

Outline of New Regulatory Requirements
For Light Water Nuclear Power Plants
(Severe Accident Measures)

Table of Contents

1. Definitions of Terms (Severe Accident Measures-related)
2. Requirements on the Severe Accident Measures
(Major systems for each measure)
 - (1) Common Requirements
 - ① Requirements on the Severe Accident Measures Equipment
 - ② Requirements for recovery work
 - ③ Miscellaneous Requirements
 - (2) Preparation of procedures, implementation of drills and development of organizational system
 - (3) Measures for reactor shutdown
 - (4) Measures for cooling reactor at high pressure
 - (5) Measures for depressurization of reactor coolant pressure boundaries
 - (6) Measures for cooling reactor at low pressure
 - (7) Measures for securing an ultimate heat sink for the Severe Accident Measures in case of accident
 - (8) Measures for cooling, depressurization and radioactive material reduction in the atmosphere of the containment vessel
 - (9) Measures for preventing the containment vessel failure due to overpressurization
 - (10) Measures for cooling molten core fallen to the bottom of the containment vessel
 - (11) Measures against hydrogen explosions inside the containment vessel
 - (12) Measures against hydrogen explosions inside the reactor building, etc.
 - (13) Measures for cooling, shielding and maintaining the sub-criticality of spent fuel storage pools
 - (14) Measures for securing make-up water and water sources

- (15) Measures for securing power sources
- (16) Control room
- (17) Emergency response center
- (18) Instrumentation facilities
- (19) Radiation monitoring facilities
- (20) Communications equipment
- (21) Measures for suppression of off-site radioactive material release

3. Accident Management for External Events beyond Design Basis

- (1) Accident management with mobile equipment, etc.
- (2) Specialized Safety Facility

4. Evaluation of the Effectiveness of Severe Accident Measures

- (1) Evaluation of the Effectiveness of preventive measures against severe core damage and containment vessel failure
- (2) Evaluation of the Effectiveness of preventive measures against severe fuel damage in spent fuel storage pools
- (3) Evaluation of the Effectiveness of preventive measures against fuel damage in a reactor during shutdown

(Caution)

- This document contains the new Regulatory Requirements (Severe Accident Management) outline compiled based on the discussions by the “The Study Team on the New Regulatory Requirements for Light Water Reactor for Electric Power Generation” incorporating the results of public comments submitted between Feb. 7 and 28, 2013.
- This document compiles regulatory requirements in a free format. Legislative structure, definitions of terms, and detailed provisions shall be determined in the future in accordance with legal examples.

Outline of New Regulatory Requirements
For Light Water Nuclear Power Plants
(Severe Accident Measures)

1. Definitions of Terms (Severe Accident Measures-related)

Definitions of Terms used in this outline are as follows.

- ① “Severe Accident” refers to the serious events designated in the Ordinance No__ of Nuclear Regulatory Authority, such as serious damage of the reactor core of the power generating nuclear reactor.
- ② “Severe Accident Measures” refer to the measures to prevent the occurrence and propagation of the severe accident.
- ③ “Design Basis Accident Measures Equipment” refers to the equipment to cope with the situations at the occurrence of design basis accident.
- ④ “Severe Accident Measures Equipment” refers to the equipment to prevent the occurrence and propagation of the severe accident after the occurrence of the beyond-design-basis accident (hereinafter called B-DBA).
- ⑤ “Severe Accident Prevention Measures Equipment” refers to the equipment among the Severe Accident Measures Equipment to prevent the occurrence of the severe accidents by substituting necessary function in the event that Design Basis Accident Measures Equipment loses safety functions for some reasons.
- ⑥ “Severe Accident Mitigation Measures Equipment” refers to the equipment among the Severe Accident Measures Equipment to prevent the propagation or to mitigate the impacts after the occurrences of severe accidents.
- ⑦ “Mobile equipment” refers to the equipment that can be moved (Self-propelled equipment included).
- ⑧ “Permanent equipment” refers to the system that is permanently installed and connected to the nuclear facilities in advance (Equipment to be connected in short period included)
- ⑨ “Specialized Safety Facility” refers to facilities with function to suppress a large amount of radioactive material release caused by containment vessel failure in the event of severe core damage or almost damaged core as a result of acts of terrorism, etc., such as intentional airplane crash, etc.

- ⑩ “Postulated B-DBA” refers to the B-DBA postulated for the Evaluations of the Effectiveness. “Postulated” in other context means the same.

B-BDA is the acronym of Beyond Design Basis Accident.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(1) Common Requirements

① Requirements on the Severe Accident Measures Equipment

[Basic Requirements]

(Capacity)

- 1 Severe Accident Measures Equipment shall be designed to have sufficient capacity required to settle the postulated B-DBA.
- 2 Mobile Severe Accident Measures Equipment shall be designed to have the required capacity with suitable margins in accordance with the equipment reliability to settle postulated B-DBA.

(Environmental and load conditions)

- 3 Severe Accident Measures Equipment shall be designed to function as required with sufficient reliability under environmental and load conditions during postulated B-DBA.

(Operability)

- 4 Severe Accident Measures Equipment shall be designed to be sure to operate under the conditions during postulated B-DBA.

(Diversity)

- 5 Permanent Severe Accident Prevention Measures Equipment shall be so designed that diversity is considered as much as possible for the Design Basis Accident Measures Equipment to be substituted.
- 6 Mobile Severe Accident Prevention Measures Equipment shall be as diverse as possible for equipment for Design Basis Accident Measures and permanent Severe Accident Prevention Measures to be substituted.

(Detrimental impact prevention)

- 7 Severe Accident Measures Equipment shall be installed so as not to cause any detrimental impact on other equipment.

(Easy Changeover)

- 8 Equipment and procedures shall be prepared so as to allow easy and certain changeover from normal line configurations in the event that other equipment is used for Severe Accident Measures Equipment different from its original use.

(Reliable connections)

- 9 Measures shall be taken to standardize connecting methods to ensure that mobile Severe Accident Measures Equipment and permanent equipment can be easily and surely connected and that such equipment can be used interchangeably between systems and units. Furthermore, multiple connections shall be prepared with appropriate spatial dispersion to avoid disconnection due to common modes.

(Seismic and Tsunami Resistance etc. (connecting piping included))

- 10 Appropriate measures (including piping, valves and electrical cables etc. within the building beyond the connections to the mobile Severe Accident Mitigation Measures Equipment) for Severe Accident Mitigation Measures Equipment Procedures shall be taken so as not to damage the necessary functions for standard ground motion and standard tsunami etc.
- 11 Severe Accident Prevention Measures Equipment (including piping, valves and electrical cables etc. within the building beyond the connections to the mobile Severe Accident Prevention Measures Equipment) shall have the equivalent seismic and tsunami resistance to the Design Basis Accident Measures Equipment to be substituted.

(Storage places)

- 12 Mobile Severe Accident Measures Equipment shall be stored dispersed in different locations, which are not easily impacted by external events (earthquakes, tsunami, etc.). Mobile Severe Accident Measures Equipment shall be stored in different locations from permanent Severe Accident Measures Equipment.

(On-site working conditions)

- 13 The locations where Severe Accident Measures Equipment are installed shall be selected in such a way that the installation, connection, operation and recovery work of mobile Severe Accident Measures can be done even in case of postulated B-DBA, by selecting the suitable place not to be affected severely by the accident or by reinforcing the shielding performance etc.

