2.8 Nuclear Fuel

2.8.1 Nuclear Fuel

Design Description

The fuel assembly is designed to ensure that possible fuel damage would not result in the release of radioactive materials in excess of prescribed limits. The fuel assembly is comprised of the fuel bundle, fuel channel and a handle with spring. The fuel bundle is comprised of fuel rods, fuel rods containing burnable neutron absorber, spacers, springs and assembly end fittings.

The following is a summary of the principal design requirements which must be met by the fuel and is evaluated using methods and criteria to assure that:

(1) Fuel rod failure is predicted to not occur as a result of normal operation and anticipated operational occurrences.

(2) Control rod insertion will not be prevented as a result of normal operation, anticipated operational occurrences or postulated accident.

(3) The number of fuel rod failures will not be underestimated for postulated accidents.

(4) Coolability will be maintained for all design basis events, including seismic and LOCA events.

(5) Specified acceptable fuel design limits (thermal and mechanical design limits) will not be exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.

(6) In the power operating ranges, the prompt inherent nuclear feedback characteristics will tend to compensate for a rapid increase in reactivity.

(7) The reactor core and associated coolant, control and protection systems will be designed to assure that power oscillations which can result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed.

2.8.2 Fuel Channel

Design Description

The fuel channels are zirconium-based (or equivalent) and preclude cross-flow in the core region. These channels form the flow path for bundle coolant flow, provide surfaces for control rod guidance, provide structural stiffness to the bundle during lateral loadings, transmit seismic loadings to the top guide and fuel support castings, and provide a heat sink during loss-of-coolant accident (LOCA).

The following is a summary of the principal design criteria which are met by the fuel channels:

(1) During any design basis events including the mechanical loading from safe shutdown earthquake event combined with LOCA event, fuel channel damage will not be so severe as to prevent control rod insertion when it is required.

(2) Coolability will be maintained for all design basis events.

(3) Channel bowing will not cause specified acceptable fuel design limits to be exceeded during normal operation and anticipated operational occurrences.

2.8.3 Control Rod

Design Description

Control rods in the reactor perform the functions of power distribution shaping, reactivity control, and scram reactivity insertion for safety shutdown response and have the following design features:

(1) A cruciform cross-sectional envelope shape.

(2) A coupling at the bottom for attachment to the control rod drive.

(3) Contain neutron absorbing materials.

The following is a summary of the principal design criteria which are met by the control rod:

(1) The control rod stresses, strains, and cumulative fatigue will be evaluated to not exceed the ultimate stress or strain of the material.

(2) The control rod will be evaluated to be capable of insertion into the core during design basis modes of operation including safe shutdown earthquake event combined with LOCA event.

(3) The material of the control rod will be compatible with the reactor environment.

(4) The reactivity worth of the control rods will be included in the plant core analyses, and will provide, under conditions of normal operation (including anticipated operational occurrences), appropriate margin for malfunctions such as two stuck rods (associated with a given accumulator), or accidental control rod withdrawal, without exceeding specified acceptable fuel design limits.

2.8.4 Loose Parts Monitoring System

Design Description

The Loose Parts Monitoring System (LPMS) monitors the reactor pressure vessel (RPV) for indications of loose metallic parts within the reactor pressure vessel. The LPMS detects structure borne sound that can indicate the presence of loose parts impacting against the reactor pressure vessel and internals. The system alarms when sensor signal characteristics exceeds preset limits.

The LPMS consists of sensors, cables, signal conditioning equipment, alarming monitors, signal analysis and data acquisition equipment. The LPMS processes signals from multiple sensors mounted on the external surfaces of the reactor coolant pressure boundary. The LPMS is classified as non-safety-related.

The LPMS has provisions for both automatic and manual startup of data acquistion equipment with automatic activation in the event the preset alert level is reached or exceeded. The system also initiates an alarm in the main control room when an alert condition is reached.

The LPMS electronic components located inside the primary containment perform their function following all seismic events which do not require plant shutdown.

Inspections, Tests, Analyses and Acceptance Criteria

Tables 2.8.4 provides a definition of the inspections, tests and/or analyses, together with associated acceptance criteria, which will be undertaken for LPMS.

Table 2.8.4 Loose Parts Monitoring System

Inspections, Tests, Analyses and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
1. Equipment comprising the LPMS is defined in Section 2.8.4.	1. Inspection of the as-built system will be conducted.	1. The as-built LPMS conforms with the description in Section 2.8.4.
2. The LPMS monitors the RPV for indication of loose metallic parts.	2. Tests will be conducted on the as-built LPMS.	2. The LPMS sensitivity, without the background noise associated with plant operation, is such that it can detect a metallic loose part that weighs from 0.11 kg to 13.6 kg and impacts with a maximum kinetic energy of 0.68 joules on the inside surface of the RPV within 0.91m of a sensor.
3. Main control room alarms provided for the LPMS are defined in Section 2.8.4.	3. Inspections will be performed on the main control room alarms for the LPMS.	3. Alarms exist or can be retrieved in the main control room as defined in Section 2.8.4.
4. The LPMS electronic components located inside the primary containment perform their function following all seismic events which do not require plant shutdown.	4. Analyses will be performed or tests will be conducted on the seismic capability of the LPMS electronic components located in the primary containment.	4. An analysis or test report exists which concludes that the LPMS electronic components located inside the primary containment perform their function following all seismic events which do not require plant shutdown.