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Development of Specific Requirements for the Transport of Large Components

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ABSTRACT

There is an increasing demand in many countries for transporting large radioactive objects, such as equipment from decommissioning or refurbishment activities at nuclear facilities (steam generators, pressurizers, reactor pressure vessels and heads, coolant pumps, etc.). However, many nuclear reactor components are difficult to package because of their large size and weight, making it challenging or impractical to meet standard packaging requirements. This often requires them to be shipped under special arrangement.

Over a hundred shipments of these types of components from replacement or dismantlement of nuclear facilities have been conducted under special arrangement around the world. Many countries have gained experience with the transport of these large components and this paper will outline the experience acquired, focusing on the regulatory challenges associated with these shipments. Technical, economic and social aspects related to these shipments are also discussed.

The advisory material from the IAEA Regulations includes specific guidance for the transport of large components under special arrangement. However, as experience with this type of transport has grown and is becoming more routine, specific regulatory requirements are needed to allow the movement of large radioactive objects without the need for special arrangement. A set of standard provisions for transport of large components, based on the IAEA "performance package" concept, are being developed for possible incorporation into the international regulations. The approach to the development of such international regulations is discussed, and specific provisions for the shipment of large components are proposed.

INTRODUCTION

Decommissioning or refurbishment of nuclear facilities necessitates either the storage or disposal of large radioactive components such as steam generators, pressurizers, reactor pressure vessels and heads, and coolant pumps, to list the major contributors. These components or objects are large in size and mass, measuring up to approximately 6 meters in diameter, up to 20 meters in length, and weighing over 400 000 kg. In many situations, the components are transported off-site to a storage, disposal or recycling/treatment facility. In some cases they may be transported unpackaged within the precepts of the current IAEA Transport Regulations [1], such as if they can be shown to meet the requirements for a low level Surface Contaminated Object (SCO-I) or Low Specific Activity (LSA-I) object, as specified in paragraph 520 of the Regulations. However, as is often the case, they cannot be transported unless they are either further decontaminated or packaged in some way.

While it is often apparent that many large components contain only surface contamination, it is not easily demonstrated that the SCO limits for inaccessible areas could be met due to non-uniform contamination deposition; nor can the interior areas be readily surveyed without dismantling the object. A steam generator, for instance, has thousands of small diameter tubes that are difficult, if not impossible to access. Decontamination of such large components also presents problems. Where there are issues with access, worker exposure can be increased, contrary to the As Low As Reasonably Achievable (ALARA) radiation safety principle for minimizing radiation doses and releases of radioactive materials.

Packaging of large components to meet standard packaging requirements can also be challenging or impractical due to their size and weight. Although many large objects are generally robust in design and construction due to their use as pressure vessels under other codes, the current regulations require packages that meet tests such as for stacking and free drop that pose significant engineering challenges and prohibitive costs. The physical drop test of a steam generator, for instance, would require a facility with specialized equipment (towers, lifting, drop surface), while a computer simulation of the drop test would require specialized software (finite element, dynamic analysis) and extensive analysis, both of which can be costly. Another option is to dismantle or segment the components in order to use a standard package configuration within the regulations, but this often requires specialized equipment and again can increase exposure to workers. It can be very costly to design and build such process equipment to limit the release of radioactive material from the cutting/dismantling of the component.

Decontamination, designing and fabricating an overpack, or developing segmentation operations and equipment to minimize exposures, can all be expensive options for the industry. As a result, because the IAEA regulations do not have specific provisions to deal with large components, large components are often shipped under special arrangement on a case by case basis. As the volume of these components being transported increases, and industry experience correspondingly grows, it is time to look at including provisions for them in the regulations as these shipments are no longer “special”, but increasingly “routine”.

SPECIAL ARRANGEMENT

In the last 50 years, the transport of radioactive material, with the exception of some used fuel and nuclear waste shipments, has remained in relative obscurity when it comes to the realm of public interest and concern. Only a few shipments out of the millions that take place every year have been the subject of protest or public demonstrations, mostly attributed to anti-nuclear sentiment rather than concern over transportation safety. However, with the advent of the Internet and greater accessibility to information, the public has begun to show greater scrutiny towards the transportation activities associated with the use of radioactive material. More frequently, the safety of transportation is questioned and debated in the various public fora [6].

