and process the waste

- anticipated disposal or waste management plans (i.e., transfer to an offsite waste disposal facility, treatment facility, or storage on site)

- description of a waste minimization plan to minimize the generation of waste

*12.12.4.10 Transportation*

This section describes the transportation of nuclear and nonnuclear materials, including radioactive waste and nonradioactive waste, and medical isotopes and the associated potential impacts.

The applicant or licensee should provide the following information in the ER. All the information listed below may not be necessary for the evaluation of potential impacts from the proposed action:

- transportation mode (i.e., truck, plane, rail, or barge) and projected destinations

- estimated transportation distance from the originating site to the projected destinations

- treatment and packaging for radioactive and nonradioactive wastes

- calculated radiological dose to members of the public and workers from incident-free transportation scenarios

*12.12.4.11 Postulated Accidents*

This section describes the radiological and nonradiological impacts from design-basis accidents (DBAs). The type of data and information needed in the ER will depend on site- and facility-specific factors and the anticipated magnitude of the potential impacts.

The applicant or licensee should provide the following information in the ER. All the information listed below may not be necessary for the evaluation of potential impacts from the proposed action :

- list of credible DBAs with the potential to cause releases into the environment
- analysis of the radiological and nonradiological consequences from the postulated DBAs

*12.12.4.12 Environmental Justice*

On February 11, 1994, the President signed Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," which directs all Federal agencies to develop strategies for considering environmental justice in their programs, policies, and activities. Environmental justice is described in the Executive Order as "identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." On December 10, 1997, the Council on Environmental Quality issued "Environmental Justice Guidance Under the National Environmental Policy Act." The Council developed this guidance to, "further assist Federal agencies with their National Environmental Policy Act (NEPA) procedures."

On August 24, 2004, the Commission published a policy statement, "Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions," in the *Federal Register* (69 FR 52040), which states, "the Commission is committed to the general goals set forth in E.O. 12898, and strives to meet those goals as part of its NEPA review process." The following guidance is consistent with this policy statement.

The scope of this section should include an analysis of impacts on minority and low-income populations and the location and significance of any environmental impacts from the proposed action including proposed facility construction, modification, operations, and decommissioning. The applicant or licensee should provide sufficient detail to permit the assessment and evaluation of human health and environmental effects and, in particular, whether these effects are likely to be disproportionately high and adverse to minority and low-income populations.

The applicant or licensee should provide the following information in the ER:

- map showing the location of minority and low-income populations and/or communities, including American Indian and Hispanic populations (as appropriate), as well as any American Indian reservations and other special communities in the vicinity of the proposed site

- discussion of the methods used to identify the location of these populations and/or communities

- assessment (qualitative or quantitative, as appropriate) of the degree to which minority or low-income population could be disproportionately affected during construction, operations, or decommissioning as compared to the effect on the general population

- assessment (qualitative or quantitative, as appropriate) of whether the human health and environmental effects on minority and low-income populations are significantly high and adverse (Significance is determined by considering the disproportionate exposure to environmental hazards from the proposed project as well as multiple-hazard and cumulative hazard conditions.)

- discussion of any mitigation measures

- description of related cumulative impacts from other past, present, and reasonably

foreseeable Federal and non-Federal projects that could also result in disproportionately high impacts on low-income and minority populations

### 12.12.5 Alternatives

The applicant or licensee should describe the environmental impacts of reasonable alternatives to the proposed action, including the no-action alternative. These impacts include the direct and indirect impacts of each alternative for each resource area discussed in Section 12.12.4. In addition, the applicant or licensee should identify alternatives eliminated from detailed study and consider how the applicant identified and selected alternatives to the proposed action.

The applicant or licensee should evaluate the impacts of construction, modification, operation, and decommissioning activities under the proposed action in sufficient detail to determine the significance of potential impacts. In addition, the ER should contain a summary of any mitigation measures that the applicant could take to reduce adverse impacts and describe the anticipated cost-effectiveness of such mitigation measures in reducing adverse impacts.

#### *12.12.5.1 No-Action Alternative*

In 10 CFR Part 51, Appendix A to Subpart A, "Format for Presentation of Material in Environmental Impact Statements," explicitly requires analysis of the no-action alternative. For applications to construct and operate a new non-power reactor, the no-action alternative usually considers the environmental impacts if the construction permit and/or operating license are denied. In such a case, the environmental impacts would generally be the same as the status quo.

The discussion in the ER should include a description of the alternative and the expected results from taking no action, including the potential and reasonably foreseeable programmatic consequences of taking no action relative to the proposed action.

#### *12.12.5.2 Reasonable Alternatives*

The applicant or licensee should summarize the history and process used to formulate the reasonable alternatives. Reasonable alternatives may include, but are not limited to, alternative sites, alternative siting within a proposed site, modification of existing facilities versus construction of an entirely new facility, alternative technology(ies), and/or alternative transportation methods. If new construction is proposed, the applicant or licensee should analyze at least one alternative location. The applicant or licensee should analyze additional sites depending on the context, degree, and intensity of potential impacts.

The applicant or licensee should provide the following information to summarize the process used to formulate the reasonable alternatives:

- description of the process used to determine reasonable alternatives to the proposed action
- description of all alternatives considered
- indication of which alternatives were eliminated from further study and which alternatives are described in further detail

- brief description of any alternatives considered that would reduce or avoid adverse effects

The applicant or licensee should provide the following information for each reasonable alternative, as applicable:

- description of the alternative
- the major direct, indirect, and cumulative impacts, similar to the impacts assessed in Sections 12.12.3 and 12.12.4
- measures used to mitigate impacts
- restoration and management actions, if applicable
- proposed monitoring

*12.12.5.3 Cost Benefit of the Alternatives*

This section should discuss the costs and benefits of each alternative and the proposed action, including a qualitative discussion of environmental impacts. The applicant or licensee should also provide assumptions and uncertainties in the analyses. The applicant or licensee should provide the following information (major costs and benefits) in the ER:

- qualitative discussion of environmental degradation (e.g., impacts on air and water quality, biotic resources, and aesthetics, as well as socioeconomic impacts such as noise, traffic congestion, increased demand for public services, and land use changes) and effects on public health and safety
- other costs as appropriate (e.g., lost tax revenue, decreased recreational value, transportation)
- qualitative discussion of the environmental benefits (comparable to the discussion of environmental degradation)
- the average annual production of commercial products
- expected increase (if any) of tax payments to State and local tax jurisdictions during (1) the construction period and (2) operations
- creation and improvement of transportation infrastructure and other facilities
- other benefits

*12.12.5.4 Comparison of the Potential Environmental Impacts*

The applicant or licensee should present the impacts of the proposed action and alternatives in a summary chart or table.

### 12.12.6 Conclusions

The applicant or licensee should provide the following information in the ER:

- unavoidable adverse environmental impacts of the proposed action
- the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity
- irreversible and irretrievable commitments of resources used to support the proposed action

### 12.12.7 List of Preparers

The applicant or licensee should list the name, educational background, and summary of work experience for all personnel who had a role in preparing the ER.

### 12.12.8 References

The applicant or licensee should provide full citations for all references cited throughout the ER.

## 12.13 Material Control and Accounting Program

In this section, the applicant should present information about the material control and accounting (MC&A) program. The description should be sufficient to ensure that the program can fulfill its functions. The applicant should consult NUREG-1065, Revision 2, "Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities," issued November 1995. The information in this section should include the following:

- MC&A organization
- measurements
- measurement control program
- statistics
- physical inventories
- item control
- shipper-receiver comparisons
- assessment and review of the MC&A program
- resolving indications of missing uranium or other SNM of significance
- informational aid for assisting in the investigation and recovery of missing uranium
- recordkeeping

## 12.14 References

Reference ANSI/ANS 15.1-1990 has been replaced with ANSI/ANS 15.1-2007.

Reference ANSI/ANS 15.4-1988 has been replaced with ANSI/ANS 15.4-2007.

Reference ANSI/ANS 15.8-1976 has been replaced with ANSI/ANS 15.8-2009.

Reference ANSI/ANS 15.11-1993 has been replaced with ANSI/ANS 15.11-2004.

Reference ANSI/ANS 15.16-1978 has been replaced with ANSI/ANS 15.16-2008.

