Resolution no. 2011-DC-0216 by the French Nuclear Safety Authority dated May 5, 2011, instructing the Institut Laue Langevin (ILL) to carry out a complementary safety assessment of its basic nuclear installation (High Flux Reactor - BNI 67) in the light of the accident which has occurred at the Fukushima Daiichi nuclear power plant

The French Nuclear Safety Authority [ASN, *Autorité de Sûreté Nucléaire*],

In view of EC Directive 2009/71/EURATOM dated June 25, 2009 establishing a European framework for the nuclear safety of nuclear installations, particularly articles 5 and 6;

In view of amended law 2006-686 of June 13, 2006, relating to transparency and security in the nuclear field, particularly articles 8, 28 and 29;

In view of amended decree 2007-1557 of November 2, 2007 relating to basic nuclear installations and control, regarding nuclear safety and the transport of radioactive substances, particularly article 18;

In view of the order of August 10, 1984 concerning the quality of the design, construction and operation of basic nuclear installations;

In view of the order of November 26, 1999 establishing the general technical provisions relating to the limits and procedures for intakes and discharges subject to authorisation carried out by basic nuclear installations;

In view of the amended order dated December 31, 1999 establishing the general technical regulations designed to prevent and mitigate nuisances and off-site risks arising from the operation of basic nuclear installations;

In view of the conclusions of the European Council session of March 24 and 25, 2011 relating in particular to the carrying out, under the control of national safety authorities, of "stress tests" on the European Union's nuclear installations;

In view of the letter from the French Prime Minister no. 005698 of March 23, 2011 requesting ASN to carry out a survey of the safety of nuclear installations, in particular nuclear power plants, in the light of the accident currently in progress at the Fukushima power plant;

In view of the reply sent by ASN to the Prime Minister dated March 25, 2011;

In view of the opinion of the High Committee on transparency and information on nuclear safety dated May 3, 2011;

In view of the letter from the Institut Laue Langevin dated May 4, 2011 in response to the consultation by ASN;

On the basis that it is important to learn as many lessons as possible from the accident which has occurred at the Fukushima nuclear power plant in Japan and that this initiative will cover a period of several years;

On the basis that it is necessary to launch the assessment process without delay in order to have initial findings available by the end of 2011;

On the basis that it is also appropriate to examine the safety of nuclear power reactors currently in operation or under construction as a priority;

On the basis that, furthermore, the safety of other nuclear installations must also be re-assessed in the light of the accident which has taken place at Fukushima, with a degree of priority commensurate with the issues at stake;

On the basis that, within the European Union, assessments conducted following national initiatives need to be as coherent as possible with the stress tests conducted at the request of the European Council;

On the basis that, in response to this same request, the Western European Nuclear Regulators Association (WENRA) has drawn up draft joint specifications for these stress tests, and that this project addresses most of the assessment needs identified at the national level, apart from a few additional aspects;

On the basis, finally, that the reports drawn up pursuant to this decision will constitute initial experience feedback following the accident at the Fukushima nuclear power plant,

HEREBY ISSUES THE FOLLOWING DECISION:

Article 1

The Institut Laue Langevin, hereinafter referred to as the "operator", shall carry out the assessment, pursuant to the specifications supplied in Appendix 1, of the high flux reactor (HFR) (BNI 67) located on the Grenoble site.

Article 2

The operator shall provide ASN with a note presenting the methodology adopted to conduct this assessment, the organisation set up to abide by the deadlines specified in this decision? and the detailed structure envisaged for the report, no later than 15 January 2012.

Article 3

The operator shall provide an initial report to ASN no later than September 15, 2011. This report shall present the conclusions of the assessment carried out using the data available and on the basis of existing safety studies and engineering judgement. It shall propose additional studies to be carried out, particularly as regards the weak points and "cliff edge" effects identified, as well as an appropriate calendar for these studies.

Article 4

The Director General of ASN shall be responsible for the implementation of this decision.

This decision shall be notified to the operator and published in the ASN's Official Bulletin.

Signed in Paris, May 5, 2011.

The Commission of the ASN*,

Signed by:

André-Claude Lacoste

Marie-Pierre Comets

Michel Bourguignon

Philippe Jamet

Jean-Jacques Dumont

*Commissioners present at this session

APPENDIX 1

To the Resolution no. 2011-DC-0216 by the French Nuclear Safety Authority dated May 5, 2011, instructing the Institut Laue Langevin (ILL) to carry out a complementary safety assessment of its basic nuclear installation (High Flux Reactor - BNI 67) in the light of the accident which has occurred at the Fukushima Daiichi nuclear power plant

French Version dated 3 May 2011

This document applies to all nuclear installations; specific characteristics (nuclear power reactors/other nuclear installations) are shown in boxes.

