THE TRANSPORT OF LARGE FRONT END FACILITY COMPONENTS FROM DECOMMISSIONING OPERATIONS

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ABSTRACT

The transport of large components from decommissioning operations raises a number of important issues in terms of regulatory compliance, safety and cost effectiveness. Transports under special arrangements are commonly used and are a viable option. However, the general perception of special arrangements needs to be improved. New methods and controls are proposed to facilitate characterisation of the contents and their classification. These new developments could eventually lead to regulatory change. WNTI has contributed largely to the new fissile exceptions being proposed during the 2009 revision cycle of TS-R-1. Many of these proposals have been made from WNTI member companies in order to improve efficiency while maintaining the same high level of safety. The transport of diffusers at the AREVA Georges Besse plant serves as an example to illustrate the practical challenges.

INTRODUCTION

Nuclear fuel cycle facilities as well as nuclear power plants (NPPs) have a limited operational life span and have to be decommissioned when shut down. Nuclear operators then face challenges to find economic and efficient solutions for the dismantling of large components.

In NPPs these are, for example, reactor vessel lids, steam generators or pressurisers. These components are typically very large, heavy and activated. They are normally small in number. By using special arrangements, transport experience was gained in several countries, such as Germany, Sweden and the United States. Common features of these transports were a preference for coastal or inland water transport and that no heavy outer packaging was used.

For the front end of the fuel cycle, some production facilities tend to be bigger in size. This is true in particular for gaseous diffusion enrichment plants. Common features of these plants are that they have hundreds of stages, each one being of significant size. The components are not activated but only surface contaminated and dose rates are very low.

Dismantling this type of enrichment facility takes several years of work on an industrial scale. Thus, the feasibility of efficient and economic transport of large components is a key factor for success in these operations.

ISSUES ENCOUNTERED REGARDING TRANSPORTS OF LARGE COMPONENTS

The transport of large components from decommissioning is one of the topics which are being studied by the WNTI Waste Transport Working Group. The various issues encountered in applying the current regulations to these transports are discussed. Some proposals are made which, while maintaining the same high level of safety, would allow more efficient and cost effective transport to be achieved.

Special Arrangements

Transport regulations cover the vast majority of radioactive material transports, but they cannot cater for unusual transports or newly emerging transport flows. Special arrangements are designed within the regulations to allow these transports.

Special arrangements are well suited (and partly intended) for one-off transports from back-end dismantling activities; for example, steam generators from NPP. Here, a full safety case for each transport has to be prepared and approved by the competent authorities.

When it comes to front-end transport of large components the characteristics are different:

- large components can be quite numerous, but are identical
- they are not activated
- they are either surface contaminated objects or contain LSA material
- some components are "fissile" under current transport regulations
- the dismantling operations on an industrial scale require hundreds or thousands of identical transports. There will be transport operations on a daily basis for nearly one decade.

Can Special Arrangements be used to allow these transports to be conducted safely and cost efficiently? The current TS-R-1 transport safety regulations [1] are perfectly adequate whilst recommending a rather cautious approach. For example, the associated advisory material TS-G-1.1 [2] points out in paragraph 238.1 that "the use of special arrangements should not be taken lightly". On the other hand, the regulations state clearly that special arrangements are just as safe as any other type of licensed transport. So there is nothing really special about them, except in the name.

In the current revision cycle of the transport regulations a new development has taken place. A new dedicated annex has been added to the latest draft of TS-G-1.1. Here, it is clearly stated that the special arrangement process is now recommended for large components transport. This is based on the experience gained from more than one hundred transports of large components all over the world. Whilst most of these transports concerned the back end, the new advisory material states explicitly that front end transports are also covered.

These recent developments are welcomed by industry organizations such as WNTI. This was made possible by:

- an excellent track record of past transport operations worldwide,
- continuous feedback from the nuclear transport industry to the regulator, for example, highlighting newly emerging transport flows which require review of the transport regulations, and
- permanent communication between all stakeholders, whereby WNTI can play a vital role.

An effort needs to be made to improve perception of special arrangements. By showing the excellent past track record and communicating on upcoming, transport operations special arrangements will be regarded in future as rather ordinary. On-site transports of large components under special arrangements will be helpful to gain further experience.

