

Updating WENRA Reference Levels for existing reactors in the light of TEPCO Fukushima Dai-ichi accident lessons learned

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Executive summary

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As requested by WENRA, its Reactor Harmonisation Working Group (RHWG) reviewed the 2008 version of the WENRA reference levels (RLs) for existing reactors in the light of TEPCO Fukushima lessons learned. This review covered the whole set of RLs, taking into consideration recommendations and suggestions published by ENSREG as a result of the complementary safety assessments performed in Europe following the TEPCO Fukushima Dai-ichi accident as well as IAEA safety requirements being under updating for the same reason and the conclusions of the 2nd Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety.

As a result of its review:

- For approx. half of the issues, there have been either no or only very limited changes.
- The issues where there have been the most significant changes are:
 - issue A (Safety Policy);
 - issue C (Management System). RLs relevant to safety culture have been introduced;
 - issue E (Design Basis Envelope for Existing Reactors);
 - issue F (Design Extension of Existing Reactors). Design extension conditions have in particular been introduced for consistency with IAEA SSR-2/1 safety standard, as well as the need for independent and diverse heat removal means, one being effective for natural hazards exceeding the design basis;
 - issue LM (Emergency Operating Procedures and Severe Accident Management Guidelines);
 - issue N (Contents and Updating of Safety Analysis Report);
 - issue O (Probabilistic Safety Analysis);
 - issue P (Periodic Safety Review);
 - issue R (On-site Emergency Preparedness);
- A new issue (Issue T), dedicated to natural hazards, is established. This issue has a strong interface with issues E and F.

In many cases, changes have been introduced to explicitly take into account spent fuel storage, sites with multiples reactors, actual conditions at the site resulting from an accident (including those which may be caused by a natural hazard), conditions more severe than the ones considered in the design basis of the plant or the need to ensure relevant equipment or facilities will remain unaffected so that foreseen actions to respond to an accident can be implemented.

RHWG is currently developing guidance documents on issues E/F and on issue T.

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Purpose of the report

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The goals of the report are to summarize:

- the process followed by RHWG to review WENRA reference levels (RLs) for existing reactors (January 2008 version) in the light of TEPCO Fukushima lessons learned;
- the main conclusions of the review.

The proposed set of RLs, updated accordingly, is not included in this report and is submitted in a separate document at www.wenra.org.

RHWG believes that the RLs have reached the stage of development where they should be made available for stakeholder consultation, prior to their finalization.

02

Historical background and context

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02.1 Developing WENRA Reference levels for existing reactors (2000-2008)

With the view to increase harmonisation within WENRA countries, as a result of efforts initiated in 2000, WENRA published in 2006 a set of **Reference Levels (RLs)** for reactors in operation at that time in WENRA member countries. The process for their development and the boundary conditions are described in detail in the January 2006 RHWG report¹. In particular:

- Given WENRA members' responsibilities, RLs should cover nuclear power reactor safety, excluding radiation protection and physical protection²;
- RLs should not go into legal and technical details;
- RLs should concentrate on safety requirements that are placed by the regulatory regime upon the licensee;
- The safety areas and issues included were selected to cover important aspects of reactor safety where differences in substance between WENRA countries might be expected. They did not seek to cover everything that could have an impact upon safety or to judge the overall level of safety in existing plants;
- As a basis for the RLs, the most recent publicly available edition of the IAEA safety requirements was used. WENRA countries also had an opportunity to propose additional RLs based on national regulations or regulatory guidance.

Following stakeholder comments³, the RLs were updated twice in 2007⁴ (for example, issues E "Design Basis Envelope for Existing Reactors" and F "Design Extension of Existing Reactors" were largely modified) and, again, in 2008⁵ following the publication of IAEA GS-R-3⁶ (issue C "Management System" was significantly modified).

WENRA members committed themselves to reach a harmonised situation for existing nuclear power plants by the end of 2010, using the RLs. In January 2011, WENRA published a status report "Progress towards harmonisation of safety for existing reactors in WENRA countries"⁷.

¹ Report available on WENRA website: http://www.wenra.org/media/filer_public/2012/11/05/rhwg_harmonization_report_final.pdf

² Despite of this goal, at the end of the RLs development process, some radiological aspects have been included in some issues (e.g. design, periodic safety review and on-site emergency preparedness) because they relate so closely to nuclear safety

³ As a result of stakeholder consultation, WENRA received 177 specific comments on the reference levels and 65 comments of a more general nature. Most of the technical comments were received from the European Nuclear Installations Safety Standards Initiative (ENISS), a consortium of European nuclear utilities.

⁴ Report available on WENRA website: http://www.wenra.org/media/filer_public/2012/11/05/list_of_reference_levels_january_2007.pdf

⁵ Report available on WENRA website: http://www.wenra.org/media/filer_public/2012/11/05/list_of_reference_levels_january_2008.pdf

⁶ The Management System for Facilities and Activities Safety Requirements, July 2006.

