PLANT SYSTEMS

12.1 PURPOSE OF REVIEW

The purpose of this review is to establish that there is reasonable assurance that the plant systems will perform their intended safety functions. Examples of plant systems are as follows: (a) a ventilation system necessary to provide certain decontamination factors for normal, offnormal, and accident conditions, (b) a cooling system necessary to provide a heat sink to prevent certain process elements from exceeding temperature limits, or (c) an electrical distribution system necessary to support various systems and components relied on for safety. This section should be used by the secondary and supporting reviewers to ensure that the plant systems as described support and are consistent with their cognitive review areas.

Part 70, as revised[1], contains Baseline Design Criteria (BDCs), §70.64, that provide general design considerations. This SRP section addresses equipment and facilities specifically as plant systems that are either identified as items relied on for safety or that are required to support the items relied on for safety that are identified in the hazard and accident analyses of the integrated safety analysis (ISA) with due consideration given to the BDCs.

12.2 RESPONSIBILITY FOR REVIEW

Primary: Discipline specific engineers

Secondary: Chemical Process Engineer, Health Physicist, Fire Protection Specialist

Supporting: Primary Reviewers of SRP Section 1.1, and Chapters 2.0, 3.0, 4.0 and 8.0. Primary Reviewers of Applicable Sections of SRP Chapter 11.0.

12.3 AREAS OF REVIEW

The review should address plant systems that have safety functions or support safety functions identified in the ISA (e.g., the ISA may state that a particular vessel has a safety limit or heat load that is maintained by the cooling water system; however, in Chapter 12, the physical cooling system is described in sufficient detail to make a determination of its availability when called upon to service the heat load). The review of plant systems should focus on the mechanical, material, electrical, I&C, and structural aspects, as necessary, of the specific systems which are integrated throughout the process flow path and should confirm the plant systems' ability to satisfy its specified performance requirements.

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[1]Nuclear Regulatory Commission (U.S.), Washington, D.C. "Domestic Licensing of Special Nuclear Material (10 CFR Part 70)." *Federal Register* : Vol. 64, No. 146. pp. 41338–41357. July 30, 1999.

12.3.1 Specific Items to be Reviewed for Each System

The specific items to be addressed are as follows:

1. Safety Function -- This provides the link between the ISA to the performance requirements of the plant system.

2. System description and safety analysis -- This is sufficient to provide reasonable assurance that the given system can satisfy its performance requirements

The applicant is encouraged to take advantage of pertinent existing safety analyses and design information (i.e., requirements and their bases) that are immediately available or can be retrieved through reasonable efforts. To facilitate review of this design information, the applicant could provide a roadmap and a brief summary for each such reference that explains its relevance to this chapter.

12.3.2 Typical Plant Systems

A listing of typical plant systems is as follows:

1. Utilities
    a. Electrical
    b. Cooling water
    c. Steam/Condensate
    d. Pneumatic
    e. Lighting systems
2. Ventilation
3. Instrumentation and Controls
4. Load handling systems
5. Chemical control systems
6. Waste management system
    a. Gaseous
    b. Solid
    c. Liquid
    d. Process sampling systems
7. Containment/confinement systems

12.4 ACCEPTANCE CRITERIA

12.4.1 Regulatory Requirements

The requirements for plant systems are addressed in the following:

Code of Federal Regulations, *Title 10, Energy*, Part 70, “Domestic Licensing of Special Nuclear Material (10 CFR Part 70)."

Specific references are as follows:

1. In § 70.22(a)(7), the applicant is required to provide a description of equipment and facilities used by the applicant to protect health and minimize danger to life and property.

2. In § 70.23(a)(3), the Commission is required to make the determination that proposed equipment and facilities are adequate to protect health and minimize danger to life and property.

Nuclear Regulatory Commission (U.S.), Washington, D.C. "Domestic Licensing of Special Nuclear Material (10 CFR Part 70)." *Federal Register* : Vol. 64, No. 146. pp. 41338–41357. July 30, 1999.

Specifically:

In §70.64, "Requirements for new facilities or new processes at existing facilities," the applicant or licensee is required to address the baseline design criteria in the design of new facilities.

12.4.2 Regulatory Guidance

None, at present, specific to 10 CFR 70 licensees.