Characterisation and Classification

In the front end of the nuclear fuel cycle the radioactive material is mostly non-irradiated. Uranium with a natural U-235 content of 0.71% is enriched up to 5%. At the same time, depleted uranium is created having a U-235 content in the 0.2% - 0.33% range. In the current TS-R-1 regulations [1] the A2 value for uranium enriched to less than 20% is unlimited. Thus, the uranium can be characterised as LSA-I material (low specific activity). The potentially fissile character of the enriched uranium will be addressed in the next sub-chapter.

Any component which has been in contact with the uranium will only be surface contaminated and not be activated. In most cases there will be only a very thin deposit which is estimated as being under 0.1 mm thick. These components can consequently be classified as SCO-I (surface contaminated objects), since the activity measurements are generally very low.

When it comes to large components several practical issues emerge when trying to characterise the object:

1. The inner surface which has been in contact with the uranium can become very large. So even relatively thin surface deposits can lead to enormous quantities of radioactive material. In many cases the limit for fissile excepted material (15 g) in the 2009 Edition of TS-R-1 [1] is reached and the surface contaminated object has to be characterised as being fissile.
2. Many large components, such as pumps, valves, compressors, heat exchangers or diffusers, have a complicated and inaccessible inner structure. By all practical means it is impossible to realise a physical examination of the interior so as to determine the thickness of the deposits or to find any potential accumulation of material. The consequences are two-fold:
   a) the regulatory requirements for SCO objects are impossible to demonstrate, since surface contamination measurements of inaccessible areas cannot be realised. Thus, a SCO classification of the component is not possible;
   b) alternatively, a characterisation as a low specific activity material could be attempted. However, the regulatory requirement of distributed activity cannot be shown when accumulation of material cannot be excluded.

As a consequence, strict application of the regulations leads to a more severe classification of the component. Without being able to demonstrate the precise nature of the inside of the component, not an Industrial Package, but a type A package, potentially suitable for fissile contents, has to be chosen.

Whilst there are no new apparent safety issues involved with large components, regulatory requirements lead to costly and burdensome transport solutions. It is clear that the current regulations were not created with radioactive material flows from dismantling operations in mind. But does this necessarily mean that the regulations have to evolve and take into account these new flows or is the current framework sufficient?

WNTI and its member companies have expressed frequently the view for stability in the regulations. Thus, any new proposals should be tested within the regulatory framework first, before a change is being proposed. Since standard provisions of the TS-R-1 cannot be used, special arrangements are necessary where real transport experience with these new approaches is sought. The guidance material TS-G-1.1 (§ 310.2) shows the way forward by encouraging the use of new techniques and new controls.

Two proposals are already being tested for on-site transports at the AREVA Tricastin site:

- any object, which is surface contaminated by LSA-I material only, can be automatically transported in the same conditions as a SCO-I. No further measurements (surface contamination or dose rate) are needed
- where an internal physical examination of a large component is not possible, a new external dose rate measurement is proposed. This measurement uses a scanning method covering the complete outer surface. After careful calibration of the tool any accumulation of radioactive material or non-distributed activity in the component (i.e. a hotspot) can be detected. Obviously, the aim is to show the absence of material accumulation and hotspots in order to allow a characterisation as SCO object or LSA material.

Fissile exceptions

Fissile exceptions are certainly the most important issue for the transport of large components from front end facilities:

- Uranium enriched up to 1% of U-235 is fissile excepted. However, nuclear fuel for civil NPP uranium is enriched up to 5% and has to be treated as a fissile material as long as other fissile exceptions do not apply.
- The current limit of 15 grams of fissile material for each package is certainly not sufficient. When it comes to low enriched uranium (e < 5%) the criticality-safe mass is significantly higher.
- Beryllium (Be), as part of a copper alloy, is often used in ordinary components such as washers. However, the mass of beryllium is limited to 1% of the maximum consignment mass, i.e. 1% of 400 grams. For large components, 4 grams of Be are rapidly reached. Whilst the 1% Be-limit may be justified for pure beryllium, this is not the case when it is part of a copper alloy. When the beryllium content in the alloy is limited to 4% the moderating effect of the Be is counteracted by the copper which acts as a neutron poison.

It becomes evident that a significant number of large components need to be characterised as fissile contents under the current transport regulations although there is no scientific need for it.

Fissile contents need to be transported in packages which respect the prescriptions for fissile packages in TS-R-1. These are very severe, such as a 9 meter drop test and a 800°C 30 minute fire. Typical fissile packages are very heavy and massive. It is common to have a ratio of payload to total mass of one to ten. As an example, for a typical diffuser weighing 40 tons a hypothetical fissile package would be in the 400 tons range. This type of transport solution is clearly not optimum in terms of cost and efficiency. There is no gain in safety either, since the contents are not really fissile.