⁷ Report available on WENRA website: http://www.wenra.org/media/filer_public/2012/11/05/rhwg_report_harmonisation_existing_npps_feb2011.pdf

02.2 Taking into account the lessons from the TEPCO Fukushima Dai-ichi accident

In March 2011, a major nuclear accident occurred at TEPCO Fukushima Dai-ichi nuclear power plant in Japan.

In Europe, the European Commission and ENSREG initiated a targeted reassessment of the safety margins of nuclear power plants, so called “stress tests”. These stress tests were largely based on a specification developed by WENRA. They included a peer review process, performed in the first half of 2012, which resulted in recommendations and suggestions from ENSREG⁸. At a worldwide level, the 2nd Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety (CNS 2012) was held in August 2012 with one objective, to review and discuss lessons learned at that time from the accident at TEPCO’s Fukushima Dai-ichi NPP.

In March 2012, WENRA published a Statement “WENRA Conclusions arising from the Consideration of the Lessons from the TEPCO Fukushima Dai-ichi Nuclear Accident”⁹, which mentioned “*WENRA emphasizes institutional (roles and responsibilities of governments, regulators and utilities) and cultural (continuous improvement) aspects of nuclear safety in addition to technical issues. WENRA is ready to tackle further issues as necessary on the basis of the lessons learned from the Fukushima accident. **WENRA’s commitment is to proceed along the path of defining or revising existing Reference Levels as well as developing guidance documents for practical use by regulators***”;

To this end, WENRA also announced in this statement the creation of several working groups to address technical issues, including to review and revise (or develop) as necessary existing RLs:

- T1 Natural hazards;
- T2 Containment in Severe Accident;
- T3 Accident Management.

WENRA mentioned that “*The results from the stress tests and conclusions from the CNS 2012 will be incorporated as soon as they become available.*”

In addition, on natural hazards, WENRA also specifically decided to develop guidance: “*WENRA will produce updated harmonised guidance for the identification of natural hazards, their assessment and the corresponding assessment for “cliff-edge” (margins) effects.*”

⁸ ENSREG published a compilation of stress test peer review recommendations and suggestions (available on ENSREG website: <http://www.ensreg.eu/NODE/513>)

⁹ Report available on WENRA website: <http://www.wenra.org/archives/wenra-conclusions-arising-consideration-lessons-te/>

03

RHWG process to develop updated RLs

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03.1 Purpose of the review and revision of RLs

The main goals of the review and, where necessary, revision of RLs were to :

- have a full review of all RLs (2008 version) but only in relation to Fukushima lessons learned;
- ensure that RLs were still consistent after the update;
- ensure that RLs were still balanced (high level vs detailed level of expectations).

Consistently with the original scope of the RLs, issues related to malicious acts were not addressed. Similarly radiation protection aspects were not addressed except if they were too closely related to nuclear safety. For example in issue R (on-site emergency preparedness), the TEPCO Fukushima Dai-ichi accident highlighted questions on ability to perform necessary emergency management actions and hence these have been included.

03.2 Inputs for the review of RLs

As a result of the WENRA decision, RHWG was tasked to review and, where necessary, revise or develop new RLs to take into account lessons learned from the TEPCO Fukushima Dai-ichi accident. To perform this task, the inputs were:

- work performed by the IAEA to review and revise Safety Requirements in the light of TEPCO Fukushima Dai-ichi accident (mainly the gap analysis performed to support the definition of IAEA DS462¹⁰ and additional inputs to DS456¹¹ and DS457¹²) as well as conclusions of the 2nd Extraordinary meeting of the Contracting Parties to the Convention on Nuclear Safety;
- compilation of ENSREG recommendations and suggestions¹³ as a result of EU Stress Tests;
- initiatives in WENRA member countries to update national requirements and guidance as a result of TEPCO Fukushima Dai-ichi accident lessons learned;
- WENRA work performed on the safety of new reactors, resulting in the RHWG report "Safety of new NPP designs"¹⁴ and the associated WENRA statement¹⁵;

¹⁰ IAEA Safety Standards preparation profile - Revision by amendment of GSR Part 1, NS-R-3, SSR-2/1, SSR-2/2 and GSR Part 4

¹¹ IAEA Safety Standards preparation profile - Leadership and Management for Safety (revision of GS-R-3)

¹² IAEA Safety Standards preparation profile - Preparedness and Response for a Nuclear or Radiological Emergency (revision of GS-R-2)

¹³ Document available on ENSREG website: <http://www.ensreg.eu/NODE/513>

¹⁴ Report available on WENRA website: http://www.wenra.org/media/filer_public/2013/04/30/rhwg_safety_of_new_npp_designs.pdf

¹⁵ Report available on WENRA website: http://www.wenra.org/media/filer_public/2013/04/05/wenra_statement_newdesigns2.pdf

- WENRA position paper on periodic safety review published in April 2013¹⁶;
- work performed by WENRA T1, T2 and T3 working groups.

