RECENT ISSUES FOUND IN A DUAL PURPOSE CASK DESIGN

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Several issues were recently found during the design of a new Dual Purpose Spent Fuel Cask. Related to the design, when dealing with several mandatory and/or recommended regulations (national, international), uncertainties, lack of definition on specific design criteria, such us, accident event under storage condition, test temperatures for transport, burnup credit data base, leakage monitoring, used fuel integrity design approach, etc., were found. Apart from design, and based on Ensa's operational experience, several issues in this area were also found. The requirements, responsibilities between stakeholders and acceptance criteria prior cask loading shall be established. For all above mentioned, a unique and worldwide accepted guide should be helpful to avoid gaps, uncertainties and discrepancies in the existing regulations.

I. INTRODUCTION

This paper presents the most recent issues found during the design process of a new Dual Purpose Spent Fuel Cask. The issues provided herein are based on the ENSA's experience in Spain.

A Dual Purpose Cask (Fig. 1) is design to be able to store and/or transport spent nuclear fuel. For this reason, Dual Purpose Casks (hereinafter called as DPC) shall comply with the requirements of both Storage and Transport applicable regulations.

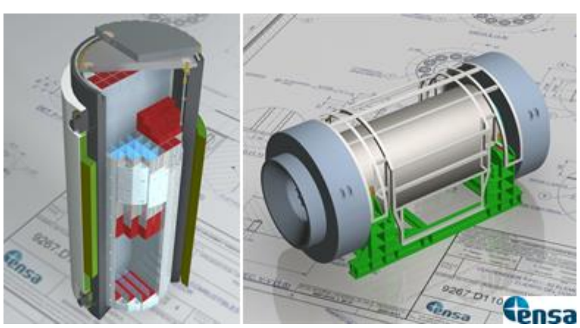

Fig. 1. ENUN 52B Dual Purpose Cask

It is the responsibility of the cask designer to assure that the design is in compliance with the requirements of both regulations, using and/or selecting bounding conditions coming from each application. The existing gaps, uncertainties and discrepancies in these regulations leave on the designer's hands the responsibility to make assumptions that could, sometime, create difficulties in the design and licensing process.

Some countries have their own national regulations, but also rely on regulations/standards from other countries with more experience, and even make these their regulations applicable, together with its local regulations.

Fig. 2. Different Storage (above) and Transport (below) Regulations

The following main regulations are applicable in Spain for DPC (Fig. 2):

1. Storage:
   a. Spain (mandatory): IS-20 (Ref. 1), IS-29 (Ref. 2), RPSRI (Ref. 3) and site-specific regulations.

   b. International (not mandatory but shall be considered): IAEA No. SSG-15 (Ref. 4).

   c. USA (not mandatory but shall be considered): 10 CFR Part 72 (Ref. 5), NUREG-1536 (Ref. 6).

2. Transport:
   a. Spain (mandatory): ADR (Ref. 7), RID (Ref. 8), IMDG (Ref. 9) and CSN Guía de Seguridad 6.4 (Ref. 10).

   b. International (not mandatory but shall be considered): IAEA No. SSR-6 (Ref. 11).

   c. USA (not mandatory but shall be considered): 10 CFR Part 71 (Ref. 12), NUREG-1617 (Ref. 13).

The above mentioned drives into several difficulties when a cask vendor starts a new DPC design. As an example, we can list the following: a) application of several different regulations; b) to establish specific design criteria for both storage and transport; c) to find a bounding condition, which is not always easy; d) existing regulations cover most of the issues, but not all. As a consequence, many of the assumptions to be considered by the designer shall be "at its own risk", with the subsequent uncertainties for licensing acceptance.

II. ISSUES RELATED TO DESIGN

II.A. Storage

The applicable storage regulations listed before provides basically general statements, resting on the designer the responsibility of the interpretation and assumption to be taken, which in most of the cases need to be justified. A few examples are provided here below:

a) When performing the storage thermal evaluation of the cask, the ISFSI site-specific ambient temperature shall be considered. Different type of data from the site should be available, but the key point is to define which of the data is the most appropriate to be considered as the ambient temperature for the thermal evaluation, so, should it be the extreme, maximum daily, maximum monthly, average…?.

