Introduction to Engineered Safety Features

Section 5.0

HRTD
Human Resources
Training & Development

Objectives

1. State the purposes of the Engineered Safety Feature (ESF) Systems.
2. Identify the three barriers designed to limit the escape of fission products to the environment.

Objectives

3. Explain the following terms:
   a. Redundancy
   b. Physical and electrical separation

Objectives

3. Continued
   c. Regulatory terms associated with safety:
      - **Important to Safety**
      - **Safety Related**
      - **Safety Grade**

Objectives

d. Seismic Category I
e. Diversity
f. Single Failure
g. Active Failure
h. Passive Failure
i. ESF Train

Objectives

- List the four design categories or conditions of operation, and give an example of each.

Objectives

5 List the five acceptance criteria for the Emergency Core Cooling Systems (ECCS).

Purpose of ESF Systems OBJ1

- The purpose of Engineered Safety Features are to mitigate the consequences of an accident.

Fission Product Barriers OBJ2

- Fuel Cladding.
- RCS Pressure Boundary

  Reactor vessel and RCS piping.
- Containment Building

General Design Criterion 35

- *Criterion 35 -- Emergency core cooling*.

  A system to provide abundant emergency core cooling shall be provided.

  The system **safety function** shall be to transfer heat from the reactor core following any loss of reactor coolant at a rate such that

  (1) fuel and clad damage that could interfere with continued effective core cooling is prevented and

  (2) clad metal-water reaction is limited to negligible amounts.

Safety Function

A safety function is any condition or action needed to either **prevent core damage** or to **minimize radiation releases** to the general public.

If all safety function acceptance criteria are satisfied, the safety of the public is preserved.

Emergency Core Cooling Systems

- High Head Injection (CCP) is a high pressure, low volume system.
- Safety Injection (Intermediate head) is an intermediate head, intermediate volume system.

Emergency Core Cooling Systems

- Low head injection (RHR) is a low pressure, high volume system.
- The four accumulators are a passive ECCS system.

ECCS Train OBJ3i

- An ECCS train consists of:
  1. One centrifugal charging pump.
  2. One safety injection pump.
  3. One RHR pump
  4. An operable flow path from the RWST to the RCS and from the containment sump back to the RCS.
  5. Power supplies and instrumentation for the above items.

Decay Heat Removal

- In addition to the ECCS, the AFW system also removes decay heat.

Redundant OBJ3a

Suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that

1) for **onsite** electric power system operation (assuming offsite power is not available) or

2) for **offsite** electric power system operation (assuming onsite power is not available)

the system safety function can be accomplished, assuming a single failure.

Physical and Electrical Separation OBJ3b

- **Systems must be physically separated so that failure of one does not prevent the other from performing its function.**
- **Standby, redundant, reliable power must be provided for each ECCS Train**

Important to Safety OBJ3c

- Those structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

Safety Related OBJ3c

- ***Safety-related structures***, **systems and components means those structures, systems and components that are relied upon to remain functional during and following design basis events to assure:**
  - **(1) The integrity of the RCS pressure boundary**
  - **(2) The capability to shut down the reactor and maintain it in a safe shutdown condition; or**
  - **(3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in 50.34(a)(1) or §100.11 of this chapter, as applicable.**

Safety-Grade OBJ3c

- Not explicitly used in regulations.
- Generally understood to be equivalent to safety-related.

Seismic Category I OBJ3d

- Those systems, structures, and components that are designed to remain functional during the safe shutdown earthquake are designated as Seismic Category I.

Safe Shutdown Earthquake

- It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional.

Diversity OBJ3e

- Systems performing the same safety function but accomplishing that function using different principles.

Single Failure OBJ3f

- **A single failure means an occurrence which results in the loss of capability of a component to perform its intended safety functions.**
- **Multiple failures resulting from a single occurrence are considered to be a single failure.**
- **Fluid and electric systems are considered to be designed against an assumed single failure if neither**

  (1) a single failure of any active component (assuming passive components function properly) nor

  (2) a single failure of a passive component (assuming active components function properly),

  results in a loss of the capability of the system to perform its safety functions.

Active Failure OBJ3g

- An active failure is a malfunction, excluding passive failures, of a component which relies on mechanical movement to complete its intended function.

Passive Failure OBJ3h

- A passive failure is a breach of a fluid pressure boundary or blockage of a process path.

Design categories or conditions - OBJ4

- Condition I - Normal Operation
- Condition II - Faults of Moderate Frequency
- Condition III - Infrequent Faults
- Condition IV - Limiting Faults

Condition I
Normal Operation OBJ4

- Condition I events are those occurrences which are expected to **happen frequently or regularly** in the course of power operation, refueling, maintenance, or changing power in the plant.

Condition II - Faults of Moderate Frequency OBJ4

- These faults, which are expected to happen on a **once per year** basis and **at worst**, result in a **reactor trip** with the plant being capable of **returning to operations**. By definition, these faults (or events) do not propagate to cause a more serious fault, i.e., a Condition III or IV event. Condition II events are **not expected to result in fuel rod failures or overpressurization of the RCS.**

Condition III - Infrequent Faults OBJ4

- Condition III occurrences are faults that are expected to happen **once in the forty year life** of the plant. This event **will result** in the **failure** of only a **small fraction of the fuel rods** although sufficient fuel damage might occur to preclude the resumption of power for a considerable outage time. The **release of radioactivity will not** be sufficient to **interrupt or restrict public use** of those areas **beyond the exclusion radius**.

Condition IV - Limiting Faults OBJ4

- Condition IV occurrences are faults which are **never expected to take place but are postulated** because the events are so severe that the consequences would include the potential for the release of significant amounts of radioactive material. These accidents are the most drastic and therefore represent the **limiting design cases**. Condition IV faults **shall not cause a fission** product **release in excess of** the guideline values of **10CFR100.**

LOCA Acceptance Criteria 10CFR 50.46 OBJ5

1. Peak cladding temperature (PCT) shall be less than 2200°F.
2. Maximum cladding oxidation shall not exceed 17% of the total cladding thickness.
3. Maximum hydrogen generated by the reaction of water or steam with the cladding shall not exceed 1% of the amount that would be generated if all the cladding reacted chemically with water or steam.
4. Coolable geometry - Any changes in core geometry shall be such that the core remains in a coolable configuration.
5. Long-term cooling - core temperatures, after the injection phase, shall be maintained at acceptably low values. Decay heat shall be removed for the extended period of time required.