Transport of Large Objects and Special Arrangement

Dedicated to the safe, efficient and reliable transport of radioactive materials
Transport of Large Objects and Special Arrangement

Background

Due to routine generation of clean electricity from nuclear power stations, various kinds of equipment are contaminated and activated. This equipment has to be treated, stored and discharged for disposal or recycling in a responsible and environmentally sensitive way at the end of their operational life. This equipment includes large objects (large components), such as reactor pressure vessels and steam generators (typically, over 20 metres long, 300 tons)[1]. Recently, the transport of large objects has been steadily increasing because of the decommissioning of nuclear power stations or replacing equipment for the extension of their operational life. For example, in Southern California, Edison transported used steam generators to the disposal site in Utah in August 2011[2], and three steam generators from Sweden’s Ringhals nuclear power plant were transported to Studsvik’s plant for decommissioning and recycling in January 2012.[3] In the U.K., two used boilers (21 metres long, 5 metres wide and weighing in at 310 tons) from the Berkeley Magnox power plant were transported to Sweden for decommissioning and recycling in March 2012[4].

Furthermore, it is predicted that the demand to transport large objects from various nuclear fuel cycle facilities for equipment replacement, decommissioning, disposal or recycling will increase[5].

However, such impressive and high-profile transports are sometimes faced by strong opposition from the public even when the relevant Competent Authorities have approved them. For example, in Canada, Bruce Power’s plan to transport 16 decommissioned steam generators from Canada to Sweden for recycling was forced to be cancelled in 2012 due to strong opposition from the public and local communities both in Canada and the U.S. even though the transport had been approved by the Canadian competent authority as being transportable under “Special Arrangement”[1][6].

An Example of Transport of Decommissioned Steam Generator [1]

1 It’s referred to as “Special Permission” in the U.S. and Canada
Introduction

The transport of radioactive material is regulated by national and international modal regulations based on the International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material a.k.a Transport Regulations (the latest version is SSR-6\(^7\)). Generally, radioactive material is packed inside a packaging (e.g. drum, freight container or cask) which satisfy the requirements of the SSR-6 according to their radioactivity and chemical/physical properties. Previously, used radioactive large objects were usually treated and their size reduced into smaller pieces, packed into a number of packagings onsite (at the nuclear power plants or the fuel cycle facilities), then transported off site to disposal or recycling facilities. However, this size reduction and packing may increase exposure of workers and risk of radioactivity release. Therefore, some large objects have been transported directly to disposal or recycling facilities without onsite dismantling or size reduction.

Intensive discussion on such transport had been conducted in the last review cycle of the IAEA Transport Regulations and a new guidance for the transport of large objects was included in the new Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (TS-G-1.1)\(^8\).

This WNTI fact sheet introduces how to transport large objects under the SSR-6 including categorisation, transport under Special Arrangement and discusses the new guidance and good practices from a practical point of view. However, activated large objects such as reactor vessels, which are categorised as Low Specific activity material (LSA), are not considered in this document at this stage because of its additional complexity.

Surface Contaminated Object (SCO)

A Surface Contaminated Object (SCO) is defined as a solid object which is not itself radioactive but which has radioactive material distributed on its surfaces, and also has limits for the radiation level and total radioactivity (SSR-6, paras 412 to 414). This means a SCO essentially has a very limited risk, and is further classified as SCO-I or SCO-II according to the surface contamination level.

The SCO can be transported by an Industrial Package (IP). Three types of industrial packages (Type IP-1, Type IP-2, Type IP-3) are defined (SSR-6, para. 231), which differ by their capability to withstand damage as specified by the Regulations. SCO-I and SCO-II should normally...
be packaged in Type IP-1 and Type IP-2 respectively. However, SCO-I can be transported unpackaged under certain conditions (SSR-6, para. 520). If an object is categorised as SCO-I, then stacking and free drop tests are not required because it is transported unpackaged (see WNTI fact sheet Package types used for Transporting Radioactive Materials).

