# 11.0 ACCIDENT ANALYSES

## I. Review Objective

In this portion of the dry cask storage system (DCSS) review, the NRC evaluates the applicant's identification and analysis of hazards, as well as the summary analysis of system responses to both off-normal and accident or design-basis events. This review ensures that the applicant has conducted thorough accident analyses, as reflected by the following factors:

1. identified all credible accidents
2. provided complete information in the safety analysis report (SAR)
3. analyzed the safety performance of the cask system in each review area
4. fulfilled all applicable regulatory requirements

## II. Areas of Review

This portion of the DCSS review evaluates the applicant's identification and analysis of hazards, with particular emphasis on the safety performance of the cask system under off-normal events and conditions and accident or design-basis events. Consequently, this chapter of the DCSS Standard Review Plan (SRP) provides guidance for use in reviewing the applicant's identification and analysis of hazards, as well as the summary analysis of system responses. A comprehensive accident analysis evaluation *may* encompass the following areas of review:

1. cause of the event
2. detection of the event
3. summary of event consequences and regulatory compliance
4. corrective course of action

## III. Regulatory Requirements

1. Structures, systems, and components (SSC) important to safety must be designed to withstand credible accidents and natural phenomena without impairing their ability to perform safety functions. [10 CFR 72.24(d)(2); 10 CFR 72.122(b)(2), (3), (d), and (g)[1]]

2. During normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid and 25 mrem to any other organ as a result of exposure to the sources listed in the regulations. [10 CFR 72.104(a); 10 CFR 72.236(d); and 10 CFR 72.24(d)]

3. Dose Limits for Design-Basis Accidents require that any individual located on or beyond the nearest boundary of the controlled area shall not receive a dose greater than 5 rem to the whole body or any organ from any design basis accident. [10 CFR 72.106(b); 10 CFR 72.24(m); and 10 CFR 72.24(d)(2)]

4. The spent fuel must be maintained in a subcritical condition under credible conditions [10 CFR 72.236(c) and 10 CFR 72.124(a)]

5. The cask and its systems important to safety must be evaluated, using appropriate tests or by other means acceptable to the Commission, to demonstrate that they will reasonably maintain confinement of radioactive material under credible accident conditions [10 CFR 72.236(l)]

6. Storage systems must allow ready retrieval of spent fuel for further processing or disposal. [10 CFR 72.122(l)]

7. Instrumentation and control systems must be provided to monitor systems that are important to safety over anticipated ranges for normal operation and off-normal operation. Those instruments and control systems that must remain operational under accident conditions must be identified in the Safety Analysis Report [10 CFR 72.122(i)]

8. Where Instrumentation and control systems are not appropriate. Storage confinement systems must have the capability for continuous monitoring in a manner such that the licensee will be able to determine when corrective action needs to be taken to maintain safe storage conditions. [72.122(h)(4)]

## IV. Acceptance Criteria

Accidents and events associated with natural phenomena may share common regulatory and design limits. Consequently, the following sections sometimes refer to these scenarios collectively as *accident conditions*.

By contrast, anticipated occurrences (off-normal conditions) are distinguished, in part, from accidents or natural phenomena by the appropriate regulatory guidance and design criteria. For example, the radiation dose from an off-normal event must not exceed the limits specified in 10 CFR Part 20 and 10 CFR 72.104(a), whereas the radiation dose from an accident or natural phenomenon must not exceed the specifications of 10 CFR 72.106(b). Accident conditions may also have different allowable structural criteria.

In general, this portion of the DCSS review seeks to ensure that the given design and the applicant's hazard identification and analyses of related system responses fulfill the following acceptance criteria:

### 1. Dose Limits for Off-Normal Events

During normal operations and anticipated occurrences, the requirements specified in 10 CFR Part 20 must be met. In addition the annual dose equivalent to any individual located beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as a result of exposure to the following sources:

a. planned discharges to the general environment of radioactive materials (with the exception of radon and its decay products)

b. direct radiation from operations of the independent spent fuel storage installation (ISFSI)

c. any other cumulative radiation from uranium fuel cycle operations (i.e., nuclear power plant) in the affected area

### 2. Dose Limit for Design-Basis Accidents

Any individual located at or beyond the nearest controlled area boundary must not receive a dose greater than 5 rem to the whole body or any organ from any design-basis accident.

### 3. Criticality

The spent fuel must be maintained in a subcritical condition under credible conditions (i.e., $k_{eff}$ equal to or less than 0.95). At least two unlikely, independent, and concurrent or sequential changes must be postulated to occur in the conditions essential to nuclear criticality safety before a nuclear criticality accident is possible (double contingency).

### 4. Confinement

The cask and its systems important to safety must be evaluated, using appropriate tests or by other means acceptable to the Commission, to demonstrate that they will reasonably maintain confinement of radioactive material under credible accident conditions.

### 5. Retrievability

Retrievability is the capability to return the stored radioactive material to a safe condition without endangering public health and safety. This generally means ensuring that any potential release of radioactive materials to the environment or radiation exposures is not in excess of the limits in 10 CFR 20[2] or 10 CFR 72.122(h)(5). ISFSI and MRS storage systems must be designed to allow ready retrieval of the stored spent fuel or high level waste (MRS only) for compliance with 10 CFR 72.122(l).