   Another external ambient parameter to be considered in the thermal evaluation is the solar radiation. For storage thermal evaluation it is allowed to use the transport requirements per 10 CFR 71 (Ref. 12) or IAEA SSR-6 (Ref. 11) for solar radiation, but also site-specific values are allowed. If so, as for the ambient temperature, it should be the maximum, average…?

   It is important to note that the above boundary conditions will be affected by the ISFSI type (building, open pad) as it can be seen in Fig. 3.

Fig. 3. Building (above) and Open Pad (below)

b) Within the structural evaluation of a DPC, several accidents scenarios are considered in the design during on-site handling, loading and transferring operations. These scenarios are normally based on traditional assumptions (cask drop and tip over – see Fig. 4). Up to now, there are no specific design requirements in the regulations, such as drop height, types, orientations, etc. Additionally to the accident scenarios described before, another open issue when evaluating the accident results is to establish the acceptance criteria. Currently, stress-based acceptance criteria is still applicable, and for some Regulatory Bodies, mandatory. The latest edition of the ASME B&PV Code, Section III, Division 3 (Ref. 14), Subsections WB/WC-3700 includes the strain-based criteria for those cases where a high load is applied to a component in a very short period of time (impact loads). This latest edition of the ASME B&PV Code is still under review by several Regulatory Bodies, so strain-based acceptance criteria may or may not be applicable, depending on the Regulatory Body position.

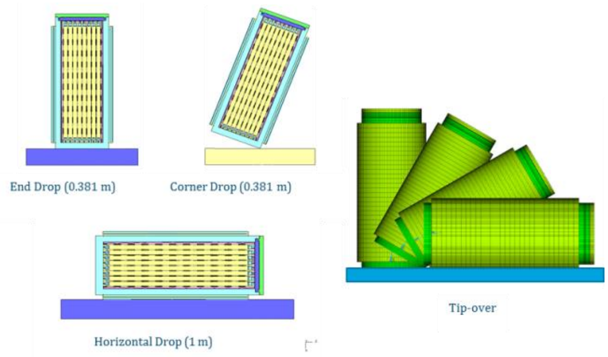

Fig. 4. Traditional Accident Scenarios

c) Another point of discussion between cask designers, Regulatory Bodies and end users is the concept of "retrievability" and "recovery" of the fuel assembly. "*Retrievability" is specified in 10 CFR 72.122(l) (Ref. 5) and requires that storage systems must be designed to allow ready retrieval of spent fuel, high-level radioactive waste, and reactor-related GTCC waste for further processing or disposal. Ready retrieval is the ability to move a canister containing spent fuel to either a transportation package or to a location where the spent fuel can be removed. Ready retrieval also means maintaining the ability to handle individual or canned spent fuel assemblies by the use of normal means. Retrievability applies to normal conditions and off-normal events, and not to design-basis accident events*.

"*Recovery" is the capability to return the stored radioactive material to a safe condition after an accident event without endangering public health and safety. This generally means ensuring that any potential release of radioactive materials to the environment or radiation exposures is not in excess of the limits in 10 CFR Part 20 during post accident recovery operations (see footnote* [*]*).*

It can be seen from these paragraphs that regulations provide definitions and basic or general guidelines to retrieve and/or recover the fuel, but do not provide any criteria (i.e. contact pressure, drag force, etc.)

d) DPC are normally designed to load intact, non-damaged and damaged fuel[15]. Intact and non-damaged fuels have no specific considerations in the design of the DPC, as they have minor or even non influence in the cask safety function. Difficulties start when the DPC has to be design to allow damaged fuel loading. A gap with no specific acceptance criteria, not to the fuel itself, but to the cask safety functions exists. Acceptance criteria will depend on the type of fuel pathology, so a definition of the different pathologies shall be established to cover all damaged fuel types and specific requirements shall be applied to the cask safety functions, based on the fuel pathology.

e) Aging Management Program for the different safety related materials shall be incorporated to the regulations. This program shall clearly identify the scope, aims and actions to be taken by the designer.

