1. Discussion about PATRAM and ICNC meeting

The PATRAM2019 proceedings are now available and the ICNC proceedings are available to registered participants. The Criticality TTEG is a good place to share information about interesting papers from these meetings.

2. UF6 transportation for enrichment higher than 5%

DB made a presentation about this topic. His presentation highlights that a lot of regulations would need to be modified to allow shipment of uranium with enrichment higher than 5% in a 30B cylinder.

For SSR-6, only para. 680(b) for isolated package configuration is impacted. DB asked what the technical basis was for para 680(b). A real technical basis for the limitation of 5% for uranium enrichment is not very clear.

Moreover, there is a general agreement that a lot of questions could be asked:

- Is this limitation a compromise resulting from the need for such transport in the past?
- Is this limitation due to other specific requirements for such packages (e.g., quality control on leak tightness of valve and plug)?
- Why do other fissile materials package designs need 2 high standard water barriers, compared to the exception in para 680(b) for cylinders filled with UF₆?

There is a general agreement that a question should be asked to the TTEG on package performance assessment concerning the last point. This question is in annex 1.

Moreover, DM says that the limitation of 5% for uranium enrichment could be linked to the array configuration justification (for this uranium enrichment, the infinite array configuration is subcritical considering the minimum thickness of 30B cylinder).

This uranium enrichment (5%) is not linked to the uranium enrichment to have a critical configuration considering an infinite amount of dry uranium (~7%).

3. Request from TTEG PPA on defective fuel rods

The experts from the Criticality TTEG discussed the question asked by the TTEG PPA regarding transportation of defective fuel rods. The answer to be sent to the chair of the TTEG PPA is in annex 2. This answer summarizes the discussion during the meeting.

4. E-learning about Fissile excepted material as asked by IAEA during TRANSSC 38
During TRANSSC 38, Steve Whittingham from IAEA asked the Criticality TTEG to prepare a module for the IAEA e-learning platform about fissile excepted material (subparas in para. 417).

This module will be for competent authorities and should not explain all the TB about requirements for fissile excepted material. This module should include paras 674 and 675 of SSR-6 since they were introduced to solve safety issues with some previous provisions for fissile excepted material. A test/exam should be prepared at the end of this module to check if the student understands this module.

The TTEG Criticality output for this topic should be a draft version (PowerPoint presentation). IAEA will rearrange this presentation to follow the format of other modules already created.

During this meeting, MM presented an old presentation which explains the difference about 2009 and 2012 edition of SSR-6 concerning the definition of fissile material (para 222), the fissile exceptions (in para 417) and FISSILE packages exempted from subcriticality demonstration (para 674 and 675). This presentation might help to prepare this module. Moreover, the IAEA-TECDOC-1768 “Application of the Revised Provisions for Transport of Fissile Material in the IAEA Regulations for the Safe Transport of Radioactive Material” is a basis to prepare this module. DI stated that WNTI also created a report on this application of the edition 2012 concerning the fissile exceptions. This report will also help to prepare the module. This report is available on the TTEG Criticality SharePoint site (TRANSSC 39 folder).

DM proposes to prepare a draft version for this module. He will try to prepare this before the end of January 2020. Exchanges about this draft version will happen between February to June 2020 and during the next TTEG Criticality meeting in order to propose a draft version of this module for IAEA during TRANSSC 40.

5. Discussion about the questionnaire

At the end of the TTEG Criticality meeting, 5 answers were received (Spain, France, Denmark, Canada and UK). Perhaps, new answer will be received before the end of the first dead-line (October 31 2019).

The members of the TTEG Criticality are aware that 6 member states are finalizing their answer (Japan, US, Sweden, Germany, Russia and South Africa). WNTI will also answer this questionnaire.

The TTEG Criticality members agreed to post-pone the initial dead-line to December 31 2019.

At the end of this dead-line, MM will upload all answers to the TTEG Criticality SharePoint site (a folder has already been created for that).

After receiving all answers, a draft report will be prepared by France. This draft report will be discussed during the next TTEG Criticality meetings. The final version of this report will be for the TTEG Criticality and will be uploaded on the TTEG Criticality SharePoint.

6. Transport of washed UF₆ cylinders

This is a topic that has been subject to discussions during previous TTEG Criticality meetings.

DM made a presentation about this topic during this meeting.

Some washed UF6 cylinders have a $^{235}$U mass higher than 3.5 g and so could not be classified as fissile excepted as per para 417(c). For these packages, the following solutions are possible:
To use para 417(e) (limitation of $^{235}$U per conveyance at 45 g and transport under exclusive use), but the number of cylinders will be limited, and the transport shall be under exclusive use, which could be a limitation for transport by sea;

- To use para 417(f), but the use of this para requires multilateral approval;

- To use para 674, but the package shall be classified as FISSILE, which adds unnecessary costs to the transport of essentially empty cylinders.

All members of the WG agree that a solution should be found for such transports. Such a solution could be to create a new fissile exception (para 417(g)). In order to do that, 2 ways seems possible:

- To propose a fissile exception based on surface contamination level (400 Bq/cm²). This will apply to excepted packages. Some caution was suggested (DM) since the link between contamination level and fissile nuclide contents could be changed by new processes such as laser enrichment (licensed in the USA).

- To propose a fissile exception based on the principle of the US fissile exception in 10 CFR 71.15(b). But such an exception has been rejected for the 2012 edition. The TTEG Criticality would like to understand the TB for this refusal, before continuing any discussion. Moreover, DB says that 2 NUREG/CRs (NUREG/CR-5342 and NUREG/CR-7239) were published to explain the US fissile exceptions.