(Securing access routes)

- 14 Access routes shall be designed and managed effectively so as to ensure the availability of required access routes outside of buildings needed to transport mobile Severe Accident Measures Equipment or to confirm the damage of equipment under the postulated environment.

(Prohibition of shared use)

15 In principle, permanent Severe Accident Measures Equipment shall not be shared by more than two nuclear reactors. However this rule shall not apply if risk can be reduced and no other detrimental impact is caused by sharing the equipment.

[Requirement details]

(Capacity)

- A Capacity for Severe Accident Measures Equipment for mobile alternative power sources and mobile water injection system shall be as follows.
- (a) More than two sets of mobile Severe Accident Measures Equipment to compensate the necessary capacity.
 - (b) In addition to the above, backup for troubles and inoperability during inspection and maintenance shall be taken into consideration for whole nuclear power stations.
 - (c) "Necessary capacity" refers to the capacity that can effectively provide necessary function in the event of postulated B-DBA for the related reactor.

(Seismic and tsunami resistance etc.)

- B "Have the equivalent seismic and tsunami resistance" refers to, the ability to maintain the necessary function even after suffering equivalent seismic ground motion and tsunami.

(Storage places)

- C Mobile Severe Accident Measures Equipment shall be stored in locations in consideration of intentional airplane crash. For example, locations shall be isolated more than 100m from reactor buildings and shall not be simultaneously affected together with the reactor building. Otherwise, locations should be robust enough to withstand an airplane crash.

2. Severe Accident Measures Requirements

(Major system for each measures)

(1) Common Requirements

② Requirements for recovery work

[Basic Requirements]

(Securing spare parts, etc.)

1 So as to conduct replacement or maintenance of component particularly important to safety, sufficient spare parts and tools necessary for replacement work shall be secured.

(Storage place)

2 Above spare parts shall be stored in dispersed locations less affected by the impact of external events (tsunami, earthquake, etc.).

(Securing access routes)

3 Access routes shall be designed and managed effectively so as to ensure the availability of required access routes outside of buildings needed to confirm the damage status of equipment and perform recovery work under the postulated environment.

[Requirement Details]

(Securing spare parts)

A “Tools necessary for replacement work” refers to, equipment necessary for operation under various weather conditions, operational vehicle for removing debris and lighting equipment needed for night work etc.

2. Severe Accident Measures Requirements

(Major system for each measures)

(1) Common Requirements

③ Miscellaneous requirements

[Basic Requirements]

(Support)

- 1 Measures prepared in advance on- site (Severe Accident Measures Equipment, spare parts, fuel, etc.) shall enable the continued accident management for seven days after the occurrence of the event. A plan to enlist the support from external organizations shall be established upon the consultation and agreement with related organizations. Measures (Severe Accident Measures Equipment, spare parts, fuel, etc.) prepared in advance outside the site shall be able to provide the support by the sixth day after occurrence of the event.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(2) Preparation of procedures, implementation of drills, and development of organizational system

[Basic Requirements]

Appropriate organizational system shall be established by the formulation of the procedures and implementation of drills in advance in order to manage B-DBA rapidly and flexibly.

[Requirement Details]

(Note: When licensing a nuclear reactor, the following basic policy shall be confirmed. Detail plans shall be confirmed by succeeding regulations, such as operational safety program approval etc.)

A Procedures shall be formulated as below.

- (a) Procedures shall compile types of information, methods for obtaining this information and judgment criteria required to ascertain plant status and in order to implement adequate Severe Accident Measures in a limited time and accurately make appropriate decisions assuming the loss of all AC and permanent DC power sources lines, multiple failures of safety related systems, instrumentation devices and simultaneous damage to the multiple units etc.
- (b) Procedures shall clarify in advance the standards for determining what operations should be prioritized in order to prevent core damage and containment vessel failure. (Including use of Stand by Liquid Control System (SLCS), seawater and venting)
- (c) Procedures shall be formulated appropriately for both operators and supporting organizations so as to allow the implementation of detailed Severe Accident Measures in accordance with the event progression. Furthermore, if procedures are divided into multiple types in accordance with the event progression, the structure of these documents as well as the criteria for transitioning between procedures shall be clarified.
- (d) Measurable parameters used as criteria for determining the implementation of actual Severe Accident Measures, such as water level, pressure and temperature, etc., shall be clearly stated in the procedures. Furthermore, parameter behavior prediction, impact assessment items, and monitoring parameters, etc., during implementation of Severe Accident Measures shall be compiled in the procedures.
- (e) Procedures to manage in advance at the time of precursors events (for example, reactor shut down and cooling operations in case of large tsunami alarm) shall be formulated.

B Drill shall be conducted as below.

- (a) Since Severe Accident Measures must be diverse enough to manage various plant situations, education and drill related to such measures shall enable trainees to improve their knowledge on the behavior of a plant during severe accident.
- (b) In addition to periodical education to improve the knowledge base according to the role of each personnel, practical drills shall be planned to check the effectiveness of Severe Accident Measures implementation organizations and support organization.
- (c) Plant personnel shall be sufficiently familiar with the plant and spare parts etc. through daily maintenance by experiencing practical work such as replacing parts voluntarily conducted as day-to-day work etc.
- (d) Personnel shall be trained how to manage accidents under various conditions such as high radiation levels, and during nighttime and under bad weather conditions.
- (e) Through normal maintenance work and inspection, personnel shall be trained and prepared so as to enable them to quickly use information and manuals related to equipment and equipment used during accidents.

C Organizational system shall be prepared as below.

- (a) Implementing and supporting organization in charge of the Severe Accident Management, system of associated role sharing and responsible persons shall be clearly defined and prepared for the effective Severe Accident Management.
- (b) Implementation organization refers to organizations that implement Severe Accident Measures, such as operators.
- (c) Implementation organizations shall be able to respond even in the event of simultaneous severe accidents at all units.
 - (d) Chief reactor engineers shall be designated at each unit exclusively.
- (e) Supporting organizations shall comprise technical support organizations providing technical advices to the implementation organization and operations support organizations enabling implementing organization to concentrate on Severe Accident Management.
- (f) Implementation organizations and support organizations shall be created under conditions that require implementation of Severe Accident Measures. Furthermore, the smooth call-up of personnel shall be enabled by establishing pre-determined network system even during night and holidays.
- (g) The functions of the Severe Accident Management implementation organization and supporting organizations, as well as the function of each group formed within the supporting organizations shall be clearly defined with appropriate nomination of the leaders.
- (h) The chain of command shall be clarified. Alternative chains of command shall also be prepared in the absence of the commanders.

- (i) Facilities and equipment shall be organized so as to effectively engage in the implementation system above.
- (j) Supporting organizations shall inform internal and external organizations as necessary of the plant status and the status of implementation of Severe Accident Measures, and provide a wide range of information.
- (k) A system for receiving support from outside the power station shall be established.

2. Severe Accident Measures Requirements

(Major system for each measure)

(3) Measures for reactor shutdown

[Basic Requirements]

Prepare equipment and procedures for maintaining reactor sub-criticality in order to prevent severe core damage in the event of an anticipated transient without scram (ATWS) or indications of ATWS, while maintaining the integrity of the reactor coolant pressure boundaries and the containment vessel.