Definitions

The complementary safety assessment (or "stress test") shall consist in targeted reassessment of the safety margins of nuclear installations in the light of the events which occurred at Fukushima, i.e. extreme natural events challenging the installation safety functions and leading to a severe accident.

This reassessment will consist :

- in an evaluation of the response of a nuclear installation when facing a set of extreme situations envisaged under the following section "technical scope" and
- in a verification of the prevention and consequence mitigation measures chosen following a defence-in-depth logic: initiating events, consequential loss of safety functions, severe accident management.

In these extreme situations, sequential loss of the lines of defence is assumed, applying a deterministic approach, irrespective of the probability of this loss. In particular, it has to be kept in mind that loss of safety functions and severe accident situations can occur only when several design provisions have failed. In addition, measures to manage these situations will be supposed to be progressively defeated.

For a given installation, the reassessment shall cover, on the one hand, the response of the installation in these extreme situations, and on the other hand, the effectiveness of prevention and consequence mitigation measures, noting any potential weak points and any cliff edge effect[1], for each of the considered extreme situations. The robustness of the defence-in-depth approach shall be assessed, as shall the relevance of current accident management measures, and any potential safety improvements shall be identified, both technical and organisational (such as procedures, human resources and emergency response organisation or use of external resources).

[1] Major discontinuity in the response of an installation.
In the event of flooding, the water level would rise progressively. A cliff edge effect would occur if the water level reaches the top of a dike and floods the entire site.

By their nature, the stress tests will tend to focus on measures that could be taken after a postulated loss of the safety systems that are installed to provide protection against accidents considered in the design. Adequate performance of those systems has been assessed in connection with plant licensing and is not re-assessed in the stress tests. Concerning reactors, it is recognised that all measures taken to protect reactor core and spent fuel storage pools integrity or to protect the reactor containment integrity constitute an essential part of the defence-in-depth. More generally, prevention is an essential element of defence-in-depth for all nuclear installations.

Furthermore, the Fukushima accident has demonstrated that the capability of the operator and, where applicable, of its contractors, to be ready to work in severe accident conditions represents a key component in bringing such situations under control. This ability also forms a vital element in the prevention of such accidents, in the maintenance of installations and in the quality of their operation. Consequently, the conditions in which use is made of subcontractors are particularly important; they should allow the operator to retain full control and responsibility for the safety of its installation. Stress tests shall therefore address this aspect.

Performance of the stress test procedure

The operators have the prime responsibility for safety. Hence, it is up to the operators to perform the reassessments, and up to ASN to independently review them.

To perform the reassessments, the operators may, due to time constraints, rely on the existing safety studies and engineering judgement[2].

Technical scope

The existing safety analysis for nuclear power plants in European countries covers a large variety of situations. The technical scope of the stress tests has been defined considering more particularly the issues that have been highlighted by the events that occurred at Fukushima, including combination of initiating events and failures. The following situations will be addressed, corresponding to steps of more and more severe situations:

<u>Initiating events conceivable at the plant site</u>

- Earthquake
- Flooding
- Other extreme natural events

<u>Consequential loss of safety functions</u>

- Loss of electrical power, including station black out (SBO)
- Loss of the ultimate heat sink (UHS)
- Combination of both

<u>Management of severe accidents</u>

For power reactors and research reactors, particular attention shall be paid to the following aspects:

- Means to protect from and to manage loss of core cooling function
- Means to protect from and to manage loss of cooling function for dry or underwater fuel storage
- Means to protect from and to manage loss of containment integrity, specifically of the reactor containment building.

[2] Due to the timeframe of the stress test process, some of the engineering studies supporting the operator's assessment may not be available for scenarios not included in the current design.

For other nuclear installations, particular attention shall be paid to the following aspects:

- Means to prevent and to manage loss of the cooling function
- Means to prevent and to manage loss of containment for radioactive and/or hazardous products
- Means to prevent and to manage loss of means for managing the risks of explosion, specifically including the risk of hydrogen explosion
- Means to prevent and to manage loss of means for preventing criticality risks
- Means to prevent and to manage loss of fire-fighting means.

