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Fact Sheet

Transport of Unpackaged Surface Contaminated Large Objects

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Background

Due to routine generation of clean electricity from nuclear power stations, numerous types 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]. Similar large objects exist also in the fuel cycle facilities.

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. In contrast, 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 sealing (e.g. welding or bolting) to close off all shell openings. Therefore, the risk of release of radioactive contents can be reduced to a point where it can be transported without harm to the public and the environment. Therefore, and quite reasonably, in some cases, some large objects have been transported directly to disposal or recycling facilities without onsite dismantling or size reduction.

To cope with the regulatory requirements, these shipments of unpackaged equipment had to be carried out using the Special Arrangement procedure.

For the last two decades, the direct 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 United Kingdom, 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]. In France, four steam generators and one pressurizer were transported from Chooz A nuclear power plant to ANDRA's disposal site in 2012 and 2013 [12].

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 United States, even though the transport had been approved by the Canadian competent authority as being transportable under "Special Arrangement"[1] [6].

Therefore, intensive discussions on such transport of unpackaged surface contaminated large objects had been conducted during the two last review cycles of the IAEA Regulations for the Safe Transport of Radioactive Material.

[1] It is referred to as "Special Permission" in the U.S. and Canada

The Regulations have prepared the Special Arrangement concept for unusual transports, including the transport of large objects. To obtain the Special Arrangement approval is a difficult and time-consuming task, as 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. In contrast, at the beginning of the 2010s, about a hundred transports of large objects had been conducted under Special Arrangement all over the world (SSG-26 [8], paras 310.5 and VII.3). Based on this experience, as a first step, 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 surface contaminated large objects. This "Guidance for Transport of Large Components under Special Arrangement" was included as Appendix VII of the Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2012 Edition) (SSG-26) [8] which pertains to the former edition of the IAEA Transport Regulations, i.e. the 2012 Edition of the IAEA Transport Regulations.

Second, a new category of material, the group SCO-III of Surfaced Contaminated Objects (SCO) is now included in the latest edition of the IAEA Transport Regulations, i.e. the 2018 Edition of the IAEA Regulations for the Safe Transport of Radioactive Material (SSR-6 (Rev. 1)) [7]. This new category of material has been introduced in the IAEA Transport Regulations, in order to accommodate the increasing need for the transport of unpackaged surface contaminated large objects, without compromising safety, by embedding these transports completely into the IAEA Transport Regulations, and then circumventing the difficulties with the potential misunderstanding of the concept of "Special Arrangement" by the public.

This WNTI fact sheet shows how to transport unpackaged surface contaminated large objects under the IAEA Transport Regulations, including categorisation, transport either under the classification SCO-III or under Special Arrangement, and discusses the available guidance and good practices from a practical point of view.

Note – Activated large objects such as reactor vessels, which are categorised as Low Specific Activity (LSA) material, are not considered in this document at this stage because of their additional complexity.

Fig 1: Going through Berkeley town

Fig 2: Transport of an unpackaged steam generator from Chooz A NPP to ANDRA repository site

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Regulatory Requirements for the Transport of Surface Contaminated Objects (SCOs) and for Transport under Special Arrangement

2.1 General

The transport of radioactive material is regulated by national, regional and international modal regulations based on the International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material, also known as the IAEA Transport Regulations (the latest version bears the reference SSR-6 (Rev. 1) [7]).

The rules for the classification of radioactive material to be transported are defined in the Section IV of the IAEA Transport Regulations [7]. Guidance regarding classification is also provided in the Schedules of Provisions of the IAEA Regulations for the Safe Transport of Radioactive Material (SSG-33) [10].

In most cases, the IAEA Transport Regulations require the radioactive material to be packaged, and radioactive material is generally packed inside a packaging (e.g. drum, freight container or cask) which satisfies the requirements of the IAEA Transport Regulations, according to their radioactivity and their chemical and physical properties.

Note - Excepted package, Industrial package Type 1 (Type IP-1), Industrial package Type 2 (Type IP-2), Industrial package Type 3 (Type IP-3), Type A package, Type B(U) package, Type B(M) package and Type C package are the eight types of packages defined in the IAEA Transport Regulations (SSR-6 (Rev. 1) [7], para. 231).

This WNTI fact sheet considers surface contaminated large objects, which for activity reasons or for practical reasons (size, mass, operation, etc.) cannot be transported in one of the above-mentioned types of package.