[Requirement Details]

- A “Indications of ATWS” refers to, cases where it is assumed from changes in parameters, such as reactor output and reactor pressure, etc., that the reactor does not scram despite that the reactor must be scrammed (emergency reactor shutdown).
- B “Equipment and procedures for maintaining reactor sub-criticality” refers to, the measures described below or equipment and procedures facilitating the measures that have the same or better effect.

Common to Boiling Water Reactor (BWR) and Pressurized Water Reactor (PWR)

(Procedures)

- (a) Manually scram the reactor in the event that ATWS indications are detected.

For BWR

(Permanent Severe Accident Preventive Measures)

- (b) Install an alternative control rod insertion circuit (ARI) independent from the reactor scram system from the sensor output to the final activating input.
- (c) Install a device that automatically trips the reactor coolant recirculation pump in order to control reactor output in the event that ATWS indications are detected. The pump shall be manually tripped if it is not automatically tripped.
- (d) Install standby liquid control system (SLCS) with sufficient capability of reactivity control. Judgment criteria for startup shall be clearly defined.
- (e) SLCS shall be started manually in the event that unstable power oscillation is detected during ATWS.

For PWR

(Procedures)

- (f) If an indication of ATWS is detected, the auxiliary feedwater pump shall be automatically started and the turbine shall be tripped in order to suppress reactor power. If this fails, it shall be done manually.
- (g) If an indication of ATWS is detected, sufficient amount of boric acid shall be injected by chemical volume control system or emergency core cooling system.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(4) Measures for cooling reactor at high pressure

[Basic Requirements]

Establish equipment and procedures for cooling the reactor by recovering relevant system or using alternative system in order to prevent severe core damage in the event that reactor-cooling function is lost when the pressure of reactor coolant pressure boundaries is high.

[Requirement Details]

A “Equipment and procedures for cooling the reactor” refers to, the measured described below or the equipment and procedures facilitating the measures that have the same or better effect.

(Mobile Severe Accident Prevention Measures)

(a) Prepare measures (procedures, mobile Severe Accident Measures, facilities, etc.) for starting up the Reactor Core Isolation Cooling System (RCIC), emergency condenser (in case of BWR), or turbine driven auxiliary feed water pump (in case of PWR) through valve operation using mobile Severe Accident Measures on site (mobile batteries, nitrogen tanks, etc.) and continuing operation for a sufficient period of time* assuming that all AC and permanent DC power sources lines are lost except the case that manual operation is easy as defined in next (b).

*“Sufficient period of time” refers to, time needed to prepare and implement “reactor coolant pressure boundary depressurization measures” and “cooling measures during reactor coolant depressurization”.

(On-site operation)

(b) Prepare measures (procedures, facilities, etc.) for starting up the RCIC, emergency condenser (in case of BWR), or turbine driven auxiliary feedwater pump (in case of PWR) through valve operated manually on-site, assuming cases where all AC and DC power sources are lost.

(Recovery operation)

(c) Startup and continuing operation for a sufficient period of time should be enabled by connecting power source to the system to cool the reactor by injecting (including recirculating) the water in case that reactor coolant pressure boundary is under high pressure (in case of BWR).

(d) Startup and continuing operation for a sufficient period of time should be enabled by connecting alternative AC power to the motor driven auxiliary feedwater pump (in case of PWR).

(Monitoring, Control)

(e) Prepare measures (procedures, instrumentation devices, facilities etc.) for estimating reactor water level (BWR and PWR) and steam generator water level (in case of PWR) assuming the loss of all AC and permanent DC power sources lines. .

(f) Prepare measures (procedures, instrumentation devices and facilities, etc.) for confirming the operational status of systems important to safety, such as the RCIC, assuming the loss of all AC and permanent DC power sources lines.

(g) Prepare measures (procedures, instrumentation devices and facilities etc.) for controlling reactor water level and steam generator water level assuming the loss of all AC and permanent DC power sources lines.

(Suppressing accident progression)

(h) Prepare procedures etc. for injecting coolant from the standby liquid control system (SLCS) and control rod drive (CRD) mechanism in order to suppress accident progression (in case of BWR).

2. Severe Accident Measures Requirements

(Major systems for each measure)

(5) Measures for depressurizing reactor coolant pressure boundaries

[Basic Requirements]

Prepare equipment and procedures, etc., for depressurizing reactor coolant pressure boundaries by recovering relevant system or by using alternative system, in order to prevent severe core damage and containment vessel failure in the event that depressurization function is lost when the pressure of reactor coolant pressure boundaries is high.

[Requirement Details]

A “Equipment and procedures, etc., for depressurizing reactor coolant pressure boundaries” refers to, the measures described below or the equipment and procedures facilitating the measures that have the same or better effect.

(Logic to be added)

(a) Addition of depressurization automated logic for activating the automatic depressurization function of safety relief valves at low reactor water level and low-pressure injection system available (in case of BWR).

(Mobile Severe Accident Measures).

(b) Manual equipment or mobile alternative AC power source equipment shall be prepared so as to enable activation of the depressurization valves (safety relief valves (in case of BWR), main steam relief valve and pressurizer relief valve (in case of PWR)) and depressurization of reactor coolant pressure boundaries even in the event of loss of permanent DC power.

(c) Mobile compressors or nitrogen tanks shall be prepared so as to enable activation of depressurization valves and depressurization of reactor coolant pressure boundaries if depressurization valves are air operated.

(d) Depressurization valve shall be sure to operate under the environment of postulated B-DBA. The environment that enables activation of depressurization valves shall be clearly defined.

(Recovery)

(e) Recovery procedures using alternative power sources shall be prepared so as to enable activation of depressurization valves and depressurization of reactor coolant pressure boundaries even in the event of loss of DC power

(SGTR)

(f) In the event of a steam generator tube rupture (SGTR), steam generator involved shall be isolated. Procedures shall be prepared to enable depressurization of reactor coolant pressure boundaries through activation of pressurization relief valves, etc., in the event that the steam generator cannot be isolated (in case of PWR).

(ISLOCA)

(g) Damage of reactor coolant pressure boundaries shall be isolated in the event of an interface system LOCA. Procedures that enable depressurization of reactor coolant pressure boundaries through activation of relief safety valves (in case of BWR), main steam relief valves and pressurizer relief valves (in case of PWR) shall be prepared in order to depressurize the reactor and suppress leaks of reactor coolant in the event that isolation is not possible.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(6) Measures for cooling reactor at low pressure

[Basic Requirements]

Prepare equipment and procedures etc. for cooling the reactor by recovering and substituting the related function in order to prevent severe core damage and prevent containment vessel failure in the event that reactor cooling function is lost when the pressure of reactor coolant pressure boundaries is low.

[Requirement Details]

A “Equipment and procedures etc.” refers to, the measured described below or the equipment and procedures facilitating the measures that have the same or better effect.

(Severe Accident Prevention Measures)

- (a) Severe Accident Prevention Measures shall be diverse and independent from the equipment for design basis accident measures and dispersed in different locations.
- (b) Mobile Severe Accident Prevention Measures shall be available and ready for use.
- (c) Permanent Severe Accident Prevention Measures operated with different principles from the equipment for design basis requirement shall be installed in order to manage the cases where time to reach the severe core damage is too short to manage accident.

(Recovery)

- (d) Measures for recovering equipment for design basis accident measures through the connection of alternative power sources to design basis accident measures shall be activated and kept operable for sufficient period.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(7) Measures for securing ultimate heat sink (UHS) for the Severe Accident Measures in case of accident

[Basic Requirements]

Prepare equipment and procedures for transferring heat to ultimate heat sink by restoring or substituting related functions in order to prevent either severe core damage or containment vessel failure at the stage prior to the core damage in the event that the function to transfer the heat to the ultimate heat sink (UHSS) is lost.