However, the considered initiating events have not been limited to earthquake and tsunami as in Fukushima: flooding will be included regardless of its origin. Furthermore, extreme weather conditions shall also form part of the stress test.

In addition, the assessment of consequences of loss of safety functions is relevant also if the situation is provoked by indirect initiating events, for instance large disturbance from the electrical power grid impacting AC power distribution systems or by other events such as malevolent acts (even if these initiating factors are not studied as such in the course of this complementary reassessment).

The review of the severe accident management issues focuses on the operators provisions but it may also comprise relevant planned off-site support for maintaining the safety functions of the plant. Although the experience feedback from the Fukushima accident may include the emergency preparedness measures managed by the relevant off-site services for public protection (fire-fighters, police, health services….), this topic is out of the scope of these stress tests.

Organisational scope

Conditions of use of contractors

- Relevant scope
- Selection procedures for contractors
- Conditions in which contractors intervene
- Oversight of subcontracting activities

* * *
*

The next sections of this document set out:

- general information required from the operators;
- issues to be considered by the operators for each considered extreme situation.

General aspects

Format of the report

The operator shall provide a single document for each site, even if there are several installations on the same site.

In a first part, the site characteristics shall be briefly described:

- location (sea, river);
- number of units;
- operator;
- the industrial environment and subsequent hazards for the installation.

The main characteristics of each installation shall be presented, particularly the following:

For power reactors and research reactors:

- the type of reactor (including the radiological inventory, the type of fuel and enrichment, the type of moderator and coolant, and the characteristics and state of the reactor containment)
- thermal power
- date of first criticality
- the existence and number of storage sites for new and spent fuel (or shared storage sites)

The particularities of the various installations which are important for safety shall be specified.

For other nuclear installations:

- the type of installation;
- the activities (nuclear, chemical, biological) including the storage of waste and/or fuel, with the maximum authorised inventory
- authorised inventories of radioactive chemical materials, with their characteristics, including their type and form
- the specific hazards (particularly nuclear and chemical hazards): criticality, irradiation, risk of explosion, fire, etc.
- date of commissioning.

In a second part, each extreme situation shall be assessed, following the indications given below.

Hypothesis

For existing installations, complementary assessments shall refer to the installation as built and operated on June 30, 2011. For installations under construction or planned, complementary assessments shall refer to the design as planned or authorised.

The approach shall be essentially deterministic: when analysing an extreme scenario, a progressive approach shall be followed, in which the accident protective measures are sequentially assumed to be defeated.

For each scenario, the installation condition shall correspond to the most unfavourable operational states permitted by the technical operating specifications. All operational states shall be envisaged (including, for research reactors, experimental sequences).

Initially, the operator shall carry out its analysis installation by installation; subsequently, it shall be assumed that all installations on the same site (reactors, pools, other storage facilities for new and spent fuel and other installations housing hazardous materials) are affected at the same time.

The operator shall take into account the possibility of degraded conditions around the site surrounding area.

Consideration should be given to:

- automatic actions;
- operators actions specified in emergency operating procedures;
- any other planned measures of prevention, recovery and mitigation of accidents;

Information to be included

Three main aspects need to be reported:

- Provisions taken in the design basis of the plant and plant conformance to its design requirements;
- Robustness of the plant beyond its design basis. For this purpose, the robustness (available design margins, diversity, redundancy, structural protection, physical separation, etc) of the safety-relevant systems, structures and components and the effectiveness of the defence-in-depth concept have to be assessed. Regarding the robustness of the installations and measures, one focus of the review is on identification of a step change in the event sequence (cliff edge effect[3]) and, if necessary, consideration of measures for its avoidance.
- any potential for modifications likely to improve the considered level of defence-in-depth, in terms of improving the resistance of components or of strengthening the independence with other levels of defence.

In addition, the operator may wish to describe protective measures aimed at avoiding the extreme scenarios that are envisaged in the stress tests in order to provide context for the stress tests.

To this aim, the operator shall identify:

- the means to maintain the three fundamental safety functions (control of reactivity or preventing the risk of criticality, fuel cooling and heat removal, confinement of radioactivity) and support functions (power supply, cooling through ultimate heat sink), taking into account the probable damage done by the initiating event and any means not credited in the safety demonstration;
- possibility of mobile external means and the conditions of their use;
- any existing rescue procedure for the installation using means from another installation.