03.3 Collective review by RHWG

New or modified RLs were drafted by the various working groups. In addition, some RHWG members also provided drafts. Four RHWG meetings (September 2012, January 2013, May 2013, September 2013) were mostly devoted to the development process, then the collective review of new or modified RLs.

At RHWG meetings, where working groups leaders were welcomed, discussions took place on:

- adequacy of the proposed modified or new RL, especially with regard to lessons learned from the TEPCO Fukushima Dai-ichi accident;
- whether a RL or guidance may be more appropriate (when a guidance document was under development);
- management of interfacing RLs or issues;
- level of detail and balance of proposed RLs;
- direction for further development at the working group level.

During the last two RHWG meetings, re-drafting was also performed to strive towards consensus within RHWG.

The RHWG view is that the draft set of updated RLs is now suitable for stakeholder comments and that such consultation should occur before the draft is finalized and approved by WENRA.

¹⁶ Position available on WENRA website : http://www.wenra.org/media/filer_public/2013/04/05/rhwg_position_psr_2013-03_final_2.pdf

04

Review and revision conclusions, including main changes incorporated in the RLs

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04.1 Issues where no or very limited changes are proposed

Although the review was performed on the 18 issues of 2008 RLs, no or very limited changes were identified in issues B (Operating organisation), D (Training and Authorisation of NPP staff (jobs with safety importance)), G (Safety Classification of Structures, Systems and Components), H (Operational Limits and Conditions), I (Ageing Management), J (System for Investigation of Events and Operational Experience Feedback), K (Maintenance, In-service Inspection and Functional Testing), Q (Plant Modification) and S (Protection against Internal Fires).

04.2 Changes proposed to issue A (Safety Policy)

RHWG proposes to add a new RL on the timely implementation of reasonably practicable safety measures as well as continuous improvement of NPP safety. This new RL widens the scope of application of continuous improvement which was contained within specific issues.

04.3 Changes proposed to issue C (Management System)

RHWG proposes to create a new section (7.) on safety culture. 3 RLs (C7.1 to C7.3) have been developed to express the need for licensees and their contractors to develop and sustain a strong safety culture with emphasis on the role of the management in supporting and demonstrating safety culture.

04.4 Changes proposed to issue E (Design Basis Envelope for Existing Reactors)

Changes to issue E are mainly clarifications, with the exception of changes introduced to highlight the need to consider spent fuel storage safety (E3.1, E9.8, E9.9, E10.1, E10.6) and to address the interface with the new issue T on natural hazards (E5.2).

RHWG proposes new RLs on attributes to support a sound safety analysis (E8.7) and to take into account site-wide issues when several reactors are collocated (E9.5).

The timely implementation of reasonably practicable safety backfitting measures resulting from reviews of the design basis is also stressed (E11.1).

As a guidance document is being developed on issue F (Design Extension of Existing Reactors), the list of transients/accidents to be considered in the design basis, which currently appears in an appendix to issue E, have been deleted to be included in the guidance.

04.5 Changes proposed to issue F (Design Extension of Existing Reactors)

The whole issue F was revisited and its structure was changed. Interfaces with issue E (Design Basis Envelope for Existing Reactors) and the new issue T (Natural Hazards) warranted specific attention, as well as the use of the concept of “Design Extension Conditions” (DEC) as established in IAEA SSR-2/1 safety standard (Safety of Nuclear Power Plants: Design – Safety Requirement 2012).

RHWG proposes RLs which:

- address safety of spent fuel storage;
- clearly express whether they are applicable to DEC involving a severe accident (DEC-B) or to DEC not involving a severe accident (DEC-A);
- clarify how DEC to be addressed in safety analysis will be identified (F2.1 to F2.3);
- explicit goals of DEC analysis as well as attributes of the safety analysis of the selected DEC;
- address adequate qualification and operability of (mobile) equipment used to manage DEC;
- address sites where several reactors are collocated;
- require independent and diverse heat removal means, one of them being effective for natural hazards more severe than the one used for design basis (F4.7);
- address availability of I&C, electric power and control room to manage a DEC (F4.7, F4.16 to F4.18).

A similar RL to E11.1 (F5.1) is also proposed to express the need for regular review of DEC.