Transport of unpackaged surface contaminated large objects can only take place under the provisions which are applicable to the transport of Surface Contaminated Objects (SCOs), SCO-I or SCO-III, or those which are applicable to Special Arrangement. Therefore, the following summarizes the regulatory requirements which pertain to the transport of Surface Contaminated Objects (SCOs) and to the transport under Special Arrangement, as they are particularly relevant to unpackaged surface contaminated large objects.

2.2 Surface Contiminated 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 has limits for the contamination on the external / accessible surface and on the inaccessible surface, for the total activity of the single object (and also for the collection of objects in a conveyance) and also for the dose rate (SSR-6 (Rev. 1) [7], paras 241 and 412 to 414). This means an SCO essentially has a very limited risk, and is further classified as SCO-I, SCO-II or SCO-III according to the surface contamination level.

These surface contaminated large objects can be categorised as one of the three groups of SCO due to the level of the surface contamination, either directly or after the chemical and/or physical decontamination of the surface which 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. This 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 [9].

The SCO can be transported in an industrial package (IP) or unpackaged. Three types of industrial packages (Type IP-1, Type IP-2, Type IP-3) are defined (SSR-6 (Rev.1) [7], 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, and SCO-III should normally be transported unpackaged. However, SCO-I can be transported unpackaged under certain conditions. **SSR-6 (Rev.1) [7], para. 520, defines the conditions which have to be met to allow a surface contaminated object to be transported unpackaged as an SCO-I or an SCO-III.**

The requirements for SCO-I are defined in SSR-6 (Rev. 1) [7] and pertain mostly to the nature and the level of surface contamination (SSR-6 (Rev.1) [7], para. 413). The complete set of requirements are described in the IAEA Transport Regulations. Valuable guidance is provided in the Schedules of Provisions of the IAEA Regulations for the Safe Transport of Radioactive Material (SSG-33) [10]. The transport of SCO-I is an activity which is routinely performed in the nuclear industry. This is not further developed in this WNTI fact sheet. It can be noticed that the level of contamination which is authorized for the inaccessible surface of an SCO I is generally far below the level of contamination on large objects issued from the decommissioning of nuclear power stations or nuclear fuel facilities, even after the intensive chemical and/or physical decontamination which can be conducted at the end of their service life.

The SCO-III concept was developed for surface contaminated objects with an activity on the inaccessible surface far above the level allowable for SCO-I. To summarise:

- The criteria for the contamination on the accessible surface of an SCO-III are similar to those of an SCO-I, as both can be transported unpackaged.

- The criteria for the contamination on the inaccessible surface of an SCO-III are similar to those of an SCO-II, though the SCO-III can be transported unpackaged whilst the SCO-II has to be transported in a package; this is due to the fact that all openings of an SCO-III are sealed to prevent release of activity: the outer shell can confine the inner radioactive contents of an SCO-III, as the packaging does for an SCO-II.

Type IP-1, SCO-I and SCO-III are not required to undergo a stacking test (for SCO-III, stacking shall not be permitted during transport). Type IP-1 and SCO-I are not required to undergo a free drop test.

SCO-III and Type IP-2 containing an SCO-II are both required to undergo a free drop test. Whilst the drop height for a Type IP-2 is determined solely by the mass of the package, the conditions of the free drop test of an SCO-III may be determined based on provisions in the transport plan (all activities associated with the shipment of an SCO-III shall be described in a transport plan, and the shipment shall be subject to multilateral approval (SSR-6 (Rev. 1) [7], para. 520)).

For Type IP-2, the specimen shall be dropped onto the target so as to suffer the maximum damage in respect of the safety features to be tested; the height of the drop is determined solely by the mass of the package, and shall be between 0.3 and 1.2 m, according to the mass of the package (SSR-6 (Rev. 1) [7], para. 722).

SSR-6 (Rev.1) [7], 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 the package is 20 m long, vertical drop tests (an end of the object is lifted vertically and dropped from more than 20 m) should be done, in order to cause the maximum damage. However, such vertical drop could seem unrealistic and alternative ways could be applied (SSG-26 [8], para. 722.6).

As for SCO-III, although the free drop tests (including the vertical drop test) should be done so as to cause maximum damage, vertical drops are impractical for the large objects (e.g. boiler units which are 21 metres in length [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 transport plan can specify the conditions to be implemented during the shipment and thus be the basis for the approval of the shipment of the SCO-III. For example, instead of satisfying the requirements for the vertical drop tests, the handling procedures can impose lifting height limits during the transport. The conditions of the free drop test of the SCO-III may be determined based on provisions in the transport plan (all activities associated with the shipment of an SCO-III shall be described in a transport plan, which are then approved by all competent authorities involved in the shipment of the SCO-III: the shipment shall be subject to multilateral approval (SSR-6 (Rev. 1) [7], para. 520)).