From a transport logistics and safety point of view this type of transport is clearly very challenging and potentially risky.

Strategically, it is preferable to classify the contents as “non fissile” or “fissile excepted”. Alternatively, the criticality assessment needs to show that the contents are intrinsically safe. Thus, industrial packages become the most viable option in terms of transport safety and efficiency. Similarly, the draft of the 20XX edition of TS-G-1.1 proposes an IP-II packaging for large component transports.

WNTI has an ongoing TS-R-1 industry working group which is representing the industry perspective while being an official observer to the Transport Safety Standards Committee (TRANSSC) of the IAEA. Several proposals were made for the 2009 revision process of TS-R-1 and the associated advisory material. Experts from the WNTI member companies provided additional expertise to substantiate the views. While the revision process is still ongoing, it seems likely that some of the proposals will be included in the future 20XX edition of TS-R-1.

Good candidates are the following new or modified fissile exceptions:

- new UN number for LSA-I fissile material
- copper-beryllium alloys with a beryllium content of up to 4%
- new table giving the maximum fissile mass as a function of enrichment. For typical enrichment values of the nuclear fuel cycle (e < 5%) the maximum fissile can be up to 1000 grams of U-235 instead of 15 grams per package and 400 grams per consignment
- approvals for fissile material excepted by the competent authorities.

All of the potential modifications to TS-R-1 and the advisory material will help the nuclear transport industry considerably, while maintaining the same high level of safety.

On-site versus Off-site transports

The decision whether dismantling can be completed off-site or has to be carried out on-site will be based on the availability of viable transport options.

On-site transport regulations are not the same compared to transports in the public domain. In any case the same high level of transport safety is required from the competent authorities and all stake holders. This is especially true when it comes to radiological protection and criticality matters.

However, on-site transports have several advantages:

- there is no general public
- there is (usually) no other traffic
- transport itineraries are known and potentially dangerous points can be avoided
- transport conditions in general and, compensatory measures in particular, can be put into place effectively and can be completely controlled
- transport personnel can receive expert training, exceeding the requirements of TS-R-1, (paragraphs 311 to 315), when necessary
- emergency services are specially trained and can intervene very rapidly

- emergency response procedures are in place and have been tested

As a consequence, special arrangements for on-site transport should be obtained more easily from the competent authorities while maintaining the same high level of transport safety and security.

EXAMPLE: TRANSPORT OF DIFFUSERS FROM THE AREVA GEORGES BESSE ENRICHMENT PLANT

The Georges Besse enrichment plant at the Tricastin site in France owned by AREVA has been in continuous operation since 1978. One thousand four hundred gaseous diffusion stages are used to enrich natural Uranium hexafluoride (UF6) up to 5% in U-235. It will come to the end of its scheduled lifespan within the next few years.

Decommissioning and dismantling operations are being prepared at the moment. They will commence immediately after the end of commercial enrichment so as to keep the main part of the current workforce in place.

The enrichment facilities will be emptied from its UF6 by consecutive mechanical and chemical rinsing processes. Thus, most components will only be slightly surface contaminated when dismantling starts. The decision whether dismantling may be conducted off-site or has to be carried out on-site will be largely dependent on viable transport options. Even on-site transports may not be practical so that the dismantling facilities might have to be built within the current buildings. Obviously, this is a strategic decision which has to be taken a long time in advance and where transport is the key decision factor.

Table 1 gives an overview of the number and size of the diffusers to be dismantled:

Table 1. Large components at the Georges Besse plant

	Diffuser "UFE" with its support	**Diffuser "UTG" with its support**	**Diffuser "USG" with its support**
Quantity	280	400	720
Length	3 730 mm	5 000 mm	6 900 mm
Width	3 000 mm	3 830 mm	6 102 mm
Height	9 900 mm	11 100 mm	12 440 mm
Total volume	110 781 dm^3	212 565 dm^3	523 771 dm^3
Total mass	18 110 kg	40 000 kg	87 000 kg
Surface in contact with uranium	133 m^2	225 m^2	358 m^2
Estimated uranium mass after rinsing	4.5 kg	10 kg	19 kg
Estimated fissile mass (U-235)	225 g	320 g	475 g

Figure 1 shows an illustration of a diffuser. It is interesting to compare its size to the individual next to it.