However, Type IP-2 packages are required to undergo a drop test (SSR-6, paras 624 and 722).

SSR-6 para. 722.
Free drop test: The specimen shall drop onto the target so as to suffer maximum damage in respect of the safety features to be tested:

If an object is 20 m long, vertical drop tests (an end of the object is lifted vertically and dropped from more than 20m) should be taken into account as to cause maximum damage. However, such vertical drop seems unrealistic and alternative ways can be applied.

**Special Arrangement**

Special Arrangement is sometimes used for the transport of large objects, as previously mentioned. It has been a concept in the IAEA Transport Regulations for a long time which allows transport of unusual consignments that cannot satisfy all the applicable requirements of the regulations, without reducing the safety.

SSR-6 para. 310.
Consignments for which conformity with the other provisions of these Regulations is impracticable shall not be transported except under Special Arrangement. Provided the competent authority is satisfied that conformity with the other provisions of these Regulations is impracticable and that the requisite standards of safety established by these Regulations have been demonstrated through means alternative to the other provisions, the competent authority may approve special arrangement transport operations for single or a planned series of multiple consignments. The overall level of safety in transport shall be at least equivalent to that which would be provided if all the applicable requirements had been met. For consignments of this type, multilateral approval shall be required.

The concept of Special Arrangement is intended to give flexibility to consignors to propose alternative safety measures that are effectively equivalent to those prescribed in the SSR-6. Special Arrangement is based on the requirements that the overall level of safety resulting
from additional operational controls must be shown to be at least equivalent to that which would be provided by all applicable provisions. As such, it is obvious that there is no compromise of safety in the concept. Furthermore, each Special Arrangement must be specifically approved by all Competent Authorities involved.

**Direct Transport of Large Objects**

By nature of their past use, large objects usually have limited amounts of contamination on the inner surface. Typically, each object is so large that it is unrealistic to pack them into a packaging as it is, but it usually has a robust outer shell which will allow transport and act as packaging. The outer shell can confine the inner radioactive contents by welding or bolting to close off all shell openings, therefore the risk of release of radioactive contents can be reduced to a point where they can be transported without harm to the public and the environment. It is reasonable to transport large objects directly in some cases.

These large objects can be categorised as SCO due to the inner surface’s radioactive contamination, though some chemical and/or physical decontamination of the inner surface is generally conducted at the end of their service life. However, the categorisation of the level of SCO is not always easy because it is sometimes difficult to demonstrate the precise inner contamination level, especially if the object has inaccessible surfaces or a complicated internal structure. In the case of steam generators, decontamination is difficult for plugged (blanked) tubes and the contamination conditions differ from one tube to another. It may be necessary to remove some tubes from the object and conduct direct measurements of the inner surface contamination level in order to demonstrate the validity of any decontamination and estimate the object’s remaining inner contamination. However, the work to remove certain parts of the object is not easy. As such, an evaluation method has been developed for determining the inner contamination level using the combination of exterior dose rate measurements (taken from outside the object) and detailed calculations.

Furthermore, the conveyance and handling devices, including the cradle and tie down system, should be designed carefully based on the potential events through the total transport route and handling procedures.

Although the free drop tests, including the vertical drop test, should be taken into account as to cause maximum
damage, vertical drops are impractical for the large objects (e.g. boiler units which are 21 metres in length\textsuperscript{(4)}). It should be recognised that it is very unlikely that one end of the object can be lifted over 20 meters high during transport operations including loading and unloading. In this context, a Special Arrangement can be applied for the transport of large objects. For example, instead of satisfying the requirements for the vertical drop tests, the handling procedures can impose lifting height limits during the transport which are then approved by all Competent Authorities involved under the SSR-6.

Although the Regulations have prepared the Special Arrangement concept for unusual transports including the transport of large objects, to obtain the Special Arrangement approval is difficult and time-consuming because some Competent Authorities do not have enough experience in shipping large objects and the specific provisions for Special Arrangement are not adequately addressed in their national regulations.

Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (TS-G-1.1)

To date, nearly 100 transports of large objects have been conducted under Special Arrangement all over the world\textsuperscript{(8)}. Based on this experience, new IAEA guidance has been developed by the Member States and industries to assist consignors and Competent Authorities in preparing and assessing applications for Special Arrangement for the transport of large objects. This new guidance “Guidance for Transport of Large Components under Special Arrangements” is added as Appendix VII of the new Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material TS-G-1.1.

The guidance provides an introduction, scope of large objects, the basic safety concept based on the Q system\textsuperscript{2}, recommended criteria to approve Special Arrangement for the large objects transport and a specific example of safety requirements for a large object transport in Germany. The recommended criteria and technical basis are summarised in Table 1 of this fact sheet. The guidance will enhance common understanding for the transport of large objects under Special Arrangement by both Competent Authorities and the industry.

\textsuperscript{2} Q System was developed to establish a radioalogical basis for the SSR-6 and the detail is shown in Appendix-I of TS-G.1.1
Conclusion

Due to the increase of decommissioning and the replacement of the large objects to support extended operation of nuclear power plants and nuclear fuel cycle facilities, it is expected that the transport of large objects will increase steadily. It is reasonable to transport them directly for disposal or to recycling facilities for safety reasons. However, due to the very nature of large objects, they cannot be transported within the general scope of the Regulations (SSR-6) and therefore these transports have to be conducted under Special Arrangement. As there are additional operational controls imposed to satisfy the safety and approval by the Competent Authorities in the transport under Special Arrangement, safety is not compromised. Furthermore, IAEA guidance has been developed for the transport of large objects under Special Arrangement in TS-G-1.1. It is expected that the guidance enhances the understanding of the transport of large objects under Special Arrangement among all stakeholders including Competent Authorities and industry.

Future Work

A new proposal for the transport of large objects was submitted from Canada in the IAEA review cycle of the SSR-6 (2012) and the discussions on its applicability have started. The WNTI has participated to the discussion and is encouraging industry to feedback its industrial experience and expertise into the discussion either directly or through the WNTI. The new provisions may then be added to the future version of the SSR-6 and this fact sheet will be updated accordingly.
References

1. PATRAM 2007, Transport of Two Steam Generators from the Nuclear Power Station Kwo to the Interim Storage Site Of Ewn, Franz Hilbert, Michael Kübel (Nuclear Cargo + Service GmbH), Burkhard Hartmann (EWN GmbH)
5. PATRAM 2010, the Transport of Large Front End Facility Components from Decommissioning Operations, J. Werle
6. Special Form Certificates, CDN/5255/X-96 (Rev.0), Canadian Nuclear Safety Commission

Photographs

1. Going through Berkeley town
2. Transport of an unpackaged steam generator from Chooz A NPP to ANDRA repository site
3. Final boiler being removed from Berkeley nuclear power station
4. Transport of a PWR pressure vessel cover in its packaging
5. Berkeley boiler removal
6. Boilers being removed from Berkeley site in Gloucestershire
## Table 1: Recommended Criteria to Approve Special Arrangement in the New Guidance of the TS-G-1.1

