

**UK ABWR**

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## UK ABWR Generic Design Assessment

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



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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 lifecycle of a facility is broken down into discrete 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.

### 5.2.3 Operating Modes

Commercial operation of UK ABWR includes five operating Modes; The operating modes for BWRs have long been established and the UK ABWR will follow the same practice – five modes are identified:

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

Each of these operating modes has clearly defined entry and exit conditions together. Movement from one mode to another is carefully managed as it is recognised changing plant state is planned.

#### (1) Startup

In this mode, the reactor is in a shutdown mode with all control rods inserted. Once the mode switch is selected to 'startup' the control rods are withdrawn from the core and the reactor is taken critical. When the mode switch is selected 'run', this mode moves on to Power Operation mode.

#### (2) Power operation

In this mode, the reactor is critical. This mode starts from when the mode switch is selected 'run' and covers power states from startup.

#### (3) Hot stand-by

In this mode, the reactor is sub-critical (effective neutron multiplication factor ( $k_{eff}$ ) < 0.95) and

coolant temperature is higher than 100°C.

(4) Cold shutdown

The shutdown process takes the plant from hot stand-by to the cold shutdown when reactor coolant temperature is lower or equal to 100°C with the reactor sub-critical (effective neutron multiplication factor ( $k_{eff}$ ) < 0.95).

(5) Refuelling outage

Once the plant is in a cold shutdown, refuelling operations may begin. This involves the flooding of the reactor well, 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 refuelling outage, many essential maintenances are carried out.

## **5.2.4 Operating Conditions**

Following Operating Conditions defined in this section are used for evaluation in ME (Mechanical Engineering) and SI (Structural Integrity) fields. Definition of fault and event is shown in Ch.5.3.

### **5.2.4.1 Operating Conditions**

The operating conditions are defined in the following sub-section 5.2.4.2 (1) to (4) 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

### **5.2.4.2 Definition of Operating Conditions**

(1) Operating Condition I:

Operating Condition I is a condition during commercial operation even with Expected Event defined in Ch.5.3. The commercial operation includes system startup, power operation, normal hot stand-by (with condenser available), system shutdown and refueling 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:

Operating Condition II is a condition with Foreseeable Event or a part of Frequent Fault defined

in Ch.5.3 deviating from Operating Condition I and other than Operating Condition III, IV 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, etc. anticipated in service period of NPP.

(3) Operating Condition III:

Operating Condition III is a condition with the rest of Frequent Fault or a part of Infrequent Fault defined in Ch.5.3 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 operating 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:

Operating Condition IV is a condition with the rest of Infrequent Fault whose consequences are such that the integrity and operability of the system may be impaired to the extent that considerations to public health and safety are involved. Though these events don't seem to occur during service period of NPP, they are postulated to estimate validity of design just in case of occurrence. 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.

## **5.2.5 Safe Shutdown Condition**

Safe shutdown condition is defined as the reactor cold shutdown has been achieved.

UK ABWR design is capable of bringing the reactor to cold shutdown within 36 hours after SCRAM even with the main condenser unavailable in the event of Loss of Offsite Power (LOOP) and assuming a single failure.