The “special arrangement” type of shipment tends to attract the most public attention, primarily by virtue of its name alone. The name “special arrangement” is often interpreted by the public to mean that the shipment has a lesser degree of safety than that of other shipments of radioactive material, or that some kind of special “deal under the table” was made between the regulator and the shipper leaving the impression of a disregard for safety. Although a “special arrangement” is intended for one-of-a-kind shipments, where the normal requirements of the regulations cannot be met, it must be scientifically shown that the method of shipment provides an equivalent level of safety in consideration of regulatory requirements. This type of shipment was meant to give flexibility to consignors and to satisfy the existing and changing needs of industry. It has in many instances had the opposite effect because of the increased public attention it attracts, triggering public hearings and media coverage which ultimately delay or stop shipments which have been shown to be safe and approved by the competent authority.

The advisory material from the IAEA Regulations includes specific guidance for the transport of large components under special arrangement. However, as experience with this type of transport has grown and is becoming more routine, specific regulatory requirements are needed to allow the movement of large radioactive objects without the need for special arrangement. With such provisions in the regulations, the public will be more likely to focus on and understand what the risks actually are and how they are mitigated. Improved communications will allow the industry and competent authorities to operate more effectively and efficiently, while also meeting their responsibility to disseminate timely scientific, technical and regulatory information to address the public's fears and concerns.

INDUSTRY EXPERIENCE AND FUTURE NEEDS

Industry experience with decommissioning and transport of large components has grown. To date, about 100 mines, 90 commercial power reactors, 45 experimental or prototype reactors, as well as over 205 research reactors have been retired from operation [2]. Many countries, including, Belgium, France, Germany, Spain, Sweden, the United Kingdom, the United States [3], as well as Canada [4], have experience in the management and transport of large components. Over a hundred shipments of these types of components from replacement or dismantlement of nuclear facilities have been conducted under special arrangement around the world. In general, most of the shipments of large objects have been for steam generators, simply because there are usually more of these at a reactor site than pressure vessels. Pressure vessels also present more of a challenge for shipment as they are more highly activated.

The IAEA Power Reactor Information System [5] indicates there are currently 434 operational reactors worldwide, with the age distribution shown in the Figure 1 below.

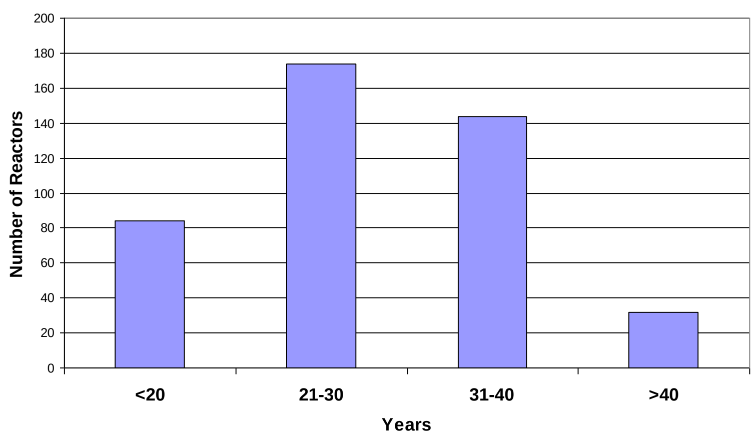

Figure 1: Age Distribution of Operational Reactors Worldwide

The above statistics indicate that in the next 15 to 20 years there will be a number of reactors reaching the end of their design life, which is typically 30 to 40 years. In the near future, therefore, there will be a large number of reactors that will be undergoing either decommissioning or refurbishment to extend their lifetimes, which will likely require the transport of many large objects. Provisions in the transport regulations for transport of large objects should be developed now in preparation for these shipments.

PROPOSED REGULATIONS

A set of standard provisions for transport of large components or objects as surface contaminated objects (new SCO-III category), based on the IAEA "performance package" concept, have been developed and submitted as an issue for possible incorporation into the SSR-6 Regulations [1] and advisory material. Led by Canada, many member state and industry representatives were involved in the development of these requirements for large objects and for their submission as an issue to the IAEA for possible inclusion into the Regulations. The contributions of the following individuals are greatly acknowledged and appreciated:

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The SCO category was chosen as the most logical place to insert requirements for large components or objects. The term "large object" was therefore selected to be more general in the definition and to align with the SCO terminology.

The key proposed changes to the regulations are described below. New or reviewed text proposed to be added to the regulations is shown in blue. Note that these proposed provisions do not include components such as reactor vessels at this time, due to the more limited experience and greater radioactivity levels with these components. Specific provisions to cover reactor vessels and other similar objects may be proposed in the future, once more international experience is gained in transporting such items.

Add to Section II Definitions

Large object

Large object shall mean a solid object which is contaminated with *radioactive material* and because of its size must be transported unpackaged.