If the large surface contaminated object cannot meet the requirements applicable to SCO-III, there is still the possibility to transport this object unpackaged, subject to the implementation of the provisions applicable to the transports under Special Arrangement, as described in the next section 2.3.

Guidance for the transport as SCO-III of unpackaged surface contaminated large objects is available in the IAEA Advisory Material [11], including its Appendix VII "Guidance of activity intake for the transport of SCO-III".

Fig.4: Transport of a PWR pressure vessel cover in its packaging

Fig.5: Berkeley boiler removal

Fig 6: Boilers being removed from Berkeley site in Gloucestershire

2.3 Special Arrangement

A 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 and allows transport of unusual consignments that cannot satisfy all the applicable requirements of the regulations, without reducing the safety.

SSR-6 (Rev.1) [7], 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 for a Special Arrangement is intended to give flexibility to consignors to propose alternative safety measures that are effectively equivalent to those prescribed in the IAEA Transport Regulations. A 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 in the transport.

Guidance for transport under Special Arrangement of unpackaged surface contaminated large objects is available in the IAEA Advisory Material [8], and particularly its Appendix VII “Guidance for transport of large components under Special Arrangement”.

The guidance provides an introduction, scope of large objects, the basic safety concept based on the Q system[2], recommended criteria to approve Special Arrangement for the large objects transport and a specific example of safety requirements relating to a large object transport in Germany. The recommended criteria and technical basis are summarised in the Appendix of this fact sheet. This guidance enhances the common understanding for the transport of large objects under Special Arrangement by both competent authorities and the industry.

[2] Q System was developed to establish a radiological basis for the IAEA Transport Regulations and the detail is shown in Appendix I of SSG-26 [8]

03

Conclusion

Due to the increase of decommissioning and the replacement of 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 as outlined previously. However, due to the very nature of large objects, they cannot normally be transported within a package. They generally have to be transported either under the classification SCO-III (where the applicable regulations are aligned with the IAEA Transport Regulations [7]), or to be transported under Special Arrangement. As there are additional operational controls imposed to satisfy the safety and approval by the competent authorities in both instances, safety is not compromised. Furthermore, IAEA requirements and guidance have been developed for the transport of large objects in both the IAEA Transport Regulations and its Advisory Material. It is expected that this will enhance the understanding of how large objects can be transported amongst all stakeholders, including competent authorities and industry.

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Disclaimer

The objective of this Fact Sheet is to provide information to aid users in the preparation of the transport of unpackaged surface contaminated large objects. In the event of a conflict or anomaly between the provisions of the Regulations and this Fact Sheet, the requirements in the Regulations apply. For regulatory purposes, reference should be made to the detailed provisions of the Regulations.

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Appendix

Recommended Criteria to Approve Special Arrangement (SSG-26) and Criteria for a Multilateral Shipment Approval for SCO-III

ITEM	SPECIAL ARRANGEMENT		SCO-III		REMARKS
	CRITERIA	SSG-26	CRITERIA	SSR-6 (REV. 1) SSG-26 (REV. 1)	
Content	The major percentage of the component's activity should be due to surface contamination on interior surfaces. The non-fixed contamination on the external surfaces should not exceed the regulatory levels specified for the external surfaces of any package (4 Bq/cm^2 for beta and gamma emitters, 0,4 Bq/cm^2 for alpha emitters) (para. 508 in SSR-6).	VII.19, 28	The contamination on the inaccessible surface shall not exceed 8 x 10^5 Bq/cm^2 for beta and gamma emitters and 8 x 10^4 Bq/cm^2 for alpha emitters. The non-fixed contamination on the external surfaces shall not exceed the regulatory levels specified for the external surfaces of any package (4 Bq/cm^2 for beta and gamma emitters, 0,4 Bq/cm^2 for alpha emitters) (para. 508 in SSR-6).	413 (c) (iii) and (iv)	Only surface contaminated objects are considered and the transport of activated components such as reactor vessels are out of the scope.
Content			The total activity shall not exceed 100 A_2 (10 A_2 for a transport on an inland waterway), except if the transport plan contains precautions during transport to obtain a level of safety at least equivalent to that which would be provided if the limits had been applied.	522	
Content	The dose rate at 3 m from the unshielded large component should not exceed 10 mSv/h.	VII.25	The dose rate at 3 m from the unshielded large component shall not exceed 10 mSv/h.	517	Limit for SCO unpackaged or packaged in an industrial package.
Content			All openings shall be sealed.	413 (c) (i)	To prevent release of activity during the tests to simulate the normal conditions of transport.
Content	The material should be non-fissile or fissile excepted.	VII.18, 21	The material shall be non-fissile or fissile excepted.	Table 1	To eliminate the possibility to be critical.