[Requirement Details]

- A “Equipment and procedures for transferring heat to ultimate heat sink” refers to, the measures described below or the equipment and procedures facilitating the measures that have the same or better effect.
- (a) Severe Accident Prevention Measures shall be installed in order to prevent core damage.
 - (b) The Severe Accident Prevention Measures shall be redundant, diverse and independent from equipment for design basis requirement and dispersed in different locations.
 - (c) Assuming the loss of ultimate heat sink due to the loss of water intake function, in case of BWR, there should be sufficient time to connect alternative UHSS loaded on the vehicles on-site and transfer heat to ultimate heat sink within certain time during which reactor cooling function is maintained by accumulating the heat to the suppression pool. In addition, the situation that the residual heat removal system (RHR) is not operable shall be considered.
In case of PWR, it shall be possible to transfer heat to ultimate heat sink by removing the heat from the secondary systems by the turbine driven auxiliary feedwater pump and main steam relief valves.
 - (d) In case of introducing filtered venting system, 2. (9), A (a) shall be applied. Dose evaluation at the site border shall be conducted when it is operated.

2. Severe Accident Measures Requirements

(Major systems for each measures)

- (8) Measures for cooling, depressurization and radioactive material reduction in the atmosphere of the containment vessel

[Basic Requirements]

- 1 Prepare equipment and procedures etc. to reduce the pressure and temperature in the atmosphere of the containment vessel in order to prevent the severe core damage in case of loss of cooling function of the atmosphere of the containment vessel.
- 2 Prepare equipment and procedures etc. to reduce the pressure, temperature and concentration of the radioactive materials in the atmosphere of containment vessel to prevent containment failure in case of severe core damage.

[Requirement Details]

- A “Equipment and procedures etc. to reduce the pressure, temperature and concentration of the radioactive materials in the atmosphere of the containment vessel” in 1 and 2 above refer to, the measured described below or the equipment and procedures facilitating the measures that have the same or better effect.

(Severe Accident Measures Equipment)

- (a) Alternative water injection system of containment vessel spray shall be deployed assuming the loss of water injection system (pumps or water sources) of containment spray for design basis accident measures equipment. Alternative water injection system shall be diverse, independent and dispersed in different locations for design basis accident.

(Shared System)

- (b) Same system could be shared for the measures for core damage prevention in 1 above and containment failure prevention in 2 above.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(9) Measures for preventing the containment vessel failure due to overpressurization

[Basic Requirements]

Equipment and procedures etc. for reducing the atmospheric pressure and temperature inside the containment vessel shall be installed in order to prevent containment vessel failure in the event of severe core damage.

[Requirement Details]

A “Equipment and procedures for reducing the pressure and temperature in the atmosphere of the containment vessel” refers to, the measures described below or measures that have the same or effect.

(a) Install containment filtered venting system or containment recirculation unit. In case of installing containment filtered venting system, the equipment described below or equipment that have the same or effect better shall be prepared.

(Equipment for radioactive material reduction)

(i) Containment filtered venting system shall reduce amount of the radioactive material contained in the exhaust air.

(Equipment against flammable gas)

(ii) Containment filtered venting system shall be equipped with equipment for preventing explosions of flammable gases.

(Detrimental impact prevention)

(iii) Piping etc. of containment filtered venting system shall not be shared with other systems (for example, SGTS) or those of other units, etc. However, this need is not be the case if there are no detrimental effects.

(iv) Equipment and procedures etc. shall be prepared to prevent the containment failure due to negative pressure in case of activating filtered venting system depending on the necessity.

(On-site operation etc.)

- (v) Isolation valves for containment filtered venting system shall be able to be opened and closed easily and surely by manual
- (vi) Radiation protection measures, such as shielding and isolation, etc., shall be implemented in order to enable operation of containment filtered venting system on-site only manually even at the times of severe core damage.
- (vii) Measures, such as preparing required equipment and materials available etc. in the neighborhood shall be implemented in order to enable operation of isolation valves for containment filtered venting system even in the event of loss of drive power for isolation valve.

(Rupture discs)

- (viii) Bypass valves shall be installed in parallel in case that rupture discs are used. However, this rule shall not apply to the cases where rupture discs set to rupture at such sufficiently low pressures that operation of the containment filtered venting shall not be disturbed (aiming not at the isolation of the containment vessel but at nitrogen charging for example) or the equipment to break the rupture disc by manual force is installed.

(Connecting positions to the containment)

- (ix) Containment filtered venting system shall be connected to the positions free from any detrimental impact of molten core and submersion in the long term.

(Radiation protection)

- (x) Radiation protection measures, such as shielding, etc., shall be implemented in order to reduce exposure from the highly active used filters, etc.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(10) Measures for cooling molten core fallen to the bottom of the containment vessel

[Basic Requirements]

Prepare equipment and procedures for cooling the molten core fallen to the bottom of the containment vessel in order to prevent containment vessel failure in the event of severe core damage.

[Requirement Details]

- A “Equipment and procedures for cooling the water core fallen to the bottom of the containment vessel refers to, the measured described below or equipment and procedures facilitating the measures etc. that have the same or better effect. Cooling of the molten core fallen to the bottom of the containment vessel is implemented to mitigate the molten core and concrete interaction (MCCI) and to prevent the spread and contact of the molten core with the containment vessel boundary.
- (a) Equipment for injecting water into the bottom of the containment shall be prepared. In case installing equipment for injecting water into the bottom of the containment, measures described below or measures that have the same and better effect shall be prepared.
 - (i) Preparation of equipment for injecting water into the bottom of the containment vessel (Example; pump trucks, pressure resistant hoses etc.) (Flow path inside the buildings, connecting mobile equipment for injecting water into the bottom of the container vessel shall be installed in advance.)
 - (ii) Equipment for injecting water into the bottom of the containment shall be redundant or diversified, independent and dispersed in the different locations. (However, this shall exclude flow path and piping over the structures inside the buildings.)
 - (b) This equipment shall be connected to alternative AC power sources.

(Delay and prevention of the fall of the molten core to the bottom of containment)

- B Measures to inject the water into the reactor pressure vessel shall be prepared in order to delay and prevent the fall of the molten core to the bottom of containment vessel.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(11) Measures against hydrogen explosions inside the containment vessel

[Basic Requirements]

Prepare equipment and procedures for preventing hydrogen explosions in the containment vessel in order to prevent containment vessel failure in the event of severe core damage.

[Requirement Details]

A “Equipment and procedures etc. for preventing hydrogen explosions” refers to, the measured described below or the equipment and procedures facilitating the measures etc. that have with the same or better effect.

<BWR>

(a) Inertize the atmosphere.

<Types of PWR if necessary>

(b) Install hydrogen concentration control equipment.

<Common to both PWR and BWR>

(c) Hydrogen explosion at discharge path shall be prevented and radioactive material reduction equipment and hydrogen and reactive material concentration measurement equipment shall be installed when discharging hydrogen gas outside the containment vessel.

(d) Install monitoring equipment that can measure to the extent possible within the fluctuation of hydrogen concentration during severe core damage.

(e) This equipment shall be connected to alternative power sources in case that AC or DC power source is necessary.