As for severe accident management, the operator shall identify, where relevant:

For power reactors and research reactors:

- the time before damage to the fuel. If the core is in the reactor vessel, indicate the time before the water level reaches the top of the core, and the time before the fuel degradation occurs (for instance, fast cladding oxidation with hydrogen production);
- for research reactors, specify the risk of critical excursion and the means to control this;
- if the fuel is stored in the spent fuel pool, the time before pool boiling, the time up to when adequate shielding against radiation is maintained, the time before the water level reaches the top of the fuel elements and the time before fuel degradation starts;
- for research reactors in which the fuel is in dry storage, the time during which adequate shielding against radiation is maintained and the time before fuel degradation starts.

[3] Example: exhaustion of the capacity of the batteries in the event of a station blackout

For other nuclear installations:

- the time before the occurrence of an event requiring emergency actions and actions to be triggered in the frame of incident/accident situations, or the time before uncontrolled discharges into the environment. For instance, in the event of units containing solutions of radioactive materials or fission products, the time before this solution boiling or before a hydrogen explosion, and for those containing vitrified waste, the time before the material degradations starts;
- For pools containing spent fuel, the time before the pool beginning to boil, the time during which adequate shielding against radiation is maintained, the time before the water level reaches the top of the fuel elements, the time before fuel degradation starts and the time before there is the risk of a hydrogen explosion.

Supporting documentation

The degree of validation of the documents referenced by the operator shall be identified:

- validated during the course of the authorisation process
- not validated during the course of the authorisation process, but monitored as part of the quality assurance process implemented by the operator
- other.

Earthquakes

I. Design basis

a) Earthquake against which the plant is designed :

- Characteristics of the design basis earthquake (DBE) expressed in terms of peak ground acceleration (PGA) with reasons for this choice. Also specify the DBE taken into account in the original licensing basis if different;
- Methodology to evaluate the DBE (return period, past events considered, their location and reasons for this choice, margins added, etc), validity of data in time;
- Conclusion on the adequacy of the design basis.

b) Provisions to protect the installation against the DBE

- Identification of the key structures, systems and components (SSCs) which are required for achieving safe shutdown state and are supposed to remain available (operational and/or with integrity maintained) after the earthquake;
- Main associated design/construction provisions;
- Main operating provisions (including emergency procedures, mobile equipment, etc) to mitigate the consequences of an earthquake, particularly to prevent damage to the reactor core and to the spent fuel storage pool and to mitigate the discharge of radioactive materials for nuclear installations other than the reactors;
- Specify whether indirect effects of the earthquake have been taken into account, including the following:
    1. Failure of SSCs that are not designed to withstand the DBE and that, in loosing their integrity, could cause a consequential damage of SSCs that need to remain available;
    2. Loss of external power supply;
    3. Situation outside the plant, including preventing or delaying access of personnel and equipment to the site;
    4. Fire and explosion.

c) Compliance of the installation with its current licensing basis

- Operator's general organisation to ensure conformity (periodic maintenance, inspections, testing, etc);
- Operator's organisation to ensure that off-site mobile equipment and supplies considered in emergency procedures are available and remain fit for duty;
- Any known deviation, and the consequences of these deviations in terms of safety; planning of remediation actions and/or compensatory measures;
- Specific compliance check already initiated by the operator following the Fukushima NPP accident.

II. Evaluation of margins

d) Based on available information (which could include seismic PSA[4], seismic margin assessment or other seismic engineering studies to support engineering judgement), give an evaluation of the range of earthquake severity above which loss of fundamental safety functions or severe damage to the fuel (in

[4] Probabilistic Safety Assessment

vessels or in fuel storage pools) becomes unavoidable or, for installations other than reactors, leads to the triggering of actions related to accident situations.

- Indicate which are the weak points of the installation and of the organisation and specify any cliff edge effects according to earthquake severity.
- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…).

e) Based on available information (which could include seismic PSA, seismic margin assessment or other seismic engineering studies to support engineering judgement), specify what is the range of earthquake severity the installation can withstand without losing confinement integrity.