ITEM	SPECIAL ARRANGEMENT		SCO-III		REMARKS
	CRITERIA	SSG-26	CRITERIA	SSR-6 (REV. 1) SSG-26 (REV. 1)	
Content	No unnecessary material should be placed in the component.	VII.22			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.
Content	Liquid content should be negligible.	VII.23	The inside of the object shall be as dry as practicable.	413 (c) (ii)	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.
Dose Rate	The maximum dose rate at the surface should be less than 2 mSv/h.	VII.24	The maximum dose rate at the surface of the vehicle shall be less than 2 mSv/h. The transport plan should contain special precautions to ensure workers and public radiation protection.	573 (b) 520.4	It is equivalent to the ordinary transport and additional shielding may be effective. There is no obligation to label an SCO-III. Therefore, the transport plan should contain provisions to ensure that the workers are well-informed of the dose rate in the vicinity of the object, so that they can protect themselves.
Transport operation	The component should be consigned as exclusive use and not by air.	VII.29, 30	The component shall be consigned as exclusive use and not by air.	520 (b), (e) (i)	Too large to be transported by air.
Transport operation			Stacking shall be prohibited.	520 (e) (ii)	To except the SCO-III from the stacking test.
Transport operation	The dose rates around the 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.	VII.33	The dose rates around the means of transport shall not exceed 2 mSv/h at any point on the outer surfaces of the vehicle and 0.1 mSv/h at any point 2 m from the vertical planes.	573 (b), (c)	Large components are sometimes larger than vehicles and the limits for the vehicle are virtually effective.
Transport documents	The transport index (TI), categories, marking, labelling, placarding and consignor's responsibilities should comply with the Regulations.	VII.31, 32	The transport index (TI), categories, marking, placarding and consignor's responsibilities should comply with the Regulations.		Same as "normal" transport.

ITEM	SPECIAL ARRANGEMENT		SCO-III		REMARKS
	CRITERIA	SSG-26	CRITERIA	SSR-6 (REV. 1) SSG-26 (REV. 1)	
Transport Documents	A written transport and emergency response plan is used to govern the transport and is approved, as part of the Special Arrangement approval. Special attention should be paid to the radiation protection programme.	VII.35	All activities associated with the shipment, including radiation protection, emergency response and any special precautions or special administrative or operational controls that are to be employed during transport shall be described in a transport plan. The transport plan shall demonstrate that the overall level of safety in transport is at least equivalent to that which would be provided if the requirements for type IP-2 had been met (with adapted tests to simulate the normal conditions of transport).	525 (e) (iii) 520.4	Transport and emergency response plans are important.
Integrity during transport	The component and any conveyance shielding are secured to the conveyance in accordance with para. 607 of the Regulations (and applicable national transport standards).	VII.34	The SCO-III and any conveyance shielding shall be secured to the conveyance in accordance with para. 607 of the Regulations (and applicable national transport standards).	520 (e) (v)	General requirements for the handling and tie down of packages should be considered.
Integrity during transport	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.	VII.26	The SCO-III, including all sealed 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	520.8	It is a basic requirement in the SSR-6 (para. 613).
Integrity during transport	The component should meet the requirements for a Type IP-2 package. If the transport conditions and emergency response plan specify a stacking prohibition and a component transport orientation restriction, the stacking test and free drop test requirement of the Regulations are not required.	VII.27, 36	The SCO-III shall meet the requirements for a Type IP-2 package except that the maximum damage for the free drop test may be determined based on provisions in the transport plan and that the stacking test is not applicable.	520 (e) (iv)	It requires the equivalent safety of IP-2 packages. However, according to the nature of the objects, stacking them may be unrealistic and / or prohibited and the transport conditions can effectively prevent the components from dropping or colliding in certain orientations. If so, the stacking test would not be required, and the free drop tests may be adapted.
Potential Risk	The activity intake by a person in the vicinity of an accident should not exceed an order of magnitude of 10^{-6} A_2.	VII.20	The activity intake by a person in the vicinity of an accident should not exceed an order of magnitude of 10^{-6} A_2.	520 (e) (iv) 522.3	The potential activity intake is equivalent to Type A packages (SCO in an industrial package).

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