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UK ABWR

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UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 5.2 : Definition of Operational Stages, Operational Conditions and Safe Shutdown Conditions of Nuclear Power Plant

Hitachi-GE Nuclear Energy, Ltd.

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5.2.1 Introduction

In this section, the operating stage throughout the plant life cycle, and the operating condition during plant operations of UK ABWR design are defined.

5.2.2 Operating Stages

The fundamental safety objective applies for all stages in the lifetime of UK ABWR. It includes planning, siting, design, manufacture, construction, commissioning and commercial operation as well as decommissioning. This includes the associated transport of radioactive material and the management of spent nuclear fuel and radioactive waste.

The Safety Assessment Principles (SAP) are relevant to design, manufacture, and construction including installation, but will apply to later operating stages. Commissioning is a key stage in providing the necessary assurance of safety and a number of SAP principles include aspects of commissioning. Decommissioning also needs to be considered at all life-cycle stages.

5.2.3 Operating Phases

Commercial operation is itself divided into a number of distinct phases:

(1) Startup
(2) Power operation
(3) Hot stand-by
(4) System shutdown
(5) Refuelling outage

(1) Startup
The process of startup starts with the reactor in a cold shutdown condition. The plant is heated and nuclear power raised to the point where electrical power is generated. The startup process involves a set sequence of operations, often involving special equipment designed for the purpose, as reactor and other parameters are outside normal operating bounds.

(2) Power operation
The Operation during plant is in rated power.

(3) Hot stand-by
The Condition in which plant is maintained in high temperature and pressure, and core is maintained in sub-critical.

(4) System shutdown
The shutdown process takes the plant from hot stand-by to a cold shutdown condition (reactor coolant < 100°C) and is the reverse process to startup. In accident conditions, the plant protection systems take the plant directly from power operation to a cold shutdown condition.

(5) Refuelling outage
Once the plant is in a cold shutdown condition, refueling operations may begin. This involves the flooding of the reactor cavity, removal of the vessel head and upper internals (steam separator and dryer) and removal of fuel to the spent fuel pool. New fuel is introduced and the plant made ready for startup. During the refueling outage, much other essential maintenance is carried out.

5.2.4 Operating Conditions

5.2.4.1 Plant Operating Conditions

The plant operating conditions are defined as following sub-section 5.2.4.2 (1) to (5) according to the operating states of Nuclear Power Plant (NPP).

(1) Operating Condition I
(2) Operating Condition II
(3) Operating Condition III
(4) Operating Condition IV
(5) Design Extension Condition

5.2.4.2 Definition of Operating Conditions

(1) Operating Condition I:
A condition during commercial operation. The commercial operation includes system startup, power operation, normal hot stand-by (with condenser available), and system shutdown, outage other than upset, emergency, faulted, or testing. In other words, Operating Condition I is the premeditated operations or the transition period between these operations.

(2) Operating Condition II:
An upset condition deviating from Operating Condition I other than Operating Condition III, IV, Design Extension Condition and Test Condition. The deviation is caused by any single failure of equipments, any single operator error or control malfunction, a loss of load or power and etc. anticipated in service period of NPP.

(3) Operating Condition III:
An emergency condition deviating from Operating Condition I, which requires shutdown. This condition is included to provide assurance that no gross loss of structural integrity will result as a concomitant effect of any damage developed in the system. The emergency conditions include infrequent operational transient caused by a multiple valve blowdown of the reactor vessel such as inadvertent actuation of automatic depressurization system (ADS), reactor overpressure with delayed scram or anticipated transient without trip (ATWT), a small line break Loss of Coolant Accident (LOCA) including crack and etc., which has sufficient lower probability than Operating Condition II.

(4) Operating Condition IV:
A faulted condition is any of those combinations of conditions associated with extremely low-probability postulated events whose consequences are such that the integrity and operability of the system may be impaired to the extent that considerations of public health and safety are involved. Though these events don't seem to occur during service period of NPP, these are postulated to estimate validity of design considering just in case of occuration. This condition includes, but is not limited to, LOCAs which are the most drastic events that must be considered in the design and thus represent limiting design base.

(5) Design Extension Condition:
A condition postulated multiple failures which are caused by occurrence of additional failure of mitigation equipment to a single failure of equipments.

5.2.5 Safe Shutdown Condition

Safe shutdown condition is defined as the reactor has been achieved cold shutdown (reactor coolant temperature below 100 °C) as well as sub-critical.
UK ABWR design is capable of bringing the reactor to cold shutdown (reactor coolant temperature below 100 °C) within 36 hours after reactor shutdown (control rods insertion) with the main condenser unavailable in the event of Loss of Offsite Power (LOOP) and assuming a single failure.