12.4.3 Regulatory Acceptance Criteria

The NRC reviewers should find the applicant's submittal regarding plant systems provides reasonable assurance that the regulatory review criteria below are adequately addressed and satisfied. Some of the information may be referenced to other sections of the SRP, or incorporated by reference, provided an adequate summary is provided and a single reference essentially contains all of the information. Accordingly, this review should have considerable interface with other review sections. In Section 12.4.3.1, general acceptance criteria are provided. In Section 12.4.3.2, specific acceptance criteria are provided for certain systems to provide the type of information that the NRC staff reviewer would be looking for as needed to support their evaluations of the respective plant systems ability to meet the performance criteria.

12.4.3.1 General Plant System Acceptance Criteria

1. <u>Safety Function</u>:

   The safety functions of the plant system should be considered acceptable if the submitted information supports the following observations:

   a. The system safety function is consistent with the ISA summary (evaluated for its acceptability in SRP Chapter 3.0, "Integrated Safety Analysis") and is inclusive of systems that support items relied on for safety or are identified as items, themselves, inclusive of both preventive and mitigative safety features.

b. Functional requirements are clearly stated to allow for the system to be adequately designed to satisfy its intended safety function. Any performance requirements, including environmental operating conditions and system availability, are also identified.

c. Process elements that the plant system supports are clearly stated. Furthermore, if the system is part of a larger process/safety system, the relation of the system to that overall system is described (e.g., I&C systems tend to be part of larger safety systems).

2. System Description:

The plant system description of the plant system should be considered acceptable if the applicant has provided the following:

a. The purpose of the system for both safety and non safety features. Non safety features should be addressed in the context of not preventing the plant system from performing its safety function (see below, Safety Analysis, 3.b).

b. The basic system description and theory, including basic theory of operation, and as applicable, credible environmental conditions, and safe upper and lower limits for such items as temperatures, pressures, flows, and material compositions.

c. As applicable, hazardous material information. This could include reference to the hazardous material information of the process system the plant system supports.

d. Structures and components including pertinent aspects that directly relate to the safety function (e.g., diesel generator load capacity, time to load (if critical)) as opposed to general industrial equipment specifications that fall out from these capabilities (e.g., starting torque, motor insulation, number and type of windings). Such lower tier details should be implicitly included only by reference to the overall specifications.

e. Assurance measures including codes and standards used for mechanical, civil, chemical, electrical, and instrumentation and control systems.

f. Drawings and procedures comprised of process and instrumentation drawings (P&IDs), or a simplified system drawing with reference to P&IDs and operating procedures.

g. I&C and Electrical requirements necessary to accomplish safety functions.

h. Management measures specific to this plant system needed to ensure performance of the system safety functions (i.e., long-term performance, testing, and maintenance features).

i. System interfaces including a description how the interface could prevent the system from performing its safety function.

3. Safety Analysis:

   The safety analysis for the plant system should be considered acceptable if the following are true:

   a. The application and referenced material demonstrate how functional requirements are satisfied by system design.

   b. The application and referenced material demonstrate how potential failure modes are factored into the system design. As applicable:

      i. Communication failures,
      ii. Isolation between safety and non-safety-related components,
      iii. Potential for common mode failures of redundant systems, and
      iv. Inappropriate actions from operators or maintenance personnel that prevent the safety function from being carried out. The application clearly demonstrates how non-safety features do not prevent the system from performing its safety function.

12.4.3.2 Acceptance Criteria Unique to Specific Plant Systems

The following provide acceptance criteria that are unique to a specific plant system. These examples, as applicable, should be discussed in addition to the generic acceptance criteria.

1. **Electrical Systems**:

   a. The basic system description and theory should also include relevant elements of off-site ac and dc systems and their interconnections; on-site ac and dc systems; stand-by power systems; system independence; redundancy; sharing of systems. The design features include capacity and capability, protection features, ability to withstand operating and environmental stressors, and considerations for long-term performance, testing and maintenance.

   b. Structures and components should including emergency and standby power sources

   c. Management measures should include tests and other verification methods that demonstrate how systems requirements have been incorporated into the electrical systems. The electrical systems requirements are traceable through design to the testing phase. Tests and verification methods demonstrate, to a sufficient degree, the ability of the electrical systems to handle credible, unexpected inputs and situations. Also, the electrical system is designed for test, calibration, and in service surveillance requirements.

   d. Safety Analysis: The safety analysis for the electrical systems should be considered acceptable if the application and referenced material demonstrate how functional requirements are satisfied by system design. As appropriate, the application and referenced material addresses how environmental effects including temperature, pressure, humidity, vibration, harmonics, electromagnetic/radio frequency interference are tolerated by the systems.