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
<th>Remarks</th>
<th>TS-G-1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>The major percentage of the component’s activity should be due to surface contamination on interior surfaces.</td>
<td>Only SCO material is considered in this guide and the transport of activated components such as reactor vessels are out of the scope of the guidance.</td>
<td>VII.19</td>
</tr>
<tr>
<td>Content</td>
<td>The material should be non-fissile or fissile excepted.</td>
<td>To eliminate the possibility to be critical.</td>
<td>VII.18</td>
</tr>
<tr>
<td>Content</td>
<td>No unnecessary material should be placed in the component.</td>
<td>To avoid extra risk. Inclusion of unnecessary material is prohibited. However, some large components contain smaller components or pipe works within their cavity, as such these have been transported as part of the large component’s structure.</td>
<td>VII.22</td>
</tr>
<tr>
<td>Content</td>
<td>Liquid content should be negligible.</td>
<td>To reduce the risk of radioactivity release. Though a threshold value for dryness is not given, drain out of water, air blow and air ventilation are procedures to dry a component.</td>
<td>VII.23</td>
</tr>
<tr>
<td>Content</td>
<td>The external radiation level at 3m from the unshielded large component should not exceed 10 mSv/h.</td>
<td>It is a limit for SCO in an industrial package.</td>
<td>VII.25</td>
</tr>
<tr>
<td>Potential Risk</td>
<td>The activity intake by a person in accident conditions should be less than an order of $10^{-6}$ A$_{eq}$.</td>
<td>The potential activity intake is equivalent to Type A packages (SCO in an industrial package).</td>
<td>VII.20</td>
</tr>
<tr>
<td>External Dose Rate</td>
<td>The maximum radiation level at the surface should be less than 2 mSv/h.</td>
<td>It is equivalent to the ordinary transport and additional shielding may be effective.</td>
<td>VII.24</td>
</tr>
<tr>
<td>Integrity during transport</td>
<td>The component, including any unpackaged penetrations, openings and crevices, as well as additional shieldings, should be capable of withstanding the effects of any acceleration, vibration or vibration resonance under routine conditions.</td>
<td>It is a basic requirement in the SSR-6 (para. 613).</td>
<td>VII.26</td>
</tr>
<tr>
<td>Item</td>
<td>Criteria</td>
<td>Remarks</td>
<td>TS-G-1.1</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Integrity during transport</td>
<td>The component should meet the IP-2 requirements. If the transport conditions and emergency response plan specifies a stacking prohibition and a component transport orientation restriction, the stacking test and free drop test requirement of the Regulations are not required.</td>
<td>It requires the equivalent safety of IP-2 packages. However, according to the nature of the objects, stacking them may be unrealistic and the transport conditions can effectively prevent the components from dropping or colliding in certain orientations. If so, the stacking test and free drop tests would not be required.</td>
<td>VII.27, 36</td>
</tr>
<tr>
<td>Integrity during transport</td>
<td>The component and any conveyance shielding are secured to the conveyance in accordance with para. 607 of the Regulations and applicable national transport standards.</td>
<td>General requirements for the handling and tie down of packages should be considered.</td>
<td>VII.34</td>
</tr>
<tr>
<td>Transport documents</td>
<td>The transport index (TI), categories, marking, labelling, placarding and consignor’s responsibilities should comply with the Regulations.</td>
<td>Same as normal transport.</td>
<td>VII.31, 32</td>
</tr>
<tr>
<td>Transport documents</td>
<td>A written transport and emergency response plan is used to govern the transport and is approved, as part of the Special Arrangement approval.</td>
<td>Transport and emergency response plans are important.</td>
<td>VII.35</td>
</tr>
<tr>
<td>Transport operation</td>
<td>The contamination of the external surface should satisfy with the limits of the Transport Regulations.</td>
<td>It is a basic requirement in the transport regulations (para. 508).</td>
<td>VII.28</td>
</tr>
<tr>
<td>Transport operation</td>
<td>Only as exclusive use and not by air.</td>
<td>Too large to transport by air.</td>
<td>VII.29, 30</td>
</tr>
<tr>
<td>Transport operation</td>
<td>The radiation levels of means of transport should not exceed the levels specified in para. 573 (b)(2 mSv/h at any point on the outer surfaces of the vehicle) and (c) (0.1 mSv/h at any point 2 m from the vertical planes) of the Regulations.</td>
<td>Large components are sometimes larger than vehicles and the limits for the vehicle are virtually effective.</td>
<td>VII.33</td>
</tr>
</tbody>
</table>