Flooding

I. Design basis

a) Flooding against the installation is designed

- Characteristics of the design basis flood (DBF), including the water level taken into account, and reasons for this choice. Also indicate the values of these parameters taken into account for the original licensing basis.
- Methodology used to evaluate the DBF (return period, past events considered, their location and reasons for choice, margins added, etc). Sources of flooding considered (tsunami, tidal, storm surge, dam failure, etc.); validity of the data over time.
- Conclusion on the adequacy of the design basis for flooding.

b) Provisions to protect the installation against the DBF

- Identification of the key structures, systems and components (SSCs) which must remain available after the subsequent to flooding to achieve safe shutdown state, including the following:
  - Provisions to maintain the water intake function (where applicable);
  - Provisions to maintain emergency electrical power supply;
  - For nuclear installations other than reactors, provisions to ensure control of the risk of dispersion of radioactive materials, criticality and explosion;
- Identification of the main design provisions to protect the site against flooding (platform level, dike, etc.);
- Main operating provisions (including emergency procedures, mobile equipment, etc) to warn of imminent flooding and mitigate the effects of this flooding
- Specify whether other effects linked to the flooding itself or to the phenomena that originated the flooding (such as very bad weather conditions) have been taken into consideration, including the following:
  - Loss of external power supply
  - Loss of water intake (effects of debris, oil slicks, etc.)
  - Situation outside the installation, including preventing or delaying access of personnel and equipment to the site.

c) Compliance of the installation with its current licensing basis

- Operator's general organisation to ensure compliance (periodic maintenance, inspections, testing, etc.);
- Operator's organisation to ensure that off-site mobile equipment and supplies considered in emergency procedures are available and remain fit for duty;
- Any known deviation, and the consequences of these deviations in terms of safety; planning of remediation actions and/or compensatory measures;
- Specific compliance check already initiated by the operator following the Fukushima NPP accident.

II. Evaluation of margins

d) Based on available information (including engineering studies to support engineering judgement), what is the level of flooding that the installation can withstand without severe damage to the fuel (in vessel or in pool) or, for installations other than the reactors, that leads to the triggering of actions related to accident situations.

- Depending on the time between warning and flooding, indicate whether any additional protective measures can be envisaged or / implemented
- Indicate which are the weak points and specify any cliff edge effects. Identify which buildings and equipment which would be flooded first
- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modifications of procedures, organisational provisions, etc.).

Other extreme natural phenomena

a) Extreme weather conditions relating to flooding (storm, heavy rainfall, etc.)

- Events and any combination of events considered and reasons for the selection (or not) as a design basis.
- Indicate which are the weak points and specify any cliff edge effects. Identify which buildings and equipment will be impacted.
- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modifications of procedures, organisational provisions, etc.).

b) Earthquake exceeding the DBE for the installation or certain infrastructures and consequent flooding exceeding DBF levels

- Indicate whether, taking into account installation location and design, such situation can be physically possible. To this aim, identify in particular if severe damages to structures that are outside or inside the installation (such as dams, dikes) could have an impact on the installation safety.
- Indicate which are the weak points and specify any cliff edge effects. Identify which buildings and which equipments will be impacted.
- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…)

Loss of electrical power
Loss of cooling systems

Electrical AC power sources are:

- off-site power sources (electrical grid);
- ordinary back-up generators (diesel generator, gas turbine…);
- in some cases other diverse back-up sources.

Sequential loss of these sources has to be considered (see a) and b) below).

For power reactors and research reactors:

The ultimate heat sink (UHS) is a medium to which the residual heat from the reactor is transferred. In some cases, the plant has the primary UHS, such as the sea or a river, which is supplemented by an alternate UHS, for example a lake, a water table or the atmosphere. Sequential loss of these sinks has to be considered (see c) below).

a) Loss of off-site power (LOOP)

For power reactors and research reactors:

- Describe how this situation is taken into account in the design and describe the backup power sources provided are designed and how to implement them;
- Indicate for how long the on-site power sources can operate without any external support;
- Specify which provisions are needed to prolong the time of on-site power supply (refuelling of diesel generators…);
- Indicate any envisaged provisions to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…).

For other nuclear installations:

- Describe how this situation is taken into account in the design, the backup power sources provided and how these are implemented;
- Indicate for how long the site can face a loss of off-site electrical power without any external support;
- Specify the provisions made to control the situation (refuelling diesel generators, etc.);
- Indicate any provisions envisaged to increase robustness of the installation (modification of hardware, modification of procedures, organisational provisions, etc.).

b) Loss of off-site power and of on-site backup power sources (SBO)

Two situations shall be considered:

- LOOP + loss of the ordinary back-up source
- LOOP + loss of the ordinary back-up sources + loss of any other diverse back-up sources.