(f) Prepare procedures for preventing hydrogen explosions of hydrogen and oxygen produced through the radiolysis of water after severe core damage.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(12) Measures against hydrogen explosions inside the reactor building, etc.

[Basic Requirements]

Prepare equipment and procedures etc. for preventing damage to the reactor building and containment vessel annulus by the accumulation and explosion of the hydrogen in the event of severe core damage.

[Requirement Details]

- A “Equipment and procedures for preventing damage caused by a hydrogen explosion” refers to, the measured described below or equipment and procedures facilitating the measures that have the same or better effect.
- (a) Install hydrogen concentration control equipment (verifying no threat of hydrogen explosion inside reactor building etc.by control) or hydrogen discharge equipment (with explosion prevention function of active components and radioactive material reduction functions.)
 - (b) Install monitoring equipment that can measure to the extent possible within the fluctuation of hydrogen concentration during postulated accidents.
 - (c) This equipment shall be connected to alternative power sources in case AC or DC power source is necessary.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(13) Measures for cooling, shielding and maintaining the sub-criticality of spent fuel storage pools

[Basic Requirements]

- 1 Prepare equipment and procedures for cooling of the fuels in the spent fuel pool, shielding and preventing criticality in the event of loss of spent fuel storage pool cooling function, or cooling water injection function or leakage of a small amount of pool water.
- 2 Prepare equipment and procedures for mitigating fuel damage and preventing criticality in the event that spent fuel storage pool water level cannot be maintained due to the leakage of a large amount of water.

[Requirement Details]

- A “Leakage of a small amount of pool water” as mentioned in 1 refers to, a pool water leak assumed as part of postulated accident 2 defined in the “4. (2) Evaluation of the Effectiveness of Preventive Measures against Fuel Damage in Spent Fuel Storage Pools.” A “leakage of a large amount of water” as mentioned in 2 refers to the leakage that exceeds the assumed amount of pool water leaked as part of postulated accident 2.
- B The equipment and procedures mentioned in 1 above shall be the measured described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Install mobile alternative cooling water injection system (Example; injection line, pump trucks etc.) as the alternative water injection system. Alternative water injection system shall be able to maintain pool water level even in the event of loss of cooling and water injection function and a small-scale leakage.
- C The equipment and procedures mentioned in 2 above shall be the measured described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Mobile spray equipment shall be prepared as spray equipment (Example; spray headers, spray lines, pump trucks).
 - (b) Spray equipment shall be able to mitigate the fuel damage by alternative cooling water injection system even in the event that spent fuel storage pool water level cannot be maintained.
 - (c) Equipment and procedures etc. to reduce the release of radioactive materials to the environment in case of fuel damage as much as possible shall be prepared.

- D The monitoring of spent fuel storage pools shall be as below in accordance with the equipment and procedures etc. mentioned in 1 and 2 above.
- (a) Spent fuel storage pool water level, pool water temperature and air dose rate above the pool shall be able to be measured to the extent possible within the fluctuation as a result of B-DBA.
 - (b) This measurement equipment shall be connected to alternative power source if AC or DC power sources are necessary.
 - (c) Pool status shall be monitored by cameras.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(14) Measures for securing make-up water and water sources

[Basic Requirements]

Prepare equipment and procedures that provide the water to the design basis equipment and Severe Accident Measures Equipment by securing the water sources for design basis equipment as well as sufficient water from those sources necessary to manage severe core damage etc.

[Requirement Details]

- A “Equipment and procedures that provide the water to the design basis measures equipment and Severe Accident Measure Equipment by securing the water source” refers to, the measured described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Provide sufficient water until the postulated B-DBA is settled.
 - (b) Secure multiple alternative freshwater sources (for example, water storage tanks, dams, reservoirs, etc.)
 - (c) Sea water can be used as water source
 - (d) Transfer routes from each water source are secured.
 - (e) Transfer hoses and pumps from alternative water sources shall be prepared in advance.
 - (f) Water source changeover procedures shall be described to ensure that the water supply is not cut off.
 - (g) Recirculation equipment which uses the containment as a water source shall be redundant and diverse by introducing alternative recirculation equipment etc. (PWR).

2. Severe Accident Measures Requirements

(Major systems for each measure)

(15) Measures for securing power sources

[Basic Requirements]

Prepare equipment and procedures for securing electricity required to prevent severe core damage, prevent containment vessel failure, prevent fuel damage in spent fuel storage pool, and prevent fuel damage during reactor shutdown in case of the accident with loss of power.

[Requirement Details]

A “Equipment and procedures for securing electricity required” refers to, the measures and procedure etc. described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.

(Alternative power source)

B Install alternative power source

- (a) Severe Accident Prevention Measures shall be independent and dispersed at different locations to equipment for design basis measures requirement.
- (b) Mobile alternative power sources (Example; power trucks, and batteries) shall be made available and ready.
- (c) Install AC and DC power source as permanent alternative power source.

(Capacity of onsite DC power source)

- (a) On site permanent DC power source shall have the capacity to keep supplying electricity 8 hours without any load shedding. Time duration for “without any load shedding” does not include the case of simple load-shedding with simple actions from main control room or neighboring electric room. In addition, electricity supply shall be assured for 24 hours in total by covering 16 hours by shedding other than essential load.
- (b) Mobile DC power equipment shall be prepared capable for 24 hours to the systems needed for the accident measures.
- (c) For further improvement of reliability, one more system (namely 3rd system) of permanent onsite DC power supply shall be prepared which secures electricity supply to the systems needed for accident measures for 24 hours in total including 8 hours “without any load shedding” (excluding the case of simple load-shedding with simple actions from main control room or neighboring electric rooms) and remaining 16 hours by shedding other than essential load.

(d) Connection of mobile power supply and start of power supply shall be feasible with sufficient time allowance within 24 hours from the onsite permanent DC power sources.

(Power sharing)

C Power sharing among the units shall be feasible at the multiple unit power stations.

(a) Prepare cables in advance and facilitate manual connection.

(b) Prepare stand-by electrical cable in order to meet the situation where installed electrical cable may not be used.

(Onsite power supply)

D Onsite power supply system (Motor Control Center (MCC), Power Center (PC), Metal-Clad-Switch Panel (MC) etc.) shall not lose the function due to the common mode and maintain its function by at least one line and human access

2. Severe Accident Measures Requirements

(Major system for each measures)

(16) Control room

[Basic Requirements]

- 1 Prepare equipment and procedures that enable operators to remain in the control room as long as possible and respond to an event in the event of severe core damage.

[Requirement Details]

- A “Equipment and procedures that enable operators to remain in the control room as long as possible and respond to an event of severe accident” refers to, the measured described below (in case of dealing with the management (masks, tanks, etc.) in addition to ventilation and shielded design of the control room), or the equipment and procedure facilitating the measure that have the same or better effect.
- (a) Power supply to the control room (ventilation, lighting, etc.) shall be provided by alternative AC power sources.
 - (b) Habitability at the control room in the case of severe core damage shall be evaluated as follows.
 - i) Assume the success sequence which will lead to the Severest results (namely the case that containment failure prevention measures like filtered venting system works effectively) among the containment failure mode to be evaluated through the Evaluation of Effectiveness.
 - ii) Operators may wear masks.
 - iii) Stand-by personnel system shall be employed
 - iv) Judgment criteria shall be preventing operators from receiving an effective dose of no more than 100mSv over seven days.
 - (c) Compartment for monitoring and cloth-changing etc. shall be prepared in order to prevent the containment of inside of the control room in case that outside of the control room is contaminated.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(17) Emergency response center

[Basic Requirements]

Install facility and procedures to maintain function as a local command center, such as communicating with the relevant parties both inside and outside the power station, and accommodating required personnel, while giving necessary measures instructions in the event of beyond design basis accidents.