# 13 ACCIDENT ANALYSIS

NUREG-1537, Chapter 13, addresses accident analyses that are specifically related to a non-power heterogeneous reactor facility. This ISG augments the NUREG to broaden its application to an AHR and a radioisotope production facility. For this purpose, this chapter of the ISG is divided into three parts as follows:

- Chapter 13a.1, "Heterogeneous Reactor Accident Analysis"
- Chapter 13a.2, "Aqueous Homogeneous Reactor Accident Analysis"
- Chapter 13b, "Radioisotope Production Facility Accident Analysis"

## 13a.1 Heterogeneous Reactor Accident Analysis

NUREG-1537, Chapter 13, Part 1, applies to heterogeneous non-power reactors and is applicable without further revisions to this chapter, except that recent changes have been made to the radiation dose limits prescribed in 10 CFR Part 20. Applicants should review the current version of these regulations and include the current radiological dose criteria in a SAR for license applications for either a new facility or revisions to an existing facility.

## 13a.2 Aqueous Homogeneous Reactor Accident Analysis

In the other chapters of the SAR, the applicant should discuss and analyze the safety considerations and functional requirements at a non-power reactor facility for the design bases that ensure safe reactor operation and shutdown and acceptable protection of the public, the operations and user staff, and the environment. In those chapters, the applicant should not only discuss potential equipment malfunctions, deviations of process variables from normal values, and potential effects of external phenomena on the facility, but should also describe how equipment will work when needed in accident situations. In this chapter of the SAR, the applicant should submit information and analyses showing that the health and safety of the public and workers are protected and that the applicant has considered potential radiological consequences in the event of malfunctions and the capability of the facility to accommodate such disturbances. The purpose of this chapter is to provide guidance to the applicant to assist in demonstrating that the facility design features, SLs, LSSSs, and LCOs have been selected to ensure that no credible accident could lead to unacceptable radiological consequences to people or the environment.

Unlike in solid fuel reactors, in an AHR the fuel is in a liquid solution, and the resulting fission products—both liquid and gaseous—must be contained within the facility rather than within cladding. The primary boundary consists of all structures that prevent the release of fuel, fission gases, and other fission products that remain in the liquid solution. For an AHR, the primary boundary includes the reactor vessel (and associated penetrations such as control rod guide tubes), the primary cooling system (e.g., cooling coils), the gas management system (including waste gas storage), and associated pumps, heat exchangers, valves, and piping.

The accidents analyzed should range from such anticipated events as a loss of normal electrical power to a postulated fission-product release with radiological consequences that exceed those of any accident considered to be credible. This limiting accident is named the maximum

hypothetical accident (MHA) for non-power reactors; the details are reactor specific. Because the MHA may be a non-mechanistic failure assumed to establish an outer limit consequence, the scenario need not be entirely credible. The initiating event and the scenario details do not require analysis, but the potential consequences should be analyzed and evaluated.

The information on the credible postulated accidents should achieve the following objectives:

- Ensure that enough events have been considered to include any accident with significant radiological consequences. Rejection of a potential event should be justified.

- Categorize the initiating events and scenarios by type and likelihood of occurrence so that only the limiting cases in each group are quantitatively analyzed.

- Develop and apply consistent, specific acceptance criteria for the consequences of each postulated event.

The selection of accident scenarios to be analyzed should be based on the consideration of phenomena unique to an AHR that could limit safe operation. Limiting phenomena refer to those physical phenomena that could occur during the course of a transient or accident that significantly affects the subsequent likelihood of failure of the primary boundary. Identification and understanding of these limiting phenomena are useful in classifying the consequences of potential transients and accidents, as well as in determining appropriate operating limits. For AHRs, the limiting phenomena include bulk boiling, fuel precipitation, fission-product precipitation, detonation and deflagration of radiolytic gases, and excessively high radiolytic gas release. These phenomena are defined as follows:

- Bulk boiling of fuel solution (i.e., change of phase occurs as liquid evaporates into gas)

  Bulk boiling refers to the formation of vapor in the AHR due to phase change of the solution. Bulk boiling could lead to several adverse effects for the AHR; for example, increased fission-product release from the core and potentially increased reactivity [1]. Bulk boiling could result in the transport of aerosols from the reactor core and lead to hot spots elsewhere in the plant system. While AHRs are generally characterized by strong negative void/temperature reactivity feedback, the potential consequences in terms of reactor dynamic power level, as well as the redistribution of fuel and fission products, could challenge primary boundary integrity.

- Precipitation of fission products/precipitation of fuel (uranium)

  Precipitation refers to the formation of solids in the AHR fuel solution. Precipitation of the fuel or fission products should be avoided in AHRs [1, 3]. Precipitation of the fuel or fission products will result in the collection of these precipitates in the bottom of the reactor, leading to core heterogeneity. Collection of radioactive fission products or fuel in concentrated areas near the reactor core primary boundary could lead to excessive local heating and high temperatures on the reactor vessel or cooling coils. Subsequent chemical and thermal-mechanical effects could then challenge primary boundary integrity.

- Detonation or deflagration of combustible gas mixtures

  The formation of radiolytic gases (hydrogen and oxygen) is characteristic of AHRs (which have historically been referred to as water boilers for this very reason) [2]. The hydrogen and oxygen produced by these reactors could ignite, causing a detonation or deflagration within the primary boundary. Such an event could compromise the integrity of the primary boundary.

- Excessively high radiolytic gas release

  Excessively high radiolytic gas release refers to a specific condition where instantaneous radiolytic gas generation rates exceed the capacity of the plant systems to recombine the gases. Under these circumstances, it is possible for the formation of the gases to result in vessel pressurization. Given that AHRs typically have a strong negative void reactivity feedback, it is possible for excessively high radiolytic gas generation rates to initiate a positive feedback in the AHR system, whereby power continues to increase and the system pressure continues to increase [3]. High pressure or rapid increases in pressure could challenge the primary boundary integrity.

  Additionally, excessive radiolytic gas release above the capacity to recombine necessarily implies the presence of hydrogen and oxygen gases in the associated gas management system. The explosion of these gases could pose a challenge to the primary boundary integrity in parts of the gas management system away from the core region.

Accordingly, for an AHR with noncirculating fuel (i.e., the fuel is not circulated to other components of the plant such as steam generators during operation), the following postulated event categories should be evaluated:

Reduction in cooling events
- MHA
- Insertion of excess reactivity
- Reduction in cooling

  Events previously categorized as loss of coolant and loss-of-coolant flow have been redefined for the AHR more generically as “reduction in cooling” events. The purpose of redefining these events is to address unique aspects of the heat removal from an AHR. The AHR fuel is liquid, and therefore, the cooling systems may differ significantly from those for more conventional solid fuel reactors. Additionally, since the fuel is liquid and lacks a cladding, gaseous fission products may escape from the core region and be transported to other areas of the plant. A reduction in cooling event is characterized by a reduced capacity to remove fission or decay heat from the fission products.

Mishandling or malfunction of fuel

  Fuel malfunction has historically referred to events where there is fuel damage or failure of the cladding to retain fission products. For AHRs, the fuel is in liquid form. The function of the primary barrier is served by the primary system boundary instead of a

cladding. Therefore, fuel malfunction in the context of the AHR must be redefined to address aspects of the fuel that could result in a failure of the primary boundary. The fuel is therefore considered to "malfunction" or to have been "mishandled" if the physical state of the fuel solution is subjected to any of the identified limiting phenomena of bulk boiling, fuel precipitation, or fission-product precipitation, or if the corrosion rates become excessively high.

Fuel temperature/void-reactivity feedback

- loss of normal electric power
- external events (include natural hazards and man-made events)
- mishandling or malfunction of equipment
- large and undamped power oscillations

Experience with AHR operation has indicated very strong fuel temperature/void reactivity feedback [1, 2,3,4]. While in most cases, experience has shown AHRs to be inherently stable, the nature of power oscillations at high-power density is not well characterized [2]. It is expected that normal operation of an AHR will include irregular power oscillations, owing to the dynamics of radiolytic gas formation and reactivity feedback. These conditions will not pose a challenge to the primary barrier, provided these power oscillations do not grow (which is indicative of an unstable condition).