04.6 Changes proposed to issue LM (Emergency Operating Procedures and Severe Accident Management Guidelines)

RHWG proposes RLs which:

- address spent fuel storage safety as well as accidents compromising safety of fuel both in the reactor and in the spent fuel storage;
- address sites with multiple reactors, both considering that all units may be challenged or that one unit may support another;
- prioritise relying on adequately qualified equipment for the implementation of SAMG;
- stress the need to carefully consider potential site conditions to ensure measures envisaged in EOP or SAMG can actually be implemented if needed;
- extend training to all licensee emergency response personnel and expect drills to reflect realistic conditions as far as practicable.

04.7 Changes proposed to issue N (Contents and Updating of Safety Analysis Report)

Changes proposed by RHWG are mostly aimed at improving consistency with issue F by referring to DEC, insisting on identification of safety margins (N2.7) and update of information related to site characteristics (N3.1).

In addition, a new RL is proposed (N2.14) to address safety of sites with multiple units.

04.8 Changes proposed to issue O (Probabilistic Safety Analysis)

RHWG proposes changes to O1.1 with respect to how natural hazards are (or not) included in level 1 PSA and to the need to include spent fuel storage in level 1 and 2 PSA.

Furthermore, RHWG proposes to stress the need to consider:

- appropriate mission time for equipment in PSA (O1.4);
- all plant staff and not only control room operators in human reliability analysis (O1.5).

04.9 Changes proposed to issue P (Periodic Safety Review)

RHWG proposes changes to insist on:

- the determination of safety significance of each PSR findings (P3.2);
- the timely implementation of reasonably practicable safety improvements (P1.4);
- the need to identify safety issues which may limit the future safe operation of the plant and measures taken by the licensee to address them (P1.5).

RHWG proposes to clarify the scope of PSR (P2.2) to increase consistency with IAEA SSG-25 safety standard (Periodic Safety Review for Nuclear Power Plants, Safety Guide 2013) and to clarify that interaction between reactors at the same site have to be considered.

Finally RHWG proposes to stress that safety improvements may be needed between PSRs if new safety significant information (e.g. lessons learned from a major accident) becomes available (P2.1).

04.10 Changes proposed to issue R (On-site Emergency Preparedness)

RHWG proposes changes to improving consideration of accidents affecting several reactors at the same site (R1.1, R2.3, R5.4), long lasting accidents (R2.3, R3.2) or events where regional infrastructure might be severely disturbed (R3.6, R3.7).

RHWG proposes also to emphasise the need for effective measures for emergency management. This covers the need for:

- adequate emergency facilities, designed to ensure workers radiation safety and enable emergency management (R4.3);
- appropriate procedures and (mobile) equipment to manage the emergency (R4.4);
- sufficient staff (R3.2) who have been appropriately trained (R5.1, R5.3), including through drills and exercises (R5.4). Where contractors are expected to contribute to emergency management, training requirements are applicable (R5.3);
- measures to accommodate long lasting situations (R2.3, R3.2) as well as the situation where site or regional infrastructure would be severely disrupted (R3.6, R.3.7, R4.4).

The potential use of mobile equipment, its associated storage and its use in drills/exercises are also explicitly covered (R4.4, R5.5).

04.11 New issue on natural hazards (issue T) and new associated RLs

RHWG proposes to create a new issue to address natural hazards¹⁷.

After stating the objective of removing or minimizing the threats from natural hazards to the plant, the proposed RLs cover the screening and assessment of natural hazards which might challenge the safety of the reactor. The RLs within this issue address:

- screening of hazards relevant to the site;
- how design basis events shall be identified. A target of $10^{-4}/y$ for event selection, as well as a 0.1g minimum PGA, are set;
- the need to develop a protection concept to minimize threats to the plant, relying preferably on passive features;
- the consideration of events that may exceed the design basis, to ensure that the design basis chosen is sound and that sufficient margins exist before cliff edge effects may occur.

04.12 Adding a foreword to the Reference Levels

RHWG proposes to include a short foreword to the reference levels, addressing their purpose, the need to consider them as a whole set and some limitations of their scope.

¹⁷ In current RLs, there is already one issue dedicated to a specific internal hazard: fire (issue S).
RHWG Report on updated RLs - November 2013

05 Conclusion

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Current status

In response to the WENRA request, RHWG has performed a thorough review of existing RLs in the light of TEPCO Fukushima Dai-ichi lessons learned, as identified mid-2013, and proposed a new set of reference levels with an additional issue on natural hazards. This would result in a list of 346 RLs, compared to 295 in the 2008 list.

In addition to reviewing the RLs and proposing relevant changes, RHWG is developing guidance document on issues E/F and T. They are currently being further drafted to take into account the latest changes proposed for the RLs.

Next steps

Following WENRA's agreement during the fall plenary meeting 2013, the revised WENRA RLs are now subject to a **3 month consultation period** to allow stakeholders to comment on the proposals before the RLs will be finalized. This will be for the period beginning on **1 December 2013 and ending on 28 February 2014**. Any comments on the proposals should be sent via the "comment" button.