II.B. Transport

In the different applicable Transport regulations it can be also found several gaps, uncertainties and discrepancies, which generate during the design process several doubts when deciding the adequate design requirements. A few examples are provided below.

a) Burnup credit application for criticality safety is becoming very popular especially for those DPC designs with high load capacity and for those to apply for moderator exclusion. ISG-8, Rev.3 (Ref. 16) provides the guidelines to perform the criticality safety evaluation considering burnup credit, but the big deal starts when the designer has to define the spent fuel and plant operating data. Several data bases of actinides and fission products have been presented and are available for cask designers (i.e. EPRI, ORNL) to be used in the criticality burnup credit calculations. As these data may or may not be representative from the evaluated fuel type, it cannot be accepted by the Regulatory Body. An international accepted reference data base/s for burnup credit evaluation with bounding conditions should be very helpful for design and licensing purposes.

b) Confirmatory tests are preformed to demonstrate that the design is capable to withstand the required loads under normal condition of transport and mostly under several accident scenarios. One of the confirmatory tests required in the applicable transport regulations[7, 11, 12] is the 9 meter drop corresponding to an accident event (see Fig. 5 next page). Confirmatory tests normally intend to simulate or represent the design conditions, this mean for this particular case, design maximum (hot, +38 ºC) and minimum (cold, -40 ºC) ambient temperatures (same values in all regulations). US NRC Regulation 10 CFR Part 71.73 clearly indicates that the initial condition for the cold test shall be at -20 ºF (-29 ºC). On the other side, International Regulation, IAEA SSR-6, does not specify any initial temperature condition for cold test, but a general statement saying that drop tests shall represent the package design conditions. As indicated in paragraph 653 for normal condition of transport, design conditions are the design ambient temperatures and the heat generated inside the package by the

[*] Extracted from NUREG-1536, Section 12.4.5 (Ref. 6).

radioactive contents (heat load). Interpretation of the initial conditions for the cold test to meet IAEA SSR-6 is open, and depends on the credit to the heat load and the acceptance of this interpretation/assumption by the Regulatory Body. It is important to notice that a cold test that is to be performed at -40 ºC, means that the cask has no spent fuel inside (no heat load), and if an accident occur in this situation it shall not be a safety related accident, while the cask has no radioactive content inside. As for information only, US NRC Regulatory Guide 7.8 (Ref. 17) provides load combinations for the structural analysis of shipping casks for Normal Condition of Transport (NCT) and Hypothetical Accident Conditions (HAC).

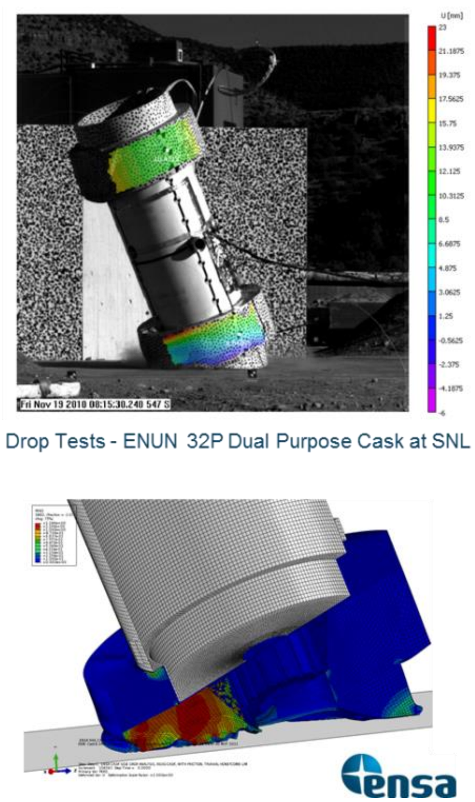

Fig. 5. Confirmatory 9 meter CGOC Drop Test on a 1/3 scale ENSA ENUN 32P cask at SNL

c) Continuing with the Hypothetical Accident Condition 9 meter drop, another important issue which is not included in any of the regulations is the maximum G load that the fuel assembly can withstand after the drop. DPC safety functions need to be assured after the drop, but the response and or status of the fuel is unclear. Document SAND90-2406 (Ref. 18) is still a reference to identify the maximum G load for the fuel. Current analytical tools together with a better knowledge and understanding of the irradiated cladding and hardware material properties will help the designer to assess new engineering approaches for determining the maximum G load for a specific fuel type. A regulatory safety guide with the methodology, fuel material data base and G limits for reference should avoid misunderstanding and will connect the cask safety related functions with the fuel integrity.