Reactivity feedback coupled with plant response could yield conditions that are not inherently stable. An example of this phenomenon includes positive feedback due to radiolytic gas formation and vessel pressurization under conditions where the recombiner capacity of an AHR is exceeded. Such conditions where positive feedback is possible must be examined to determine if the reactor remains stable or, if the reactor becomes so unstable that the power oscillations are large and undamped, whether these unstable power oscillations can be acceptably detected and suppressed.

Detonation and deflagration

For AHRs, formation of radiolytic gases introduces the possibility of detonation or deflagration by chemical reaction between hydrogen and oxygen gases. Explosion within the primary boundary presents two potentially challenging consequences: (1) the explosion will send a pressure wave throughout the system, which could result in a reactivity insertion, and (2) the explosion itself could compromise primary boundary integrity and at the same time result in the energetic dispersal of the contents of vessels holding fuel and fission products.

Unintended exothermic chemical reactions other than explosion

Depending on the fuel solution, the formation of radiolytic gases other than oxygen and hydrogen introduce the possibility of exothermic chemical reactions other than the recombination of hydrogen and oxygen. For example, the oxidation of NOx gases is exothermic.

Facility system interaction events

For radioisotope production AHRs, the reactor (or reactors at a multi-unit facility) supply feed products to chemical processing facilities. Therefore, events occurring within the processing facility could have an influence on the reactor. Additionally, for multi-reactor facilities, shared systems could initiate transient or accident events that affect more than a single reactor. Facility system interaction events generally classify the influence of shared systems and coupled systems to the reactor or reactors. An example of such an event is the common-mode failure of external chemical processing systems that challenge (simultaneously) the primary boundary integrity for multiple reactor units. Within this category, event propagation to other units should also be considered. For example, an event initiated in one reactor unit could influence an adjoining unit through phenomena such as pipe rupture caused by an explosion, whereby the ruptured pipe could physically interact with another system or the shock wave could affect other systems.

Events in each of the above categories should be evaluated systematically to identify the limiting event selected for detailed quantitative analysis. Limiting events in each category should have potential consequences that exceed all others in that group. The MHA selected should bound all credible potential accidents at that facility.

### 13a.2.1 Accident-Initiating Events and Scenarios

In this section of the SAR, the applicant should describe potential accident-initiating events and scenarios. For documents on general accident scenarios and analysis, radiological consequences, and fuel types, see Section 13a.4, “References.” The following sections discuss selecting and categorizing postulated accidents.

#### *13a.2.1.1 Maximum Hypothetical Accident*

The MHA could be based on a breach of the primary boundary of the various vessels that results in unrestricted dispersal of the radioactive material. Possible MHAs for an AHR could be one or a combination of the following events:

- Energetic dispersal of the contents of the primary boundary with bypass of any scrubbing capacity (e.g., by a pool surrounding the fuel vessel)
- Detonation of hydrogen in the recombiner resulting in waste gas tank failure and release of some or all of the fuel and fission-product contents in aerosolized form
- Complete loss of fuel inventory (e.g., vessel break)

For multi-reactor AHR facilities, the MHA could be a facility-wide event that simultaneously releases a radioactive inventory from within the facility that exceeds that of a single reactor. For multi-reactor AHR facilities, consideration should be given to hypothetical events that could release radioactivity from multiple vessels, holdup tanks, and processing systems holding both liquids and fission gases.

Possible MHAs for a multi-reactor AHR facility could be one or both of the following events:

- Manmade external event that breaches the primary boundary of more than one unit

- Facility-wide external event that breaches various systems containing radioactive fluids

*13a.2.1.2 Insertion of Excess Reactivity*

For AHRs, the insertion of excess reactivity can become an initiating event that leads to a challenge to the integrity of the primary fission-product boundary. The following AHR-specific reactivity insertion events should be considered along-side more traditional reactivity insertion events, such as control rod withdrawal or ejection and experiment malfunction.

For AHRs, the following events leading to insertion of excess reactivity should be considered:

Pressurization of the fuel fluid

This event should be considered for an AHR given the large, negative void reactivity coefficient characteristic of this reactor type.

Excessive cool down via cooling system malfunction

This event should be considered for an AHR given the large, negative temperature reactivity coefficient characteristic of this reactor type.

Moderator addition due to cooling system malfunction (e.g., cooling tube rupture)

AHRs are expected to have internal cooling heat exchangers (e.g., coils) submerged in the liquid reactor fuel. A breach of this heat exchanger piping could introduce additional moderator to the fuel and potentially increase reactivity. Moderator (water) addition can also occur if the reactor core vessel itself is breached and if the pool water intrudes into the vessel.

The normal operating condition of an AHR could be over-moderated. However, positive reactivity will be inserted directly if the water makes a layer that works as a reflector in the vessel.

Indirectly, there could be several possible reactivity insertion scenarios. For example, a hypothetical event whereby water is injected in the middle of the vessel could confer negative reactivity (depending on the under- or over-moderation) and power could decrease. Radiolytic gas formation will also be reduced, and such a reduction in void could add reactivity. Such reactivity effects will be dependent on the core geometry, plant system configurations, and solution characteristics.

Fuel injection

Liquid-fueled reactors are expected to have systems for defueling and refueling the primary boundary vessel. Therefore, failures in plant systems or control systems could add liquid fuel to a critical reactor, thus increasing reactivity.

Realistic, adverse geometry changes

For liquid-fueled AHRs, the core geometry is variable. Therefore, a phenomenon such as sloshing of the reactor fuel because of vibration or other mechanisms could reduce neutron leakage and increase reactivity.

Reactivity insertion due to moderator lumping effects

AHRs are expected to have internal cooling heat exchangers (e.g., coils) submerged in the liquid reactor fuel. Void formation within the heat exchanger changes the moderation profile within the reactor. Since the moderating effect of the cooling system is separate from the fuel solution, such changes have the potential to introduce negative or positive reactivity depending on the design-specific geometry and neutron spectrum. The reactivity effect of lumped moderator changes within the primary cooling system should be considered.

Inadvertent introduction of other material into the fuel solution

AHRs are expected to have systems for adding additional materials into the reactor core. Nitrate-based systems will generally require the addition of nitric acid to compensate for the radiolytic formation and loss of NOx. Malfunction of such makeup systems could introduce other material into the reactor.

*13a.2.1.3 Reduction in Cooling*

The effect of reduction in cooling should be considered for all AHRs. The cooling systems include all systems and components that remove heat from the reactor vessel and the fission gases as identified in Section 5.1 of the SAR. They consist of the cooling coils inside the vessel, the pool that provides external cooling of the vessel, and cooling systems in the off-gas handling system for removing heat from the gases generated in the fission process. The reduction in cooling caused by an initiating event such as: loss of electric power; failure of an active component in the heat removal system; a cooling coil or heat exchanger tube rupture; flow obstruction in a heat exchanger or other event, could lead to a negative effect. These effects include a high temperature, subsequent adverse chemical effects, or excessive thermal stress, or reduction in cooling, which could induce a reactivity insertion that could ultimately challenge the integrity of the primary boundary. For example, a reduction or fluctuation of cooling to the recombiner could result in a local hot spot in the primary boundary and a subsequent failure of the primary boundary due to thermal stress or burnout.

*13a.2.1.4 Mishandling or Malfunction of Fuel*

Since the fuel in the AHR is liquid, fuel mishandling events can be characterized as fuel spills or leaks where some amount of this fuel could gather or migrate to unintended locations. One immediate concern for the outcome of such a spill or leak is the accumulation of a sufficient mass of fuel in a geometry leading to an unintended criticality. The applicant should address these events and the consequences of fuel spills and leaks in the SAR under this Section 13a for accidents in the reactor facility and also under Section 13b for accidents in the radioisotope production facility.

Fuel leakage or excessive fuel leakage should be considered within the context of this class of accidents.