2. **Cooling Water Systems**

a. The basic system description and theory, including how the cooling water system and its subsystems transfer heat loads from safety-related structures, systems, and components to an appropriate heat sink under both normal operating and accident conditions. The description also addresses the availability of adequate water supply under normal and hazardous conditions, component redundancy and the capability to isolate components, systems or piping for maintaining system safety function under varying system configuration, and the capability of integrated system control.

b. Management measures including tests and other verification methods that demonstrate the structural integrity and system leak tightness, the operability and adequate performance of active system components, and the capability of the system to perform required functions during normal, and accident situations.

c. Descriptions of the system showing the capability for withstanding environmental hazards resulting from pipe line breaks and dynamic effects associated with flow instability and attendant loads such as water hammer, or cavitation, and measures to prevent such dynamic conditions from occurring.

d. Design features which include capacity and capability for detecting leakage of radioactivity, chemical contamination from one system to another, and allowing inservice component inspection, system maintenance, and operational functional testing of the system and its components.

3. **I&C**

a. The basic system description and theory, including real-time parameters(i.e. system response-times, sample rates, and delays), range of input and output values for normal and abnormal conditions, setpoint calculations, accuracy of signal measurements, and other detail requirements governing I&C design and acquisition. A description on how the various I&C components (both hardware and software) carry out the safety function(s). When appropriate, the description addresses how environmental effects (i.e. temperature, humidity, vibration, and electromagnetic/radio frequency interference) are tolerated by the I&C system. In addition, provisions for manual actuation of the I&C safety function(s) are described.

b. Assurance measures including codes and standards for hardware/software development and setpoint methodology.

c. Drawings and procedures comprised of logic diagrams, or a simplified system drawing with reference to drawings and procedures. In addition, references to documents are provided for hardware/software requirements specifications, P&IDs, hardware/software design documents, software code, schematics, test procedures/reports, and supporting manuals.

d. Management measures specific to the plant system needed to ensure performance of the system safety functions including long-term performance, testing, and maintenance features. Tests and other verification/validation methods for hardware/software that demonstrate that all system requirements have been incorporated into the I&C system. I&C system requirements are traceable through design to the testing phase. Tests and verification methods demonstrate, to a sufficient degree, the ability of the I&C system to handle credible, unexpected inputs and situations. Also, the I&C system is designed for easy test and calibration.

e. Description of system interfaces that provide the following information: an evaluation of potential communication failures, isolation between safety and non-safety components(considers both electrical and logic isolation), and inappropriate actions from operators or maintenance personnel that prevent the safety function from being carried out (coordinate with human factors review in Section 11.6). Interfaces with supporting systems such as power supplies, HVAC, etc., are also described.

4. **Containment/Confinement Systems**

a. The basic system description and theory, including how the various structural systems, sub-systems and their interfaces carry out their safety functions. When appropriate, the description addresses how environmental effects including temperature, pressure, humidity, wind, tornadoes, flood, lightning, and earthquakes are tolerated by the systems. The design features include capacity and capability, protection features, withstanding operating and environmental stressors, and long-term performance over time.

b. Management measures specific to the plant system needed to ensure performance of the system safety functions including long-term performance, testing, and maintenance features. Tests and other verification methods that demonstrate all systems requirements have been incorporated into the structural systems. Tests and verification method demonstrate, to a sufficient degree, the ability of the structural system to handle credible, unexpected loads and load combinations.

5. **Ventilation System**

a. The basic system description and theory including system layout and details of fans, ducts, dampers and other components sufficient to describe how the system performs its safety function. System capacities, pressure differentials between contamination zones, and efficiencies of filters should be included in this description. Alarm set points and interlocks to prevent inadvertent pressurization of an area should also be described.

b. Structures and components including aspects that directly relate to the safety function (e.g. normal operating capacities and maximum capacities of fans and blowers, heating requirements for outside intake units, dispersion capabilities of release stacks and etc.) The capability of the system to withstand severe natural events should also be described.

c. Drawings and procedures comprised of P&IDs, volume flow diagrams or balance reports, or a simplified system drawing with reference to drawings and procedures. References to documents and manuals which describe the ventilation system and its associated support systems.

d. Management measures specific to the plant system needed to ensure performance of the system safety functions including long-term performance, testing, and maintenance features. Tests and other verification methods should demonstrate that all system requirements have been incorporated into the ventilation system. Tests and verification methods should demonstrate, to a sufficient degree, the ability of the ventilation system to handle credible, unexpected concentrations of radioactive or hazardous gases or aerosols including combustion products. Also, as necessary, the ventilation system is designed for testing and in service surveillance requirements.