[Requirement Details]

- A “Equipment and procedures to maintain function as a local command center” refers to, the measured described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Emergency response center shall be seismically isolated and not lose function as the result of design basis earthquake and it shall also not be impacted by design basis tsunami.
 - (b) Emergency response center and control room shall not lose the functions simultaneously by common causes.
 - (c) Emergency response center shall be supplied power from alternative AC power sources.
 - (d) Prepare measures to obtain the information to grasp the plant status in order to issue orders.
 - (e) Emergency response center shall be equipped with equipment for the personnel (dosimeters, masks, etc.) and sufficient radiation management shall be prepared.
 - (f) Equipment and information to review measures needed shall be available.
 - (g) Enough food and drinking water to continue activities for one week without outside support shall be stored in the emergency response center.
 - (h) Emergency response center shall be appropriately designed to be shielded and have ventilation systems in order to ensure habitability.
 - (i) Habitability in the emergency response center during B-DBA shall be assessed as follows.
 - i) The assumed amount of radioactive material released shall be equivalent to that of the TEPCO Fukushima Daiichi NPP accident.
 - ii) Excluding cases where special protection measures are implemented when radioactivity plumes pass over, etc., the emergency response center shall be assessed under the assumption that personnel will not wear masks inside the emergency response center
 - iii) Stand-by personnel system, doping of the stabilized iodine, temporary facilities etc. shall be taken into consideration.

- iv) Judgment criteria shall be to prevent operators from receiving an effective dose of no more than 100mSv over seven days.
- (j) Partitioning for monitoring and the changing of work clothes shall be prepared under the situation that the outside of the emergency response center is contaminated, in order to avoid the carry-in of the contaminated materials into the emergency response center.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(18) Instrumentation devices

[Basic Requirements]

Prepare equipment and procedures for estimating necessary plant data in the event that difficulties arise to get the necessary plant data due to the malfunction of some normal and emergency instrumentation devices caused by B-DBA.

[Requirement Details]

- A “Equipment and procedures for estimating necessary plant data” refers to, the measured described below or the equipment and procedures facilitating the measures have the same or better effect.
- B Furthermore, “necessary plant data” refers to, plant status information that shall be collected in order for licensees to implement successful core damage prevention measures and containment vessel failure prevention measures.
 - (a) Clarify the capability of instruments to understand plant status in case of beyond design basis accidents. (Maximum measurable temperature, etc.)
 - (b) Preparation of measures for estimating plant status in the event that situations exceed the ability to grasp the plant conditions.
 - i) Preparation of measures for estimating temperature, pressure, and water level inside the reactor pressure vessel.
 - ii) Preparation of measures for estimating the amount of water injected into the reactor pressure vessel and containment vessel.
 - iii) Parameters needed to make such estimates shall be prioritized in advance considering the accuracy among multiple parameters.
 - (c) Parameters required to manage beyond design basis accidents, such as temperature, pressure, water level, hydrogen concentration and dose rate inside the containment vessel shall be able to be measured or monitored and recorded.
 - (d) Preparation of measures for measuring and monitoring especially important parameters during loss of DC power (Example; testers, conversion table, etc.).

2. Severe Accident Measures Requirements

(Major systems for each measures)

(19) Radiation monitoring facilities

[Basic Requirements]

- 1 Prepare equipment and procedures for monitoring, measuring and recording radioactive material released from nuclear facilities and radiation conditions both on shore and at sea in the event of severe core damage.
- 2 Prepare equipment and procedures for measuring and recording wind direction and wind speed, etc.

[Requirement Details]

- A “Equipment and procedures for monitoring, measuring and recording radioactive material released from reactor facilities and radiation conditions” refers to, the measured described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Monitoring equipment shall be able to measure radioactive material release and radiation conditions postulated in the event of core damage and containment vessel failure.
 - (b) A sufficient number of monitoring cars and mobile alternative monitoring equipment shall be available and ready so as to substitute in the event the permanent monitoring facilities (Example; monitoring posts) lose the function.
 - (c) Permanent monitoring equipment shall be connected to alternative AC power sources.
 - (d) Off-site monitoring shall establish appropriate coordination with other organizational systems.

(Recovery work)

- B Background radiation reduction measures shall be considered so as to avoid situations where radiation levels cannot be measured due to contamination of the area after the accident.

2. Severe Accident Measures Requirements

(Major systems for each measure)

(20) Communications devices

[Basic Requirements]

Prepare equipment and procedures for communicating with necessary locations both within and outside the nuclear power plant in the event of beyond design basis accidents.

[Requirement Details]

- A “Equipment and procedures for communicating with necessary offices” refers to, the measured described below and the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Communications equipment shall be connected to alternative power sources (including backup power sources such as batteries etc.)
 - (b) Measures to share the important parameters obtained by the monitoring etc. shall be prepared at the locations necessary.

2. Severe Accident Measures Requirements

(Major systems for each measures)

(21) Measures for suppression of off-site radioactive material release

Prepare equipment and procedures for suppressing off-site radioactive material release in the event of severe core damage and containment failure or fuel damage in spent fuel storage pool.

[Requirement Details]

- A “Equipment and procedures for suppressing off-site radioactive material release” refers to, the measured described below or the equipment and procedures facilitating the measures etc. that have the same or better effect.
- (a) Install equipment that sprays water to the reactor building.
 - (b) Water spraying equipment shall be able to deal with aircraft fuel fires.
 - (c) Water spraying equipment shall be able to be mobile and spray water on the reactor building from multiple directions.
 - (d) A quantity of water spraying equipment that equals half the number of units at the site (rounded number) shall be prepared under the assumption that such equipment will be used simultaneously for multiple plants.
 - (e) Equipment and procedures etc. shall be prepared to suppress release dispersion of the radioactive materials to the sea.

3. Accident Management for External Events beyond Design Basis

(1) Accident management with mobile equipment, etc.

[Basic Requirements]

Procedures shall be prepared for the following items under the situation that the plant has suffered large-scale damage due to a large-scale natural disaster or acts of terrorism such as intentional airplane crash. Furthermore, organizational systems and necessary equipment enabling these activities in accordance with the procedures shall be prepared.

a. Activities to extinguish a large-scale fire

b. Measures to mitigate fuel damage

c. Measures to mitigate containment vessel failure.

d. Measures to minimize the release of radioactive material

e. Measures to maintain necessary water levels and measures to mitigate fuel damage in spent fuel storage pools

(Note) Requirements are described in “2. Requirement on the Severe Accident Measures (Major Systems for each measure)”

[Requirement Details]

A “Activities to extinguish a large-scale fire” refers to the following.

(a) The preparation of procedures for engaging in fire extinguishing activities using a foam release cannon under the assumption of an external fire resulting from the intentional airplane crash.

B Prepare procedures for the following items in “2. Requirement on the Severe Accident Measures (Major Systems for each measure)”, assuming a large-scale natural disaster

(4) Measures for cooling reactor at high pressure

(5) Measures for depressurization of reactor coolant pressure boundaries

(6) Measures for cooling reactor at low pressure

(7) Measures for securing ultimate heat sink of Severe Accident Prevention Measures at an accident.