For power reactors and research reactors:

For each of these situations:

- Provide information on the battery capacity and duration.
- Indicate for how long the site can withstand a SBO without any external support before severe damage to the fuel becomes unavoidable.
- Specify which (external) actions are foreseen to prevent fuel degradation:
  - equipment already present on site, e.g. equipment from another reactor;
  - assuming that all reactors on the same site are equally damaged, equipment available off-site;
  - near-by power stations (e.g. hydropower, gas turbine) that can be aligned to provide power via a dedicated direct connection;
  - time necessary to have each of the above systems operating;
  - availability of competent human resources to establish and make operational this exceptional connection;
  - identification of when the main cliff edge effects occur.
- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…)

For other nuclear installations:

For each of these situations:

- Provide information on battery capacity and duration
- indicate how long the site can withstand SBO without any external support before a severe accident occurs
- Specify which (off-site) actions are foreseen before a severe accident occurs:
  - equipment already present on site, e.g. equipment from another installation;
  - assuming that all installations on the same site have been damaged, equipment available off-site;
  - the time necessary to have each of the above systems operating;
  - availability of competent human resources;
  - availability of inert gases;
  - identification of when the main cliff edge effects occur.
- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions, etc.).

c) Loss of the primary ultimate heat sink (UHS)

For power reactors and research reactors:

- Provide a description of design provisions to prevent the loss of the UHS (e.g. various water intakes for primary UHS at different locations, use of alternative UHS, ...)"

Two situations have to be considered:

- Loss of primary ultimate heat sink (UHS), i.e. access to water from the river or the sea;
- Loss of primary ultimate heat sink (UHS) and the alternate UHS.

For each of these situations:

- Indicate for how long the site can withstand the situation without any external support before damage to the fuel becomes unavoidable:
- Specify which external actions are foreseen to prevent fuel degradation:
  - equipment already present on site, e.g. equipment from another reactor;
  - assuming that all reactors on the same site are equally damaged, equipment available off-site;
  - availability of competent human resources ;
  - time necessary to have these systems operating;
  - identification of when the main cliff edge effects occur.
- Indicate if any provisions can be envisaged to prevent these cliff edge effect, to improve the autonomy of the site and increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…).

For other nuclear installations:

In the event of the loss of all heat sink functions:

- Indicate how long the site can withstand the situation without any external support before a severe accident becomes unavoidable;
- Specify what off-site actions are planned to prevent such an accident:
  - equipment already present on site, e.g. equipment from another installation;
  - assuming that all installations on the same site are equally damaged, equipment available off-site;
  - availability of competent human resources;
  - the time necessary to have these systems operating,
  - identification of when the main cliff edge effects occur.
- Indicate what provisions can be envisaged to prevent or delay these cliff edge effects, to improve the autonomy of the site and increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions, etc.).

d) Loss of the primary UHS, combined with SBO

For power reactors and research reactors:

- Indicate how long the site can withstand the loss of its "primary" UHS, combined with SBO without any external support before severe damage to the fuel becomes unavoidable

- Specify which external actions are planned to prevent fuel degradation:
  - equipment already present on site, e.g. equipment from another reactor;
  - assuming that all reactors on the same site are equally damaged, equipment available off-site;
  - availability of human resources;
  - the time necessary to have these systems operating,
  - identification of when the main cliff edge effects occur.

- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…)

For other nuclear installations:

- Indicate how long the site can withstand the loss of its "primary" UHS, combined with SBO and no off-site external support before a severe accident becomes unavoidable

- Specify what off-site actions are planned to prevent such an accident:
  - equipment already present on site, e.g. equipment from another installation;
  - assuming that all installations on the same site are equally damaged, equipment available off-site;
  - availability of human resources;
  - the time necessary to have these systems operating,
  - identification of when the main cliff edge effects occur.