Fuel malfunction events for an AHR may be thought of as those events where the physical or chemical form of the fuel or solvent undergoes a change resulting in adverse chemical effects such as fuel precipitation or excessive corrosion. The following initiators need to be considered in this event category:

- Failure to control pH of the fuel solution (e.g., failure to add proper chemicals at prescribed times to the fuel solution)

- Failure to control solution temperature (e.g., excessive cooling of the fuel during off-normal operation, resulting in fuel crystallization or precipitation)

- Failure to control solution pressure (e.g., exposing the primary vessel to a vacuum, thereby initiating fuel boiling)

*13a.2.1.5 Loss of Normal Electrical Power*

This accident initiator can result from an onsite or offsite power failure. Emergency power is assumed to operate. Failure of emergency power coincident with loss of normal power can create a station blackout condition. It is assumed that control rods will operate under gravity to make the reactor subcritical. However, the consequent loss of all active heat removal capability and its impact on removing decay heat from the primary vessel, the off-gas system, and the waste gas storage tank should be analyzed.

*13a.2.1.6 External Events*

These events include natural phenomena, such as extreme winds, tornadoes, floods, or seismic events, as well as manmade events, such as explosions or toxic releases in the vicinity of the reactor building. For example, the impact of seismically induced changes in the geometry of the fuel solution should be considered.

*13a.2.1.7 Mishandling or Malfunction of Equipment*

The applicant should consider the consequences of mishandling or malfunction of equipment that could result in the spillage or leakage of contaminated fluids. Additionally, since fission gases are not retained in the fuel for the AHR, the applicant should consider the leakage or release of fission gases. For example, a stuck-open relief valve or inadvertent opening of a valve in the waste gas storage systems or holdup tanks is an equipment malfunction that could allow radioactive gases to leak out of the primary boundary at an excessive rate. Such an equipment malfunction would constitute a loss of integrity of the boundary of the waste gas holding tank that allows escape of fission gas and radiolysis gas into the building confinement.

*13a.2.1.8 Large Undamped Power Oscillations*

The AHR design is expected to experience a strong temperature and density feedback. The SAR should include a discussion of those conditions that could lead to positive feedback and result in growing power oscillations that are large and undamped. Such large, undamped power oscillations could challenge the integrity of the primary barrier.

In its determination of reactor stability, the applicant should evaluate plant system behavior. For instance, pressurization caused by excessive radiolytic gas formation could result in a positive feedback mechanism.

*13a.2.1.9 Detonation and Deflagration*

The formation and release of radiolytic gas from the fuel solution introduces the potential for deflagration or combustion of these gases within the primary boundary. The applicant should identify and evaluate the consequences of postulated deflagration and detonation events.

*13a.2.1.10 Unintended Exothermic Chemical Reactions Other Than Detonation*

This class of accidents is characterized by the unintended reaction of gases other than the hydrogen/oxygen reaction that could challenge the integrity of the primary boundary. An example of an event in this category is the exothermic reaction of NOx with oxygen. It may be postulated that a large quantity of NOx has evolved in a hypothetical AHR waste gas system. The rapid oxidation of these gases could increase system pressure and temperature, which could, in turn, breach the waste gas system primary boundary.

*13a.2.1.11 Facility System Interaction Events*

This class of accident initiators is characterized by the dynamic interactions of connected or co-located plant systems. For the AHR isotope production facility, in particular, licensees should review potential system interactions that could occur between the reactor side and the isotope separation side of the facility. This includes malfunctions or accidents in isotope processing operational facilities, such as hot cells, that could impact the reactor. Since the facility can consist of multiple reactors and processing units that potentially share systems, structures and components, interactions between these systems could exacerbate consequences relative to a single reactor facility. Initiators in this class include the following:

- Common-mode failures affecting multiple units
- Propagation of a failure to then impact another unit (e.g., pipe whip)

**13a.2.2 Accident Analysis and Determination of Consequences**

In this section of the SAR, the applicant should discuss each event and give information consistently and systematically that will lead to a clear understanding of the specific reactor and facilitate comparisons with similar reactors. Many of the steps used to select the limiting event in each category are semi-quantitative. However, the analyses and determination of consequences of the limiting events should be as quantitative as possible. Licensees should take the following steps when selecting the limiting event in each category:

- State the initial conditions of the reactor and equipment. Discuss relevant conditions depending on fuel burn-up, experiments in the reactor, core configurations, or other variables. Use the most limiting conditions in the analyses.

- Identify the causes that initiate the event; the causes include equipment malfunction, operator error, solubility, precipitation, chemical accidents, or other natural phenomenon or ones caused by humans. Base the scenario on a single initiating malfunction rather than on multiple causes.

- List the sequence of events, assumed equipment operation and malfunction, and operator actions until a final stabilized condition is reached. Discuss functions and actions assumed to occur that change the course of the accident or mitigate the consequences, such as reactor scrams or initiation of such ESFs as emergency core cooling. If credit is taken for mitigation of the accident consequences, discuss the bases used to determine that the systems are operable and discuss the system functions.

- Classify damage that might occur to components during the accident until the situation is stabilized. Discuss all components and barriers that could affect the transfer of radiation and radioactivity from the reactor to the public and that ensure continued stability of conditions after the accident.

- Prepare realistic analyses to demonstrate a detailed, quantitative evaluation of the accident evolution, including the performance of all barriers and the transport of radioactive materials to the unrestricted area. Include the assumptions, approximations, methodology, uncertainties and degree of conservatism, margins of safety, and both intermediate transient and ultimate radiological conditions. Justify the methods used. Further, ensure that the information is sufficiently complete to allow the results to be independently reproduced or confirmed. Demonstrate the validation of the computational models, codes, assumptions, and approximations by comparison with measurements and experiments when possible. Describe in detail computer codes that are used; include the name and type of code, the way it is used, and its validity on the basis of experiments or confirmed predictions for similar operating non-power reactors. Include estimates of the accuracy of the analytical methods. Chapter 11, “Radiation Protection Program and Waste Management,” of the SAR discusses the methods and assumptions used to analyze the release and dispersion of radioactive materials from normal operations. Adapt these methods as appropriate for accident analyses.

- Define and derive the radiation source terms, if any are involved. Include in the source terms the quantity and type of radionuclides that could be released, their physical and chemical forms, and the duration of potential releases. Describe potential radiation sources that could cause direct or scattered radiation exposure to the facility staff and the public.

- Evaluate the potential radiological consequences using realistic methods. Discuss the degree of conservatism in the evaluation. For example, include a discussion of the degree of conservatism introduced by the use of postulated release fractions or assumption of an infinite hemispherical cloud.

- Include specific environmental and meteorological conditions for the facility site to illustrate consequences of the accident. Give an account of the exposure conditions for the facility staff until the situation is stabilized (including staff evacuation and reentry), the most exposed member of the public in the unrestricted environment until the accident conditions are terminated or the person is moved, and the integrated exposure at the facility boundary and the nearest permanent residence. The radiological consequences should include external and internal exposures. Address contamination of land and water where applicable, and include exposure control measures to be initiated.

## 13a.3 Summary and Conclusions

In this section of the SAR, the applicant should summarize the important conclusions about the postulated accidents and the potential consequences. The applicant should compare the projected radiological consequences with the acceptance criteria discussed previously in this chapter. The information should demonstrate that all reasonable measures have been incorporated into the facility design bases to prevent undue radiation exposures and contamination of the unrestricted environment. The discussions should show that ESFs have been incorporated where necessary to limit consequences to acceptable levels.

## 13a.4 References


1. International Atomic Energy Agency, IAEA-TECDOC-1601, "Homogeneous Aqueous Solution Nuclear Reactors for the Production of Mo-99 and Other Short Lived Radioisotopes," September 2008.

2. Los Alamos National Laboratory, LA-UR-10-02947, "Lessons Learned from 65 Years of Experience with Aqueous Homogeneous Reactors," May 2010.

3. Lane, James A., ed., *Fluid Fuel Reactors*, "Part 1 Aqueous Homogeneous Reactors," Addison-Wesley, 1958.

4. Los Alamos National Laboratory, LA-UR-10-04318, "Stability Analysis of the SUPO Reactor," June 2010.


References for non-power reactors in the current version of NUREG-1537 remain applicable.

ANSI/ANS 5.1, "Decay Heat Power in Light Water Reactors," has been updated. The current version is dated 2005.