(8) Measures for cooling, depressurization and radioactive material reduction in the atmosphere of the containment vessel.

(9) Measures to prevent the containment failure due to overpressurization.

(10) Measures to cool the molten core fallen to the bottom of the containment vessel

(11) Measures to prevent the hydrogen explosions inside the containment vessel

- (12) Measures to prevent the hydrogen explosions inside the reactor building, etc.
 - (13) Measures for cooling, shielding and maintaining the sub-criticality of spent fuel storage pools
 - (14) Measures for securing make-up water and water sources
 - (15) Measures for securing electricity sources
 - (21) Measures for suppression of off-site radioactive release.
- C Prepare procedures for the items above assuming acts of terrorism, such as intentional airplane crash.

3. Accident Management for External Events beyond Design Basis

(2) Specialized Safety Facility

[Basic Requirements]

(Requirements for Specified Safety Facility)

- 1 Specialized Safety Facility shall be installed in accordance with the following.
 - a. Specialized Safety Facility shall be equipped with adequate measures for preventing the loss of necessary function due to the intentional crashing of a large airplane into the reactor building.
 - b. Specialized Safety Facility shall be equipped with adequate measures for preventing the loss of necessary function due to design basis seismic motion and tsunamis.
 - c. Specialized Safety Facility shall be installed with equipment required to prevent containment vessel failure.
 - d. Equipment shall be designed so as to allow the use over a certain period of time.

(Establish organizational systems to maintain the function of Specialized Safety Facility)

- 2 Organization to maintain the function of Specialized Safety Facility shall be established.

[Requirement Details]

- A “Shall be equipped with adequate measures for preventing the loss of necessary function due to the intentional crash of a large airplane into the reactor building” mentioned in 1.a. refers to, for example, ensuring the enough distance (for example over 100 m) between Specialized Safety Facility and reactor building or to be accommodated in a robust structure that can withstand the intentional airplane crash so as to prevent simultaneous failure of both facilities.
- B “Shall be equipped with adequate measures for preventing the loss of necessary function due to design basis seismic motion and tsunamis” mentioned in 1.b. refers to, applying the same allowable limit value for equipment design basis requirement against design basis seismic motion and tsunamis. The robustness against earthquake or tsunami beyond design basis is required by applying the different measures (diversity) by nature as much as possible. For example, while equipment for design basis accident measures has rigid structures, Specialized Safety Facility shall be seismically isolated, have seismic resistant structures, and shall be housed in the watertight buildings or in the buildings located on high ground.
- C The requirements of 1.a. and 1.b. does not have to be satisfied by a single facility and may rather be satisfied by multiple facilities.

D “Shall be installed with equipment required to prevent containment vessel failure” mentioned in 1.c. refers to the measures described below or measures that have the same or better effect.

(a) Following function shall be prepared.

(i) Depressurization operating function for reactor coolant pressure boundaries (Example: equipment for reactor depressurization operation from emergency control room)

(ii) Cooling function of molten core in the reactor (Example: equipment for injecting low pressure water inside the reactor)

(iii) Cooling function of molten core fallen to the bottom of the containment vessel (Example: equipment for cooling water injection into the bottom of the containment vessel)

(iv) Cooling/depressurization/radioactive material reduction function (Example: equipment for injecting water into containment vessel sprays)

(v) Containment vessel failure prevention function due to overpressurization (Example: filtered venting (excluding exhaust stacks))

(vi) Detonation prevention function for the hydrogen inside the containment vessel (reactor type if necessary) (Example: hydrogen concentration control system)

(vii) Support function (Example: power source, instrumentation devices, communication equipment etc.)

(viii) Related functions for above (Example: depressurization valves, pipes etc.)

(b) Emergency control room that controls the above function shall be prepared.

(c) Measures that have that the above function shall be as much as redundant or diverse independent and dispersed in different locations for Design Basis Accident Measures Equipment and Severe Accident Measures Equipment required in section 2.

(d) In the event that containment failure prevention system does not function, evaluation on the habitability of the emergency control room shall be conducted in the same way as the control room assuming the operation at the emergency control room moved from the control room. Release amount of the radioactive material to be postulated shall be as much as for TEPCO’s Fukushima Daiichi accident case.

(e) Communication equipment shall be installed in the secondary control room and enable communication among the main control room, on-site emergency response center and at necessary locations.

(f) Power supply shall provide electricity to “equipment required to prevent containment vessel failure” and shall fulfill the requirements for Specialized Safety Facility mentioned in 1.a. and 1.b. Mobile alternative power sources and permanent alternative power sources shall be able to be connected to the above power supply. Furthermore, even though power supply equipment is part of Specialized Safety Facility, it shall be able to be used in case of severe core damage.

E “Certain period of time” mentioned in 1.d. refers to the duration of the time until outside support can be received (for example, at least for seven days).

4. Evaluation of the Effectiveness of Severe Accidents Measures

(1) Evaluation of the Effectiveness of preventive measures against core damage and containment vessel failure

[Basic Requirements]

(Evaluation of the Effectiveness of preventive measures against severe core damage)

- 1 Licensees must postulate B-DBA which may cause severe core damage and prepare appropriate measures to prevent severe core damage.

(Evaluation of the Effectiveness of preventive measures against containment vessel failure)

- 2 Licensees must postulate the containment vessel failure mode that may occur in conjunction with severe core damage and prepare appropriate measures to prevent containment vessel failure.

[Requirement Details]

(Evaluation of the Effectiveness of measures against severe core damage)

- A “Beyond design basis accidents which may cause severe damage to the core” refers to the cases where SSC designed for protecting the safety of reactor against transients and accidents has lost its functions and consists of the following accident sequence groups with potential severe core damage. Furthermore, the accident sequence groups of (a) must be subject to the evaluation regardless of the investigation results of the accident sequence groups of (b).

(a) Accident sequence groups designated by the Nuclear Regulatory Authority

i) BWR

- Loss of high-pressure/low pressure water injection function
- Loss of high-pressure water injection/depressurization function
- Loss of all AC power
- Loss of decay heat removal function
- Loss of reactor shutdown function
- Loss of water injection function during LOCA
- Containment vessel bypass (interface system LOCA)

ii) PWR

- Loss of secondary system heat removal function
- Loss of AC power (including “Loss of All AC/DC power”)

- Loss of component cooling function
- Loss of containment vessel heat removal function
- Loss of reactor shutdown function
- Loss of ECCS water injection function
- Loss of ECCS recirculation function
- Containment vessel bypass (interface system LOCA, steam generator tube rupture)

(b) Accident sequence groups identified through individual plant evaluation.

i) Evaluate through individual plant internal event probabilistic risk assessment (PRA) and external event PRA (where applicable), or equivalent methods.

ii) As a result, if accident sequence groups that cause a significant frequency or impact and are not included in the accident sequence groups designated by the Nuclear Regulatory Authority are identified, they shall be added as accident sequence groups that require measures. “Accident sequence group that cause a significant frequency or impact “shall be equivalent to the accident sequence groups designated by the Nuclear Regulatory Authority in terms of the core damage frequency or its impact.

B “Prepare appropriate measures to prevent severe core damage” refers to the fulfillment of the following requirements.

(a) For the postulated accident sequence groups which can expect the function of the containment after core damage, to verify that sufficient measures are prepared to prevent core damage and those measures could be effective within the condition that those measures postulate.