- Indicate if any provisions can be envisaged to prevent these cliff edge effects or to increase robustness of the installation (modifications of hardware, modification of procedures, organisational provisions…)

Severe accident management

For power reactors and research reactors:

a) Describe the accident management measures currently in place at the various stages of a severe accident in particular subsequent to a loss of the core cooling function:

- before occurrence of fuel damage in the reactor pressure vessel
  - last resorts to prevent fuel damage
  - elimination of the possibility of fuel damage at high pressure
- after occurrence of fuel damage in the reactor pressure vessel
- after failure of the reactor pressure vessel (fusion of the core in the reactor pit)

b) Describe the accident management measures and installation design features for protecting containment integrity after occurrence of fuel damage

- prevention of H_2 deflagration or H_2 detonation (inerting, recombiners, or igniters), also taking into account venting processes;
- prevention of over-pressurization of the containment;
- prevention of re-criticality
- prevention of basemat melt through
- need for and supply of electrical AC and DC power to equipment used for protecting containment integrity.

c) Describe the management measures of consequences of a loss of cooling function for the pool water or other fuel storage facility (the following indications relate to the fuel storage facility):

- before/after losing adequate shielding against radiation
- before and after occurrence of uncover of the top of fuel in the fuel pool
- before and after occurrence of severe fuel damage in the fuel storage facility.

For *a*), *b*) and *c*) for each stage:

- identify any cliff edge effect and evaluate the time before it
- assess the adequacy of the existing management measures, including the procedural guidance to cope with a severe accident, and evaluate the potential for additional measures. In particular, the operator is asked to consider:
  - the suitability and availability of the required instrumentation
  - the availability and habitability of the control room
  - the potential for H_2 accumulations in buildings other than the containment building.

For installations other than reactors:

a) Describe the measures planned to prevent and manage accidents (criticality, explosion, fire, uncontrolled discharges into the environment, etc.).

b) In the particular case of spent fuel storage pools, describe the measures currently in place to prevent/manage the consequences of a loss of the water cooling function:

- before/after losing adequate shielding against radiation
- before and after occurrence of uncover of the top of fuel in the fuel pool
- before and after severe fuel damage in the fuel storage facility.

For *a*), and b) above, for each stage:

- identify the hardware (equipment and instrumentation) used for accident management, in particular items which are common to different installations
- identify any cliff edge effect and assess the time before its occurrence
- assess the adequacy of existing response measures and the interest of any supplementary measures. In

particular, the operator shall examine the adequacy and availability of instrumentation and equipment required to mitigate the consequences of any accident

- assess risks relating to hydrogen, identifying the following:
  - phenomena which may generate hydrogen (radiolysis, zirconium-steam reactions)
  - possible build-ups of hydrogen
  - means implemented to prevent hydrogen deflagrations and detonations
- assess the prevention of criticality risks, particularly during emptying or filling of fuel storage pools

The following aspects have to be addressed:

- Organisation of the operator to manage the situation, including:
  - staffing and shift management;
  - measures taken to enable optimum intervention by personnel (taking into account stress, psychological pressure, etc.)
  - use of off-site technical support for accident management (and contingencies if this becomes unavailable);
  - procedures, training and exercises;
- Possibility to use existing equipment;
- Provisions to use mobile devices (availability of such devices, time to bring them on site and put them in operation);
- Provisions for and management of supplies (fuel for diesel generators, water…);
- Management of radioactive releases, provisions to limit them;
- Communication and information systems (internal, external).

The envisaged accident management measures shall be evaluated considering what the situation could be on a site:

- Extensive destruction of infrastructure around the installation including the communication facilities (making technical and personnel support from outside more difficult);
- Impairment of work performance (including impact on the accessibility and habitability of the main and secondary control rooms) due to high local dose rates, radioactive contamination and destruction of some facilities on site;
- Feasibility and effectiveness of accident management measures under the conditions of external hazards (earthquakes, floods);
- Unavailability of power supply;
- Potential failure of instrumentation;
- Potential effects from the other neighbouring installations at site.

The operator shall identify which conditions would prevent staff from working in the main or secondary control room. It shall also determine the measures to be taken to avoid such conditions occurring. It shall also determine the measures to be taken should such a situation nevertheless arise.

Conditions of recourse to contractors

a) Describe the scope of the activities in question, with supporting arguments.

Demonstrate that this scope is compatible with the full responsibility of the operator in terms of nuclear safety and protection from radioactivity.

b) Describe the process by which contractors are chosen: requirements in terms of the qualifications of contractors (including training of personnel in nuclear safety and radiation protection from radioactivity), formalisation of specifications and types of contracts, the process by which contracts are awarded, measures taken to enable subcontractors and their employees to have medium-term visibility with regard to their activity.

c) Describe the measures taken to allow for satisfactory working conditions for contractors. Describe the organisation implemented to provide radiation protection for workers.

d) Describe the procedures for oversight of subcontracted activities, particularly the way in which the operator continues to assume responsibility with regard to nuclear safety and radiation protection.