## 13b Radioisotope Production Facility Accident Analysis

Sections 13a.1 and 13a.2 of this chapter provide guidance concerning hazards and accident analyses that should be included in any license application SAR for non-power reactors. According to the requirements in 10 CFR Part 50, the analyzed accident consequences, as mitigated by plant and administrative safety measures, are evaluated against the acceptable dose limits of 10 CFR Part 20 or 10 CFR Part 100, as appropriate.

This section (13b) of Chapter 13 of the ISG addresses the analysis of potential hazards and accidents that could be encountered in production facility operations with SNM (irradiated and unirradiated) that are conducted outside of the reactor and operations with radioisotopes and hazardous chemicals that are related to operations involving licensed material. The regulations in Subpart H of 10 CFR Part 70 require licensees possessing and processing SNM in quantities that are greater than a critical mass to conduct integrated safety analyses (ISAs) of all such operations.

Operations with SNM and hazardous chemicals outside of the reactor in a non-power reactor and radioisotope production facility are licensed under 10 CFR Part 50; guidance applicable to these licenses can be found in NUREG-1537. Relevant sections of 10 CFR Part 70 and NUREG-1520 that are not addressed in NUREG-1537 are included in this ISG. The guidance for conducting accident analyses under both 10 CFR Part 50 and 10 CFR Part 70 is basically the same regarding the elements of the analysis and the use of a graded approach, which requires protective measures that are commensurate with the severity of any consequences from abnormal or accident conditions.

Regulation 10 CFR Part 70 requires licensees to limit the probability of accident occurrence according to the magnitude or severity of post-accident consequences. Accidents resulting in more serious consequences require more extensive measures to prevent their occurrence. The post-accident consequences that are specified in 10 CFR 70.61 (performance criteria) require that protective measures against higher consequence accidents be more robust than those for lower consequence accidents. This regulation is intended to make accidents with high consequences much less likely to occur than the accidents with low consequences. In 10 CFR 70.62, the NRC requires that, through a well-defined safety program (refer to Section 12.1.6 of this ISG), all processes involving licensed material be examined through an ISA. The ISA identifies protective devices, called IROFS, and management measures applied to the IROFS to ensure they are available and reliable to perform their function when needed. The IROFS protecting against accidents are analogous to, and may become, TS in the license under 10 CFR 50.36.

Section 50.36(b) requires that utilization and production facility license applications include TS that are derived from the SAR. Licensees are required to submit the SAR according to 10 CFR 50.34, “Contents of Applications; Technical Information,” and the guidance in NUREG-1537 for non-power reactors and radioisotope production facilities. For utilization and production facilities, 10 CFR 50.36 prescribes a graded approach to establishing TS. SLs and limiting control settings are those specifications that are intended to protect against or mitigate the consequences of the more serious abnormal or accident conditions. LCOs, surveillance requirements, design features, and administrative controls are other categories of TS that are required for safe operation. Another application of a graded approach to establishing realistic and practicable TS is the latitude allowed licensees in the required responses to deviations from TS. As provided in 10 CFR 50.36, remedial actions need not include stopping operations as long as safe and effective alternative means of maintaining safe operations, as justified in the pertinent safety analyses, are allowed within the stated specification.

Except for analyzing accidents involving hazardous chemicals, the guidance of NUREG-1537, as supplemented by NUREG-1520, applies to operations with SNM and radioactive materials outside of the reactor. Section 13b.3 below provides guidance for analyzing accidents involving hazardous chemicals.

## 13b.1 Radioisotope Production Facility Accident Analysis Methodology

Operations with SNM and radioisotopes fall into distinct categories according to the type of process performed in the facility and the nature of the processing hazards. The regulations in 10 CFR Part 70 require that an integrated safety analyses be performed for each process or process segment. Licensees should perform the accident analyses systematically to ensure compliance with the regulatory requirements.

### 13b.1.1 Processes Conducted Outside of the Reactor

Processes that are conducted outside of the reactor and that must be analyzed under accident conditions are divided into three general categories:

- operations with SNM
  - irradiated fuel processed for radioisotope extraction
  - irradiated fuel processed for reuse in the reactor or for waste disposal
  - operations with unirradiated SNM
- radiochemical operations
- operations with hazardous chemicals

### 13b.1.2 Accident-Initiating Events

The ISAs for the above categories of operations and any other planned operations with SNM that may be conducted and that are not listed above should include the following initiating events:

- Criticality accident (could be MHA)
- Loss of electrical power
- External events (meteorological, seismic, fire, flood)
- Critical equipment malfunction
- Operator error
- Facility fire
- Any other event that could be related to unique operations within the facility

## 13b.2 Analyses of Accidents with Radiological Consequences

The applicant for a license should discuss in this section of the SAR the MHA and credible accident conditions that could result in a release of radioactive material or hazardous chemicals into or outside of the controlled areas of the facility. These analyses should include accident scenarios within the operating categories listed in Section 13b.1.1 and, as a minimum, include accidents caused by those initiating events listed in Section 13b.1.2 within each operating category. The following steps are suggested for each analysis:

- State the initial conditions of the process, such as the potential source term, the condition of processing components, and control equipment.

- Identify the initiating condition of the event, whether natural external phenomena, process equipment failure, human error, or other. Base the scenario on a single initiating event.

- Describe the sequence of actions that occur during the course of the accident (e.g., equipment operations, operator actions) until a final stable condition is reached. If credit is taken for any mitigation of the accident consequences, state the bases used for determining that the systems are operable by TSs and describe their function.

- Discuss the function of each component or barrier that affects the transfer of radioactive material from the process to uncontrolled areas during the event and continuing after a stable condition has been achieved.

- Prepare realistic analyses to demonstrate a detailed and quantitative evaluation of the accident evolution, including the performance of all barriers regarding the transport of radioactive materials to uncontrolled areas. The analyses should include basic assumptions, methodology, uncertainties, degree of conservatism, margins of safety, and intermediate and ultimate radiological conditions. Justify the methods used. Demonstrate the validity of any models, codes, assumptions, and approximations by comparison with relevant data or experiments. Provide enough detail to allow the results to be independently reproduced or confirmed. Provide some estimate of the accuracy of the methods employed. Methods used in the accident analyses should be consistent with those used in Chapter 11 of the SAR for the analyses of dispersion of radioactive material to the environment under normal operating conditions.

- Define the radiation source terms by identity, quantity, physical and chemical forms, and the duration of their releases.

- Evaluate the potential radiological consequences using realistic methods. Discuss the degree of conservatism in the evaluation (e.g., the use of worst meteorological conditions, the use of minimum effects of mitigating circumstances, use of maximum release fractions).

- Identify IROFS and their function as preventive, mitigative, or both in achieving the performance requirements in 10 CFR 70.61. Qualify IROFS as either an ESF or some form of TS per 10 CFR 50.36 and ensure their analyses and inclusion in appropriate sections of the SAR.

Radiation dose estimates should include estimates for the operating staff throughout the event and during recovery operations and also for the maximally exposed individual in the uncontrolled areas and at the nearest permanent residence. The radiological consequences should be in terms of TEDE. The evaluation should include potential contamination of surrounding land, surface water, and ground water. As stated in Part 2, Section 13a2.5.1, *Maximum Hypothetical Accident*, both external radiation dose and inhalation doses should be considered.

## 13b.3 Analyses of Accidents with Hazardous Chemicals

The applicant should ensure that the application for the proposed facility addresses the following areas:

Chemical Accidents Description

This section should include:

- A general description of the accident involving hazardous chemicals interacting with licensed material or the chemical risks of plant conditions that affect the safety of licensed materials.

- A description of the chemical hazards that could result in unacceptable consequences. Each accident description identified by the applicant should include a chemical hazard evaluation of potential interactions of process chemicals with confinement vessels, process equipment, and facility personnel. The hazard evaluation should use appropriate accepted methods.

- A conclusion that the applicant has reasonable assurance that measures to mitigate the consequences of accidents are consistent with actions described in the emergency plan.

Chemical Accident Consequences

This section should include:

- An estimate of the concentrations for releases of hazardous chemicals interacting with licensed material or by abnormal plant conditions that could affect the safety of licensed materials. This estimate should use appropriate techniques and valid assumptions.

- Evidence that the dispersion models used to determine whether a release of chemicals might affect worker or public health and safety are appropriate. The applicant should demonstrate that the models used lead to a conservative estimate of potential consequences.