(b) For the postulated accident sequence that cannot expect the function of the containment vessel after core damage (sequence of containment failure before core damage, containment vessel by pass.) to verify that measure to prevent core damage is effective.

C “To verify the effectiveness” refers to the confirmation that following evaluation item are appropriately fulfilled.

(a) Core is not severely damaged and can be sufficiently cooled.

(b) Pressure on the reactor coolant pressure boundary shall be lower than 1.2 time of maximum operating pressure or limiting pressure.

(c) Pressure on the containment vessel boundary shall be lower than the maximum operating pressure or limiting pressure.

(d) Temperature on containment vessel boundary shall be lower than the maximum operating temperature or limiting temperature.

- D “Sufficient measures are prepared” means that measures equivalent to the advanced measures deployed domestically and internationally, are prepared.
- E “Core is not severely damaged and can be sufficiently cooled” refers to the fulfillment of the following requirements. However, this shall not apply to cases where sufficient scientific evidence has been offered in regards to the maximum temperature of fuel cladding tubes and the amount of oxidation.
- (a) Fuel cladding tube maximum temperature shall be below 1200°C.
 - (b) The amount of oxidation of fuel cladding tubes shall be less than 15% of the thickness of the cladding tube prior to severe oxidation.
- F The requirements of C (b). do not have to be fulfilled if the cause of the event is loss of reactor coolant pressure boundary, such as LOCA.
- G If limiting pressure and limiting temperature are used as judgment criteria, basis and reason shall be presented.

(Evaluation of the Effectiveness of preventive measures against containment failure)

- H “Containment failure mode” mentioned in 2 above refers to the following.
- Containment vessel failure modes of (a) must be covered regardless of the investigation results of the containment vessel failure modes of (b).
- (a) Containment vessel failure modes designated by the Nuclear Regulatory Authority
 - i) Static loads by internal pressure/temperature (damage by containment vessel overpressurization/over-heating)
 - ii) High pressure melt ejection/direct heating of containment vessel atmosphere
 - iii) Ex-vessel fuel-coolant interaction (FCI)
 - iv) Hydrogen explosion
 - v) Direct contact with containment vessel (shell attack)
 - vi) Melted core and concrete interactions (MCCI)
 - (b) Containment vessel failure modes that produce significantly frequent failure selected through individual plant internal event probabilistic risk assessment (PRA) and external event PRA (where applicable).
 - i) Evaluate through individual plant internal event probabilistic risk assessment (PRA) and external event PRA, or similar methods.
 - ii) As a result, if containment vessel failure modes that are not included in the containment failure modes designated by the Nuclear Regulatory Authority but that

may cause a significant frequency or impact are identified, they shall be added as containment failure mode that require measures.

- I “Prepare appropriate measure to prevent containment vessel failure” refer to the fulfillment of the following requirements.
- (a) To confirm the effectiveness of measures to prevent the containment failure and extraordinary release of radioactive material to off-site against postulated containment failure model.
- J “To confirm the Effectiveness” refers to the confirmation that following evaluation items are almost fulfilled against the above containment failure mode.
- (a) Internal pressures in containment vessel shall be lower than maximum operating pressures or limiting pressure.
 - (b) Internal temperatures in containment vessel shall be lower than maximum operating temperatures or limiting temperature.
 - (c) Total release amount of radioactive material shall be under performance requirement values.
 - (d) Reactor coolant pressure shall be reduced to below 2.0MPa until the reactor pressure vessel failure.
 - (e) Containment vessel shall withstand thermal and dynamic loads caused by rapid ex-vessel Fuel-Clad Interaction (FCI).
 - (f) Prevention of the detonation of hydrogen that may cause containment vessel failure.
 - (g) Fulfillment of the requirements of (a) even in the event that flammable gas accumulates and burns.
 - (h) Molten core material fallen to the floor of the containment vessel shall not spread across the floor and come in direct contact with the containment vessel boundary and molten core shall be cooled in an adequate manner.
 - (i) The support structure of containment vessel shall not lose its function with the erosion cause by the molten core and molten core shall be cooled in an adequate manner.
- K If limiting pressure and limiting temperature are used as evaluation standpoints, basis and reason shall be presented.
- L “Prevention of the detonation of hydrogen that may cause containment vessel failure” mentioned in J (f) shall fulfill the following requirements.
- (a) Hydrogen concentration inside the containment vessel shall fall below 13vol% and oxygen concentration shall be lower than 5vol% converted under dry conditions.

4. Evaluation of the Effectiveness of Severe Accidents Measures

(2) Evaluation of the Effectiveness of preventive measures against fuel damage in spent fuel storage pools

[Basic Requirements]

- 1 Licensees must prepare appropriate preventive measures against fuel damage by postulating an accident that may cause severe damage to the fuel stored in spent fuel storage pools

[Requirement Details]

A “An accident that that may cause severe damage to the fuel stored in spent fuel storage pools” refers to; the following accidents that have the potential to damage fuel stored in spent fuel storage pools.

(a) Postulated accident 1:

Pool water temperature rises and water level drops due to evaporation as the result of a malfunctioning of auxiliary feedwater system (required by design basis) causing auxiliary feed failure.

(b) Postulated accident 2:

A small amount of water is lost due to the siphoning effect, etc., and pool water level decreases.

B “To prepare appropriate measures preventive against fuel damage” refers to the fulfillment of following requirements.

(a) To verify that following evaluation items are fulfilled in the “accident that may cause severe damage to fuel stored in spent fuel storage pool” postulated in (A) above.

- (i) Top of active fuel is submerged.
- (ii) A water level that shields radiation is maintained.
- (iii) Sub-criticality is maintained.

4. Evaluation of the Effectiveness of Severe Accidents Measures

(3) Evaluation of the Effectiveness of preventive measures against fuel damage in a reactor during shutdown

[Basic Requirements]

- 1 Licensees must prepare appropriate preventive measures against fuel damage in reactor during shutdown assuming the possibility of an accident that that may cause severe damage to the fuel in reactor during shutdown

[Requirement Details]

- A “Accident that may cause damage to fuel in shutdown reactors” refers to, the following accidents that may result in damage to fuel in shutdown reactors. Furthermore, the accident sequence groups of (a) must be covered regardless of the investigation results of the accident sequence groups of (b).
- (a) Accident sequence groups designated by the Nuclear Regulatory Authority
 - i) Loss of decay heat removal function (loss of cooling function of RHR during shutdown)
 - ii) Loss all AC power
 - iii) Reactor coolant leak
 - iv) Inadvertent insertion of reactivity
 - (b) Accident sequence groups that produce significantly frequent fuel damage selected through individual plant probabilistic risk assessment (PRA) during shutdown.
 - i) Assessed through individual plant PRA during shutdown or other equivalent methods.
 - ii) As a result, if accident sequence groups that cause a significant frequency or impact and are not included in the accident sequence groups designated by the Nuclear Regulatory Authority are identified, they shall be added as accident sequence groups that require measures.
- B “To prepare appropriate preventive measures against fuel damage” refers to the fulfillment of the following requirements.
- (a) To verify that following evaluation items are fulfilled in the “accident that may cause damage to fuel in reactor during shutdown “postulated in (A) above.
 - i) Top of active fuel is submerged.

- ii) A water fuel that shields radiation is maintained.
- iii) Sub-criticality is maintained.