12.5 REVIEW PROCEDURES

12.5.1 Acceptance Review

The primary reviewer evaluates the application to determine whether it addresses the “Areas of Review” discussed in Section 12.3, above. If significant deficiencies are identified, the applicant should be requested to submit additional material before the start of the safety evaluation.

12.5.2 Safety Evaluation

After determining that the application is acceptable for review in accordance with Section 12.5.1, above, the primary reviewer will perform a safety evaluation against the acceptance criteria described in Section 12.4. If during the course of the safety evaluation, the primary reviewer determines the need for additional information, the primary reviewer coordinates a request for additional information with the licensing project manager.

Because the results of the ISA identify the items relied on for safety that form the safety functions discussed above, the primary reviewers should also review the ISA Summary (see SRP Chapter 3.0). Plant systems, as defined in the SAR, should conform to the level of safety to support the ISA summary. The primary reviewer should establish that the applicant’s facility design and operations provide reasonable assurance that the plant systems satisfy the acceptance criteria in Section 12.4 and will perform their intended safety functions.

The secondary reviewers should confirm that the described plant systems are consistent with other sections of the application. Information provided for plant systems should be of comparable quality and detail, and should not contradict or adversely impact information contained in other sections of the application.

Supporting reviewers should confirm that provisions made in the application for plant systems are in accordance and consistent with specified sections of the SRP. For example, the primary reviewer from SRP Chapter 4.0, "Radiation Safety" (usually a health physicist), as a supporting reviewer for plant systems, should establish that the applicant provides reasonable assurance for the facility and its operations will not have unacceptably adverse impacts on the radiological safety at the facility. For another example, the primary reviewer of SRP Section 11.2, "Configuration Management," as a supporting reviewer for plant systems verifies that these safety systems are properly captured in the applicant's configuration management program.

For an existing facility, the NRC reviewers may wish to visit the site and facility personnel in order to gain a better understanding of the represented plant systems and their intended safety functions. For a planned facility, the NRC reviewers may wish to meet with the design team in order to gain a better understanding of the process, its potential hazards, and safety approaches.

When the safety evaluation is complete, the primary reviewer, with assistance from the other reviewers, should prepare the plant systems input for the Safety Evaluation Report (SER), as described in Section 12.6 using the acceptance criteria from Section 12.4. The secondary reviewer should coordinate the plant systems input with the balance of the reviews and the SER.

12.6 EVALUATION FINDINGS

The primary reviewer writes an SER section addressing each topic reviewed under this SRP Chapter and explains why the NRC staff has reasonable assurance that the chemical safety part of the application is acceptable. License conditions may be proposed to impose requirements where the application is deficient. The SER should include a summary statement of what was evaluated and the basis for the reviewers' conclusions.

The staff can document the evaluation as follows:

> *The staff has evaluated .....* [Insert a summary statement of what was evaluated and why the reviewer finds the submittal acceptable.] *Based on the review of the license application, the NRC staff has concluded that the applicant has adequately described and designed plant systems in order to adequately perform their intended safety functions as identified in the ISA. In doing so the applicant has satisfactorily addressed the baseline design criteria contained in 10 CFR Part 70, as revised.*

12.7 REFERENCES

1. Nuclear Regulatory Commission (U.S.), Washington, D.C. "Domestic Licensing of Special Nuclear Material (10 CFR Part 70)." *Federal Register* : Vol. 64, No. 146. pp. 41338–41357. July 30, 1999.

2. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-0800, "Standard Review Plan for

the Review of Safety Analysis Reports for Nuclear Power Plants." Section 3.8.4, "Other Seismic Category I Structures." NRC: Washington, D.C. June 1996.

3. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-0800. Chapter 8, "Electric Power." NRC: Washington, D.C. June 1996.

4. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-0800. Chapter 9, "Auxiliary Systems." NRC: Washington, D.C. June 1996.

5. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-0800. Chapter 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria, Design Certification." NRC: Washington, D.C. June 1996.

6. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-0800. Chapter 7, "Instrumentation and Controls," NRC: Washington, D.C. July 1997.