- Consequence analyses that conform to the guidance on atmospheric and consequence modeling in NUREG/CR-6410.

- If the applicant does not use the methods in NUREG/CR-6410, it may propose an alternative method accompanied by supporting documentation to justify the selection of such an alternative. (e.g. code benchmarking, peer review, cross comparisons, etc.)

- A description of the quantitative standards (chemical concentration limits) used to assess the unmitigated and mitigated consequences to an individual outside the control area (public) or to a worker from acute chemical exposure to licensed material, chemicals produced by licensed materials, or chemicals in contact with licensed materials that are on site or expected to be on site.

Notes regarding the treatment of accident consequences:

- Acceptable exposure standards include, but are not limited to, the Emergency Response Planning Guidelines established by the American Industrial Hygiene Association, the Acute Exposure Guideline Levels established by the National Advisory Committee for Acute Guideline Levels for Hazardous Substances, and the exposure limits established by the U.S. Occupational Safety and Health Administration. The applicant needs to verify that the selected standard applies to the worker or the individual outside the control area. Note that all the standards mentioned above apply to airborne exposure to gases, vapors, and particulates. Those limits are not intended to evaluate the consequences of chemical exposures through other exposure paths.

- If the applicant does not use a published exposure standard or knows of no such standard for a chemical, it may propose an alternative, accompanied by supporting documentation to justify it. (e. g. research results from targeted studies, analogs to published studies, etc.)

- Consequence categorization is acceptable.

Chemical Process Controls

This section should include:

- A discussion that identifies the design basis for chemical process safety for normal operation and demonstrates that the proposed equipment and facilities adequately protect public health and safety and the environment. Based on a comparison of the unmitigated chemical consequences determined, the applicant should provide a list of chemical-process safety controls suitable to prevent or mitigate potential accidents. This list should also briefly describe the controls in sufficient detail to permit an understanding of their safety functions pursuant to 10 CFR 70.62. The application should also identify controls for those accidents containing a chemical system or process failure that could ultimately lead to radiological consequences that exceed the performance requirements. The applicant should demonstrate that the consequences of each credible event will be reduced after the implementation of controls, so that the consequences of the event will be low. Preventive controls are preferable to mitigative controls. Chemical safety-related controls should be included in the license technical specifications as appropriate.

Chemical Process Surveillance Requirements

This section should include:

- A description of the engineering approach, basis, or schemes employed to maintain safety during normal operations.
  - A discussion of the administrative and engineered controls to prevent or mitigate a chemical process risk (the hazard being mitigated). The applicant should also

explain how it graded the surveillance requirements and how this grading is commensurate with the reduction in risk that the controls are designed to achieve. Surveillance requirements related to serious accident prevention should be included in the license technical specifications.

- A demonstration that the surveillance requirements ensure that the chemical safety controls are available and reliable by briefly describing the following:

  – procedures to ensure the reliable operation of ESFs, TS, or both (e.g., inspection and testing procedures and frequencies, calibration programs, functional tests, corrective and preventive maintenance programs, criteria for acceptable test results)

  – procedures to ensure that administrative ESFs 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, training program evaluation)

## 13b.4 References

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

U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility," NUREG-1520, Revision 1, May 2010.

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.

# 14 TECHNICAL SPECIFICATIONS

This chapter generally describes the information that should be included in the TS of the SAR. The basic NUREG-1537 document primarily addresses TS for heterogeneous non-power reactors. This ISG is intended to broaden the application of NUREG-1537, Chapter 14 to include specifications for non-power AHRs and radioisotope production facilities, as appropriate. In the introductory comments, wherever there is reference to a "non-power reactor," the term should be understood to mean "non-power reactor, radioisotope, and SNM processing facilities."

TS will be developed after all reactor and radioisotope production facility operating characteristics are known and all credible accident conditions are evaluated. This ISG includes supplemental information and guidance from NUREG-1520, which provides direction for performing ISAs and deriving any required IROFS while working with SNM outside of the reactor. IROFS could be the equivalent of the TS as prescribed in 10 CFR 50.36 and as ESFs identified in Chapter 6 of NUREG-1537, and they will be designated TS and ESFs, as appropriate.

## Appendix 14.1

Additional sections have been added to this chapter as follows:

- Section 14a.1, "Heterogeneous Reactor Technical Specifications"
- Section 14a.2, "Aqueous Homogeneous Reactor Technical Specifications"
- Section 14b, "Technical Specifications for Radioisotope and Special Nuclear Material Processing Outside of the Reactor"

ISG for each of these options follows.

## 14a.1 Heterogeneous Reactor Technical Specifications

NUREG-1537 is applicable to a heterogeneous non-power reactor without any further guidance in this ISG.

## 14a.2 Aqueous Homogeneous Reactor Technical Specifications

NUREG-1537 can be used as guidance for writing an SAR for an AHR facility with the following modification: The numbering system for the various sections of NUREG-1537, Appendix 14.1, is revised in accordance with the following expanded sections for the AHR and radioisotope production facilities.

### 14a.2-1 Introduction

The current wording of NUREG-1537, Appendix 14.1, is applicable to an AHR without changes in this ISG.

*14a.2-2.1 Safety Limits and Limiting Safety System Settings*

The following sentence is added to the first paragraph: "For aqueous homogeneous core reactors, the gas management system is also part of the primary fission-product barrier."

The following sentences should be added to the end of the section: "For aqueous homogeneous reactors, the saturation temperature of the fuel solution should not be exceeded. There may be other limits on the character and quality of the fuel that might warrant setting additional safety limits (i.e., the operating-power density, the uranium concentration, the volume, the pH, and the temperature and pressure of the fuel solution)."

14a.2-2.1.1 Important Process Variables

The following should be added as a last paragraph: "When addressing safety limits for cooling systems in AHRs, the cooling requirements of the gas management system (i.e., recombiner and condenser) should be included in any analyses of SLs."

14a.2-2.1.2 Criteria—Reactors with Engineered Cooling Systems

This section of the current NUREG-1537 refers to cooling requirements to prevent damage to fuel cladding. In the case of an AHR, the term "cladding" should be interpreted to mean primary "fission-product barrier," which includes the core vessel and the components of the gas management system. Also, in the case of AHRs, excessive fuel temperatures could lead to bulk boiling of the fuel solution, reactivity instability, and consequent failure of the primary fission-product barrier by means other than high-temperature failure of the core or the gas management system vessels. SLs to prevent these events could be more limiting.

14a.2-2.1.3 Criteria—Reactors without Engineered Cooling Systems

As in the preceding Section 14a.2-2.1.2, this section refers to cooling requirements to prevent damage to fuel cladding. In the case of an AHR, the term "cladding" should be interpreted to mean "primary fission-product barrier," which includes the core vessel and the gas management system components. Appropriate limits should be established to prevent all mechanisms that would cause failure of the primary fission-product barrier.

*14a.2-2.2 Limiting Safety System Settings*

The current wording applies to an AHR.

**14a.2-3 Limiting Conditions for Operation**

The following section should be added:

> 14a.2-3.1(6)(e) AHR fuel
>
> The SAR must include the LCOs required by 10 CFR 50.36(c)(2) for liquid fuel including volume of the fuel solution, uranium burnup, uranium concentration in

solution, U-235 enrichment, fuel ambient and operating temperature limits, fuel solute concentration and pH limits, and others that could be necessary.

*14a.2-3.2 Reactor Control and Safety Systems*

14a.2-3.2.4 Scram Channels

Add channels deemed necessary for AHR operating limits, such as reactor vessel and gas management system component pressure, fission-product gas holdup tank pressure(s), recombiner temperature, recombiner coolant temperature, fuel solution pH, fuel solution level in the core vessel, inert cover gas concentration or flow rate, etc.

*14a.2-3.3, -3.4, -3.5, -3.6, -3.7, -3.8, and -3.9*

The current wording of these sections applies to an AHR facility without modification or augmentation by this ISG.

**14a.2-4 Surveillance Requirements**

*14a.2-4.1 Reactor Core Parameters*

The SAR should include the surveillance requirements for liquid fuel, including fuel physical and chemical parameters. If fuel is characterized as a routine function of normal operations, the surveillance measures could be the calibration of the various analytical methods used to perform routine characterization.