Modifications to Section IV Activity Limits and Classification

- Table 1, change UN 2913 PROPER SHIPPING NAME and description to;

  "RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I or SCO-II or SCO-III), non fissile or fissile-excepted[b]"

- 413. *SCO* shall be in one of three groups:

  (a) *SCO-I*… (as is)
  (b) *SCO-II*…(as is)
  (c) *SCO-III*: A *large object* for which:

(i) All openings are sealed to prevent release of *radioactive material* during routine conditions of transport;
(ii) The inside of the object is as dry as reasonably achievable;
(iii) The *non-fixed contamination* on the external surface does not exceed the limits specified in para. 508;
(iv) The *non-fixed contamination* plus the *fixed contamination* on the inaccessible surface averaged over 300 cm^2 does not exceed 8×10^5 Bq/cm^2 for beta and gamma emitters and *low toxicity alpha emitters*, or 8×10^4 Bq/cm^2 for all other alpha emitters, unless it can be demonstrated that, in accident conditions of transport, the activity intake by a person in the vicinity of the accident does not exceed $10^{-6}A_2$ or a corresponding inhalation dose of 50 mSv.

Modifications to Section V Requirements and Controls for Transport

- 517. The quantity of *LSA material* or SCO in a single *Type IP-1*, *Type IP-2*, *Type IP-3 package*, or large object, object or collection of objects, whichever is appropriate, shall be so restricted that the external *radiation level* at 3 m from the unshielded material or object or collection of objects does not exceed 10 mSv/h.

- 520. *LSA material* and *SCO* in groups *LSA-I*, ~~and~~ *SCO-I* and *SCO-III* may be transported, unpackaged, under the following conditions:

  (a) through (d) as is; …
  (e) For *SCO-III*;

    (i) Transport shall be under *exclusive use* by road, rail or vessel;
    (ii) Stacking shall not be permitted;
    (iii) The requirements of para. 624 for a *Type IP-2 package* shall be satisfied, except that the "maximum damage" requirement of para. 722 may be met using orientation restrictions specified in the transport plan (para. 8X2(d)), and the requirements of para. 723 are not applicable.

- 522. The total activity in a single hold or compartment of an inland waterway craft, or in another *conveyance*, for carriage of LSA *material* or *SCO* in a *Type IP-1*, *Type IP-2*, *Type IP-3 package* or unpackaged, shall not exceed the limits shown in Table 6. For SCO-III, the limits in Table 6 may be exceeded provided it can be demonstrated that, in accident conditions of transport, the activity intake by a person in the vicinity of the accident does not exceed $10^{-6}A_2$ or a corresponding inhalation dose of 50 mSv.

Add to Section VIII Approval and Administrative Requirements

APPROVAL FOR LARGE OBJECT SHIPMENTS

8X1. Each *consignment* transported as a *large object* shall require multilateral *approval.*

8X2. An application for *approval* of *large object shipments* shall include:

(a) A detailed description of the proposed *radioactive contents* with reference to their physical and chemical states and the nature of the radiation emitted;

(b) A detailed statement of the *design* of the *large object*, including complete engineering drawings and schedules of materials and methods of manufacture;

(c) All information necessary to satisfy the *competent authority* that the requirements of para. 520(e) and the requirements of paras. 413(c)(iv) and 522, if applicable, are satisfied,;

(d) A plan covering all activities associated with the transport, including radiation protection, emergency response, and any special precautions or special administrative or operational controls which are to be employed during transit;

(e) A specification of the applicable *management system* as required in para. 306.

8X3. Upon *approval* of *large object shipments* the *competent authority* shall issue a certificate of *approval*.

Modifications to the Advisory Material (DS425)

- Remove paragraph 310.15 and distribute the applicable guidance to the appropriate paragraphs of the Regulations above and remove any references to special arrangement.
- Remove Appendix VII and distribute the applicable guidance to appropriate paragraphs of the Regulations above and remove any references to special arrangement. Note that in many cases the guidance currently in Appendix VII has been moved to the proposed Regulations above and may be removed altogether. Also note that guidance should be added for paragraph 413 above indicating that contamination on the inaccessible surface may be determined by conservative estimates and/or analysis by methods other than direct contamination measurements.

CONCLUSION

There has been an increasing demand in many countries for transportation of large radioactive objects. Many large objects must currently be transported under special arrangement. However, as experience with this type of transport has grown and is becoming more routine, specific regulatory requirements are needed to allow the movement of large radioactive objects without the need for special arrangement. A set of standard provisions for transport of large components are being developed for possible incorporation into the international regulations. These have been submitted as part of the current review cycle for the 2012 Edition of the IAEA Transport Regulations [1].

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