### 6. Instrumentation

The SAR must identify all instruments and control systems that must remain operational under accident conditions.

## V. Review Procedures

More detailed review procedures are under staff consideration and will be provided in a future revision to this SRP.

The review procedures presented here describe general procedures for reviewing a DCSS submittal.

Review the off-normal conditions, accidents, and natural phenomena events identified in SAR Section 2. For each type of event, this discussion should include the applicant's evaluation of the following areas, as applicable.

### 1. Cause of the Event

In some cases, an event may be analyzed for regulatory purposes even though no credible cause can be identified. Such events should be clearly identified as "non-mechanistic."

### 2. Detection of the Event

The licensee may detect an event through visual surveillance or monitoring instrumentation and alarms. The method of detection will be intuitively obvious for some events, whereas other events (e.g., fuel rod rupture) may remain undetected, at least for a significant period of time.

DCSS monitoring equipment (such as a pressure monitoring system) would be classified as important to safety in accordance with NUREG/CR-6407[3], "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety." Refer to Chapter 7 of this SRP.

Plant monitoring equipment (such as the seismic monitoring system) used by the ISFSI would be classified in accordance with the regulations of 10 CFR 50.55a and guidance provided in NUREG-0800[4], "SRP for the Review of SAR for Nuclear Power Plants," Section 7.5, "Information Systems Important to Safety."

*Note that if the licensed power plant is decommissioned, any plant monitoring equipment that is relied on by the ISFSI must be added to the ISFSI monitoring equipment.*

### 3. Summary of Event Consequences and Regulatory Compliance

The applicant should address event consequences in each functional area corresponding to earlier sections of the SAR (i.e., structural, thermal, shielding, criticality, confinement, and radiation protection). This discussion should refer back to each SAR section in which the individual consequences are evaluated in detail. In addition, the applicant should show that the consequences comply with the applicable regulatory criteria. For anticipated occurrences, the applicant should demonstrate compliance with Part 20 as well as Part 72

Because of the stringent design requirements for dry storage casks, it is expected that significant releases of radioactive material will not occur under normal, off-normal, and design-basis accident conditions; the major source of exposure is expected to be direct radiation. However, to demonstrate the overall safety of the cask storage system, and to illustrate compliance with regulatory limits, the applicant's analyses should presume that a non-mechanistic event will result in a release of radioactive material. This approach is normally applied in the environmental assessment, to illustrate compliance with regulatory dose requirements, and to aid the licensee in establishing an appropriate controlled area boundary.

### 4. Corrective Course of Action

The applicant should identify what action(s), if any, would be necessary to recover from the event. If various courses of action are possible, the applicant should present a discussion concerning the selection

of the most appropriate action. Because the fuel must be readily retrievable, returning the cask to the fuel handling building and reloading the spent fuel into a new cask is a viable option.

The primary emphasis in this portion of the DCSS review is to assess whether the applicant has provided complete information regarding the accident analyses. Therefore, the individual reviewers should ensure that the applicant has identified and analyzed credible situations, addressed their impact on each review area, and satisfied the applicable regulatory criteria.

## VI. Evaluation Findings

Review the 10 CFR Part 72 acceptance criteria and provide a summary statement for each. These statements should be similar to the following model:

- Structures, systems, and components of the [cask designation] are adequate to prevent accidents and to mitigate the consequences of accidents and natural phenomena events that do occur.
- The spacing of casks, discussed in Section _____ of the safety evaluation report (SER) and included as an operating limit in Section 12 of the SAR will ensure accessibility of the equipment and services required for emergency response.
- Table ___ of the SER lists the Technical Specifications for the [cask system designation]. These Technical Specifications are further discussed in Section _____ of the SER.
- The applicant has evaluated the [cask designation] to demonstrate that it will reasonably maintain confinement of radioactive material under credible accident conditions.
- An accident or natural phenomena event will not preclude the ready retrieval of spent fuel for further processing or disposal.
- The spent fuel will be maintained in a subcritical condition under accident conditions.
- Neither off-normal nor accident conditions will result in a dose, to an individual outside the controlled area, that exceeds the limits of 10 CFR 72.104(a) or 72.106(b), respectively.
- No instruments or control systems are required to remain operational under accident conditions [as applicable].

The staff concludes that the accident design criteria for the [cask designation] are in compliance with 10 CFR Part 72 and the accident design and acceptance criteria have been satisfied. The applicant's accident evaluation of the cask adequately demonstrates that it will provide for safe storage of spent fuel during credible accident situations. This finding is reached on the basis of a review that considered independent confirmatory calculations, the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

## VII. References

1. *U.S. Code of Federal Regulations*, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-level Radioactive Waste," Part 72, Title 10, "Energy."

2. *U.S. Code of Federal Regulations*, Part 20, "Standards for Protection Against Radiation," Title 10, "Energy."

3. NUREG/CR 6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," February 1996.

4. U.S. Nuclear Regulatory Commission, NUREG-0800; "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,"