*14a.2-4.2 and 14a.2-4.3*

The current wording of these sections applies to an AHR without modification or augmentation by this ISG.

*14a.2-4.4 Containment and Confinement*

14a.2-4.4.1 Containment

The reactor vessel and gas management system (primary fission-product barrier) of an AHR or the structure that houses them can be considered the containment.

14a.2-4.4.2 Confinement

The confinement of an AHR may consist of the structure around the reactor vessel and gas management system, the structure, or part of the structure in which they are housed. It could also serve as a biological shield. Surveillance of the function and efficiency of the confinement components should be conducted periodically.

*14a.2-4.5 Ventilation Systems*

The current wording of this section applies to an AHR.

*14a.2-4.6, -4.7, -4.8, -4.9*

The current wording of these sections applies to an AHR.

**14a.2-5, 14a.2-6, 14a.2-7, 14a2-8**

The current wording of these sections applies to an AHR.

## 14b Technical Specifications for Radioisotope and Special Nuclear Material Processing Outside of the Reactor

### 14b.1 Introduction

The TS for SNM, radiochemical, and chemical processing that is conducted outside of the reactor are derived from ISAs that are required by 10 CFR Part 70, Subpart H, and in particular by 10 CFR 70.61(e). The ISAs of these processes indicate that certain limits on process variables and engineered or administrative control measures may become necessary to meet the performance requirements specified in 10 CFR 70.61(b), (c), and (d) and also in accordance with the criteria for TS in 10 CFR 50.36. Certain engineered or administrative control measures will be designated as IROFS, and they should be listed in these TS to ensure that they will be available and reliable to perform their intended functions if needed.

The format and content of the TS for radiochemical, chemical, and SNM processing outside of the reactor may be presented as prescribed below (per Appendix 14.1 to this chapter of NUREG-1537).

The assignment of TS for a radioisotope production facility must comply with the regulations in 10 CFR 50.36 pertaining to a fuel reprocessing facility, which is a specific type of production facility akin to a radioisotope separation facility. The TS should be assigned using a graded approach. SLs and control setpoints should be placed on those process variables that, if breached, would lead to the uncontrolled release of radioactive material. Ideally, these would apply to a critical few variables. The majority of the process variables would be assigned to the other specification categories that are less critical.

The format of the TS may be as suggested in appendix 14.1 to Chapter 14 of NUREG-1537, or the TS may be organized differently as necessary for the particular purpose of the specifications. Responses or reactions to deviations from TS depend on the severity of the situation, and appropriate response actions should be included as part of the specification.

### 14b.2 Safety Limits and Limiting Safety System Settings

The SL and limiting control settings are derived from ISAs. They are primarily engineered controls that are put in place to ensure that operations are maintained within adequate margins

of safety. NUREG-1537, Part 1, Appendix 14.2, applies to operations with radioactive material, SNM, and hazardous chemicals, as well as to reactor operations.

The format and content of the TS for radiochemical, chemical, and SNM processing outside of the reactor may be presented as prescribed below (per Appendix 14.1 to chapter 14 of NUREG-1537).

### 14b.2.1 Safety Limits for Processing Irradiated Special Nuclear Material Outside of the Reactor

The paramount concern with any work involving SNM is to avoid criticality accidents. Limits should be derived using the guidance and criteria for criticality accident prevention in Section 6b.3 and also as derived from performing ISAs according to Sections 13b.1 and 13b.2 of this ISG. Limits should be specified, using the double-contingency principal, to avoid a criticality accident. Limits should be set with a conservative margin.

Containment of fission products is necessary when processing irradiated SNM. Appropriate limits must be imposed pursuant to 10 CFR 50.36(c)(1) to ensure that fission products will be controlled to prevent excessive releases from the containment components, systems, or structures, particularly those structures, systems, and components containing large inventories of byproduct material.

### 14b.2.2 Safety Limits for Processing Unirradiated Special Nuclear Material Outside of the Reactor

The paramount concern with any work involving SNM is to avoid criticality accidents. Limits should be specified, using the double-contingency principal, to avoid a criticality accident. Limits should be set with a conservative margin.

### 14b.2.3 Safety Limits for Radiochemical Processing

Operations with radioactive materials must be conducted within limits pursuant to 10 CFR 50.36 to protect the staff and the public (refer to Section 14b.1, Introduction). The amount of radiation should be limited so as not to exceed the shielding and confinement capabilities of the systems and components in which the materials are processed or stored.

### 14b.2.4 Safety Limits for Chemical Processing

If operations with hazardous chemicals are conducted coincident to operations with SNM or radioactive material, the licensee must ensure that the performance requirements of 10 CFR 70.61 are met.

### 14b.2.5 Limiting Safety System Settings

For each process variable or parameter for which an SL is specified and for which monitoring instruments are employed, a protective operating limit should be set to avoid exceeding the SL. This setpoint should be calculated to provide a conservative margin below the SL and to

account for overall measurement uncertainty, operating characteristics of control systems, and accuracy of control instrumentation.

LSSSs should be established, as much as possible, to ensure adequate safety margins for each of the processes listed in Sections 14b.2.1, 14b.2.2, 14b.2.3, and 14b.2.4 above.

## 14b.3 Limiting Conditions for Operation

LCOs are derived from SARs and ISAs. They are administrative or engineered controls in addition to LSSSs that are put in place to ensure that operations are maintained within safe limits. The wording in NUREG-1537, Part 1, Appendix 14, Section 14.3, applies to operations with radioactive material, SNM, and hazardous chemicals, as well as to reactor operations.

### 14b.3.1 Primary Process Components and Systems

Processing structures, systems, or components and procedures that are designed and constructed to ensure that processing is conducted safely must have LCOs established for each of the processes defined in Sections 14b.2.1, 14b.2, 14b.3, and 14b.4 above. These limiting conditions should be operable when each of the corresponding processes are conducted. This section should enumerate these components and systems.

### 14b.3.2 Containment and Confinement

Any confinement or containment systems that are required as a result of the SAR or ISA for a particular process must be defined as an LCO and must be listed as such in this section pursuant to 10 CFR 50.36(c)(1).

### 14b.3.3 Ventilation Systems

If the SAR or ISA for any of the above-referenced processes prescribes the need for certain ventilation configurations, they must be listed here as an LCO pursuant to 10 CFR 50.36(c)(1).

### 14b.3.4 Emergency Electrical Power

If the SAR or ISA for any of the above-referenced processes prescribes the need for emergency electrical power, the power supply must be listed as an LCO pursuant to 10 CFR 50.36(c)(1).

### 14b.3.5 Radiation Monitoring Systems and Effluents

Refer to NUREG-1537, Chapter 14, Appendix 14.1, Section 3.7. The requirements of this section must be specified here as they pertain to any of the above-referenced processes pursuant to 10 CFR 50.36(c)(1).

## 14b.4 Surveillance Requirements

Surveillance requirements for any of the LSSSs and LCOs listed in the previous sections pertaining to the processing of SNM, radioactive materials, and hazardous chemicals must be

established and also be listed as a TS pursuant to 10 CFR 50.36(c)(3). Surveillance requirements should exist for the LSSSs and LCOs in the following categories:

- Process control instrumentation
- Process cooling systems
- Process containment/confinement systems
- Process-related ventilation systems
- Emergency power supplies
- Radiation monitoring systems

## 14b.5 Design Features

Refer to NUREG-1537, Chapter 14, Appendix 14.1, Section 5. The requirements of 10 CFR 50.36(c)(4) must be specified here as they pertain to any of the above-referenced processes.

## 14b.6 Administrative Controls

Refer to NUREG-1537, Chapter 14, Appendix 14.1, Section 6. The requirements of 10 CFR 50.36(c)(5) must be specified here as they pertain to any of the above-referenced processes.

## 14b.7 References

The references cited in Appendix 14.1 to NUREG-1537, Chapter 14, apply. The following references have been updated:

- ANSI/ANS 15.1 was updated in 2007.

- ANSI/ANS 15.4 was updated in 2009.