Such new proposals for fissile exceptions will be discussed during the next TTEG Criticality meetings.
**Number of Request:** 19-02  
**Date:** 29.10.2019  
**Issued by:** TTEG Criticality  
**Adressed to:** TTEG PPA  
**Classification:** Question  
**Expected response:** statement  
**Para:** 680(b)  
**Keywords:** uranium hexafluoride, criticality safety

**Background:**
SSR-6 Paragraph 680 states that, if a fissile material package design incorporates special features to prevent such leakage of water into or out of certain void spaces, even as a result of error, absence of leakage may be assumed in respect of those void spaces. Paragraph 680(b) further states that, for packages containing uranium hexafluoride enriched to no more than 5.0 mass percent in uranium 235, a special feature can be considered a package where the cylinder valve or plug does not contact any other part of the packaging after the hypothetical accident conditions tests, and the valve and plug remain leak-tight. Other fissile material package designs (e.g., UO₂ powder/pellet packages, fresh and spent fuel packages) are not excepted from the water in-leakage requirement of paragraph 680 unless they meet 680(a), which requires multiple high-standard water barriers which remain water-tight after the hypothetical accident conditions tests.

**Issue/Question:**
Uranium hexafluoride packages, although they have to be tested and shown to be leak-tight, are considerably less structurally robust than other fissile material packages which must consider water in-leakage (i.e., spent fuel packages), and do not have multiple water barriers. From a package performance assessment standpoint, what is the technical basis for the exception in paragraph 680(b) for uranium hexafluoride packages?

**Response:**

**References/Attachments:**

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Due to decommissioning activities in various countries, solutions for transport and storage of defective fuel rods have been developed recently. Package designers provide Inner packages of the dimension of a spent fuel assembly lodgement containing the defective fuel rods. In detail the design concepts differ:
- packages have to be leak tight or not
- packages should be bolted or welded or just closed with sieve or filter
- mixed with regular spent fuel assemblies or not

Issue/Question:
Package designers provide quite different concepts for defective fuel rods in dual purpose casks (DPC) with respect to design and safety justifications. It might be a significant difference, if the fuel rods are enclosed in an inner package which have to be leak tight or if it is introduced in an inner package with sieve or filter at the axial ends to enable pressure release and water flow. Despite the different mechanical and operational aspects, there are also questions raised from the TTEG Package Performance and Assessment with respect to criticality safety:
1) Are there different approaches to criticality safety justifications acceptable or is there a need for harmonisation with respect to defective fuel rods?
2) Are the Transport Regulations sufficiently equipped to address requirements for the package design with respect to defective spent fuel rods?
3) Should any additional guidance be developed for the package design with respect to defective spent fuel rods?
4) Are there any particular design requirements which have to be reviewed by mechanical or thermal assessments with respect to defective spent fuel rods?

Response:
After the mechanical and thermal tests, the condition of the fissile material is very important for the criticality safety experts (the hypotheses for the criticality calculations depend on this condition). For example, the criticality demonstration is very different depending on whether the fissile material remains inside the fuel cladding or not.

Taking into account the results of mechanical and thermal tests, for criticality safety specialists, the condition of a fuel assembly or fuel rods could be divided into 3 categories:
- Intact fuel: rods are not breached and the assembly (skeleton) and rod geometry is not deformed, such that the fuel can fulfil all fuel-specific and system-related functions;
- Undamaged fuel: rods are essentially undamaged (breached to an insignificant extent such that there is no fissile material release, e.g., hairline cracks or pinhole leaks) but the assembly (skeleton) and rods geometry may be deformed (for example, the rod pitch could be modified). The fuel assembly can still be handled by normal means, and can fulfil all fuel-specific and system-related functions;
- Damaged fuel: rods are grossly breached such that fuel particle or pellets can be released, and the fuel cannot fulfil all fuel-specific and system-related functions.
If there is no specific justification for the performance of the fuel (e.g. mechanical and thermal tests, calculation, reasoned argument etc as per SSR-6 para 701), the damaged fuel category should be considered in the criticality safety analysis. This point is consistent with the 2018 edition of SSR-6 (see para 676).

However, the interpretation of the mechanical and thermal test requirements and results could vary between Competent Authorities which could lead to different approaches for the criticality safety analysis. The TTEG criticality questionnaire will help to identify the practices in different member state countries regarding this topic (questions 2.3.a and 2.3.b are on the hypotheses considered after tests).

Nevertheless, the approach for criticality safety analysis in different countries is similar when the fuel category is the same. For example, for the damaged fuel category, the worst credible, criticality configuration considering the available information, will be considered in the criticality safety analysis: the fissile material and water in the configuration (place and form) that leads to the maximum neutron multiplication factor. For packages with multiple high standard water barriers (para. 680 (a)), the amount of water may be limited.

Concerning defective fuel rods loaded inside a box, when the criticality configuration accounts for an unrestricted amount of water inside the packaging cavity, criticality specialists usually consider the same principal hypotheses:
- The hypothesis for the defective rods depends on the fuel category. In most cases, a damaged fuel category is assumed unless there is a demonstration of fuel performance following the HCT tests;
- A different water distribution (e.g. water level and density) may be taken into account inside the box and outside the box (for example, water is in the box and air outside it).

In conclusion, and in order to answer the 4 questions:
- Approaches to criticality safety justifications depend on the evaluation of mechanical and thermal tests. Different approaches are acceptable as a function of the condition of the fuel assemblies or fuel rods as a result of these tests;
- The SSR-6 edition 2018 is sufficiently equipped to address requirements for the package design with respect to defective spent fuel assemblies or fuel rods;
- This answer could be a part of the guidance for the package design with respect to defective spent fuel assemblies or fuel rods;
- No particular requirements have to be added with respect to defective spent fuel assemblies or fuel rods.

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