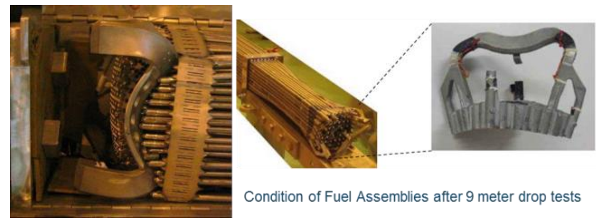

Fig. 6. Fuels Condition after a 9 m Drop

d) Another important point of consideration nowadays is loading of "damaged fuel". Several regulations indicate that all the spent fuels that are to be loaded in a DPC should be capable to be transported just after loading or after a storage period. As explained for storage, spent fuel assembly pathologies shall be identified in order to cover all damaged fuel types (i.e. oxide spalling, hydride effects, mechanical damage). Examples of damaged fuel are shown in Fig. 7. An acceptance criteria to load these damaged fuel types need to be developed and implemented in the regulations. Design requirements for any type of damaged fuel shall directly apply to any of the safety functions of the DPC or it can be only related/applied to the fuel.

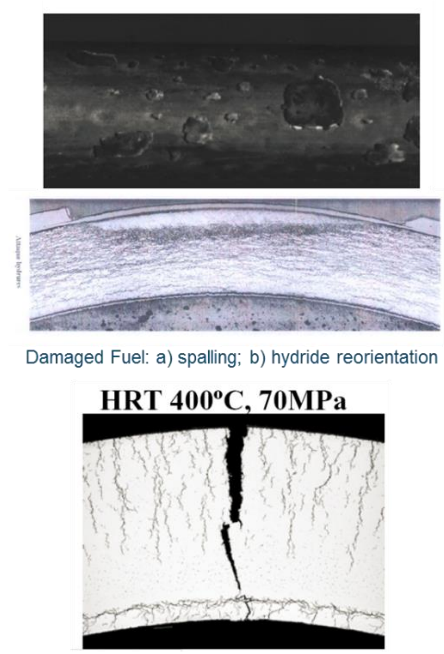

Fig. 7. Damaged Fuel. Different Pathologies

e) As it is used in dry storage to detect any possible leakage in the confinement barrier, monitoring of the interlid region pressure may be required to assure that no leakage will occur in the containment under Normal Condition of Transport (NCT). Although one shipment is not considered as a long term activity, this requirement could be based on the leak tightness concerns due to vibration effects on the closure system (seals aging and bolt relaxation).

II.C. Loading Operation

Based on the experience of Ensa's personnel during annual loading campaigns since 2002 (Fig. 8), when the first two dual purpose metal casks were loaded in Spain, to date with a total of 28 dual purpose metal casks and 14 dry storage concrete modular systems loaded, several observations were found. As a result, modifications on the plant procedures were required to implement the correctives actions derived from these observations.

Fig. 8. Ensa Services Division during Dry Storage Casks Loading Campaigns

A guideline to establish the loading procedures and acceptance criteria (other than spent fuel loading identification and verification) shall be developed and implemented into the current regulations. Some of the activities that should be considered, but no limited to, are the a) verification of the proper assembly of the different cask items before loading; b) to assure the availability of the spare parts on time and c) verification of the functionality of the different loading fixtures.

III. CONCLUSIONS

As indicated along this paper, dual purpose casks shall comply with the storage and transport regulations, and sometimes even from different countries. For this reason, design requirements may be different, so the definition of the bounding conditions is not always an easy job for the cask designer.

As it is obvious, all storage and transport design requirements cannot be included in the regulations, so this leaves in the designer's hands the final decision and responsibility of the different assessments and engineering approaches on the cask final design, creating in some cases conflicts during the licensing process.

To avoid gaps, uncertainties and discrepancies in the existing regulations, a unique guide for Dual Purpose Casks design should be very helpful, including as much clear and detailed information as possible.

To conclude, it is important to mention that programs such *ESCP (Extended Storage Collaboration Program)* leaded by EPRI, US NRC and DOE or the *International Workshop on the Development and Application of a Safety Case for Dual Purpose Casks for Spent Nuclear Fuel*, leaded by the IAEA, are becoming necessary and really helpful to close these gaps, and in general, the concerns and lack of knowledge or understanding in several areas of the dry storage and transportation of spent nuclear fuel.

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