- NRC Regulatory Guide 2.4, 1977, “Review of Experiments for Research Reactors”

# 15 FINANCIAL QUALIFICATIONS

The current wording of this chapter in NUREG-1537, Part 1, is broad enough to apply to any type of reactor facility. It may also apply to a radioisotope production facility provided that the term "non-power reactor" is understood to mean a "reactor or a radioisotope production facility." Since the NUREG was initially issued in 1996, some changes to the regulations and guidance have occurred that are reflected in this ISG.

In the second paragraph, the reference to 10 CFR 2.790 has been replaced with 10 CFR 2.390, "Public inspections, exemptions, requests for withholding." This will provide the regulatory basis for Sections 15.1 through 15.3 below.

## 15.1 Financial Ability To Construct a Non-power Reactor

The first paragraph is replaced with: "An applicant for a construction permit to build a non-power reactor shall submit information that demonstrates that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover estimated construction costs and related fuel cycle costs. Pursuant to 10 CFR 50.75 the applicant shall submit estimates of the total construction estimates of the facility and related fuel cycle costs and shall indicate the sources of funds to cover these costs."

## 15.2 Financial Ability To Operate a Non-power Reactor

The first paragraph is replaced with: "An applicant for an operating license shall submit information that demonstrates that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover estimated operation costs for the period of the license. The applicant shall submit estimates for total annual operating costs for each of the first 5 years of operation of the facility. Pursuant to 10 CFR 50.75 the applicant shall also indicate the sources of funds to cover these costs. An applicant for renewal of an operating license for a non-power reactor shall include the financial information that is required in an application for an initial license pursuant to."

## 15.3 Financial Ability To Decommission the Facility

The fourth sentence of the first paragraph is replaced with: "The decommissioning report must contain a cost estimate for decommissioning the facility, an indication of which method or methods described in 10 CFR 50.75(e) are to be used to provide funds for decommissioning, and a description of the means of adjusting the cost estimate and associated funding level periodically over the life of the facility to account for changes in the costs of such items as labor, energy, and waste disposal."

The first sentence of the third paragraph is replaced with: "The acceptable methods of providing financial assurance for decommissioning are discussed in 10 CFR 50.75(e)(1)."

# 16 OTHER LICENSE CONSIDERATIONS

The current wording of NUREG-1537 is applicable to non-power reactors and radioisotope production facilities, without the need for modification or augmentation in this ISG.

# 17 DECOMMISSIONING AND POSSESSION-ONLY LICENSE AMENDMENTS

This ISG augments NUREG-1537, Part 1, so that it applies to non-power reactors and radioisotope production facilities for separating fission-product radioisotopes from the reactor fuel.

Most of the current content of this introductory section is outdated. For the purpose of this ISG, it should read: "The NRC has developed a systematic approach for licensee and NRC actions to terminate facility licenses. Regulation 10 CFR 50.82 requires that an application for termination of a license be preceded or accompanied by a proposed decommissioning plan (DP). The following guidance is offered to facilitate the composition and review of such DPs."

## 17.1 Decommissioning

The following new section has been added to NUREG-1537, Part 1:

### 17.1.0 Decommissioning Report

> Under 10 CFR 50.33(k)(1), an application for an operating license or a combined license for a production or utilization facility must state, in the form of a report as described in 10 CFR 50.75, how reasonable assurance will be provided that funds will be available to decommission the facility. At a minimum, this report must include a cost estimate, the proposed decommissioning method to be used, and a proposed means of projecting changes to the cost estimate. Additional information on funding can be found in NUREG-1537, Chapter 15, 'Financial Qualifications.'

### 17.1.1 Preliminary Decommissioning Plan

This section is amended to read:

> Under 10 CFR 50.75(f)(4), licensees must submit a preliminary DP at or about 2 years before the projected end of operation of the facility. The plan shall include an estimate of the cost and an up-to-date assessment of the major technical factors that could affect planning for decommissioning. The factors to be considered include the following:

The current list of factors [(1) through (5)] in this section of the NUREG-1537 apply to a non-power reactor and radioisotope production facility, except that the regulation referenced in (1) should be changed to 10 CFR 50.82(b)(4)(i).

The last paragraph of this section is amended to read: "The preliminary DP only needs to address the five factors listed above and may be substantially less detailed than the final DP. Additional information on financial aspects of decommissioning may be found in Chapter 15, 'Financial Qualifications,' of this guide."

### 17.1.2 Decommissioning Plan

The current NUREG-1537 remains unchanged except as follows:

- In the second paragraph, the references to sections of the regulations are changed from 10 CFR 50.82(b)(1)(ii) to 10 CFR 50.82(b) and from 10 CFR 50.82(b)(1)(iii) to 10 CFR 50.82(b)(4)(i).

- In the fourth paragraph, the reference to the section of the regulations is changed from 10 CFR 51.53(b) to 10 CFR 51.53(d).

### 17.1.3 Decommissioning Alternatives

The current NUREG-1537 remains valid except in the last paragraph, where the reference to the regulations is changed from 10 CFR 50.82(b)(1)(iii) to 10 CFR 50.82(b)(4)(i) in the first sentence.

### 17.1.4 Release Criteria and Final Survey

The current wording of this section no longer applies. It's revised to read: "As set forth in 10 CFR 20.1402, prior to terminating a license, the NRC shall determine that the health and safety of the public will continue to be protected after the facility and site are released. The requirements for terminating a non-power reactor license are found in 10 CFR 50.82(b). The criteria that must be met to release sites that are licensed under 10 CFR Part 50 (and others) for unrestricted use are in 10 CFR 20.1402, which requires that the residual radioactivity be reduced to a level that is ALARA and that any radiation above background radiation will not result in an annual TEDE to an average member of the critical group greater than 0.25 mSv (25 mrem), including the dose from ground water sources of drinking water."

### 17.1.5 Format and Content of Decommissioning Plan

The last paragraph of this section should be changed to read: "Subsequent to the issuance of this NUREG, the majority of decommissioning oversight responsibility has been shifted to the NRC Office of Federal and State Materials and Environmental Management Programs (FSME), Division of Waste Management and Environmental Protection (DWMEP), Materials Decommissioning Branch. More guidance has been published on decommissioning methods, particularly on the subject of conducting surveys and satisfying acceptance criteria. This recently developed guidance is contained in NUREG-1757, Volume 1, "Consolidated Decommissioning Guidance: Decommissioning Process for Material Licensee," Rev. 2, September 2006; NUREG-1757, Volume 2, "Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria," Rev.1, September 2006; and NUREG-1757, Volume 3, "consolidated NMSS Decommissioning Guidance: Financial Assurance, Recordkeeping, and Timeliness," September 2003." Therefore, NUREG-1537, Appendix 17.1, "Format and Content of Decommissioning Plan for Non-Power Reactors," may serve as the basic outline for the DP, but the content should be augmented by including appropriate parts of NUREG-1757."

## 17.2 Possession-Only License Amendment

This section, as currently worded, applies to a non-power reactor and radioisotope production facility. The references to the regulations in this section is changed as follows: in the second paragraph, the reference to 10 CFR 50.82(b)(1)(iii) is changed to 10 CFR 50.82(b)(4)(i).

### 17.2.1 Application for a Possession-Only License

The section and subsections of NUREG-1537, Part 1, as currently worded, apply to a non-power reactor and radioisotope production facility.

## Appendix 17.1

As stated in Section 17.1.5 of this chapter, this appendix should be used in conjunction with the newer document NUREG-1757, Volume 1, "Consolidated Decommissioning Guidance: Decommissioning Process for Material Licensee," Rev. 2, September 2006; NUREG-1757, Volume 2, "Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria," Rev.1, September 2006; and NUREG-1757, Volume 3, "consolidated NMSS Decommissioning Guidance: Financial Assurance, Recordkeeping, and Timeliness," September 2003.

## 17.10 References

The current list of references applies, with the exception of ANSI/ANS 15.1, which was updated in 2007.

# 18 HIGHLY ENRICHED URANIUM TO LOW-ENRICHED URANIUM CONVERSION

The current version of NUREG-1537, Part 1, can apply to all types of non-power reactor and radioisotope production facilities without modification or augmentation of this ISG, provided that wherever the term “reactor” appears, it is understood to also mean “radioisotope production facility,” as appropriate.