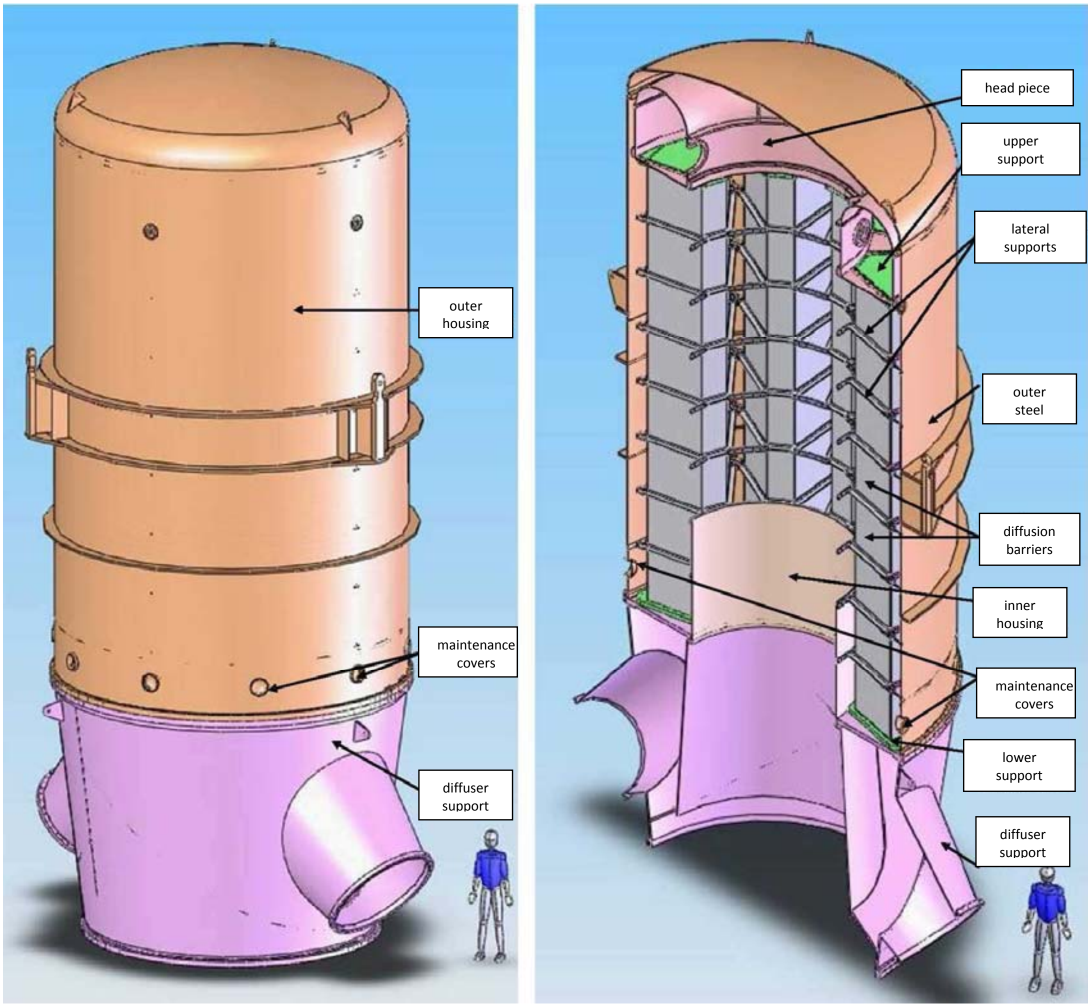

Figure 1. USG diffuser from the AREVA Georges Besse plant

It is obvious that these diffusers cannot be packaged in any reasonable way. The outer housings of the diffusers are made of solid steel which can be used for confinement. There is practically no contamination at the outside and only surface contaminated components on the inside. Enrichment can be higher than 1%, thereby not permitting the use of the corresponding fissile exceptions. Also there is a significant amount of beryllium present, notably in washers made from a copper-beryllium alloy (Be content of 2% max.). Consequently, the contents have to be considered as being fissile.

The overall surface which has been in contact with the UF6 is also given in Table 1. Even after the rinsing the remaining mass of uranium is sufficiently high, so that the maximum mass for fissile excepted contents cannot be met.

Under current regulations these transports would have to be packaged using an industrial package Type IP-II design for fissile material. Instead, a special arrangement will be applied for using the transport arrangement shown in Figure 2.

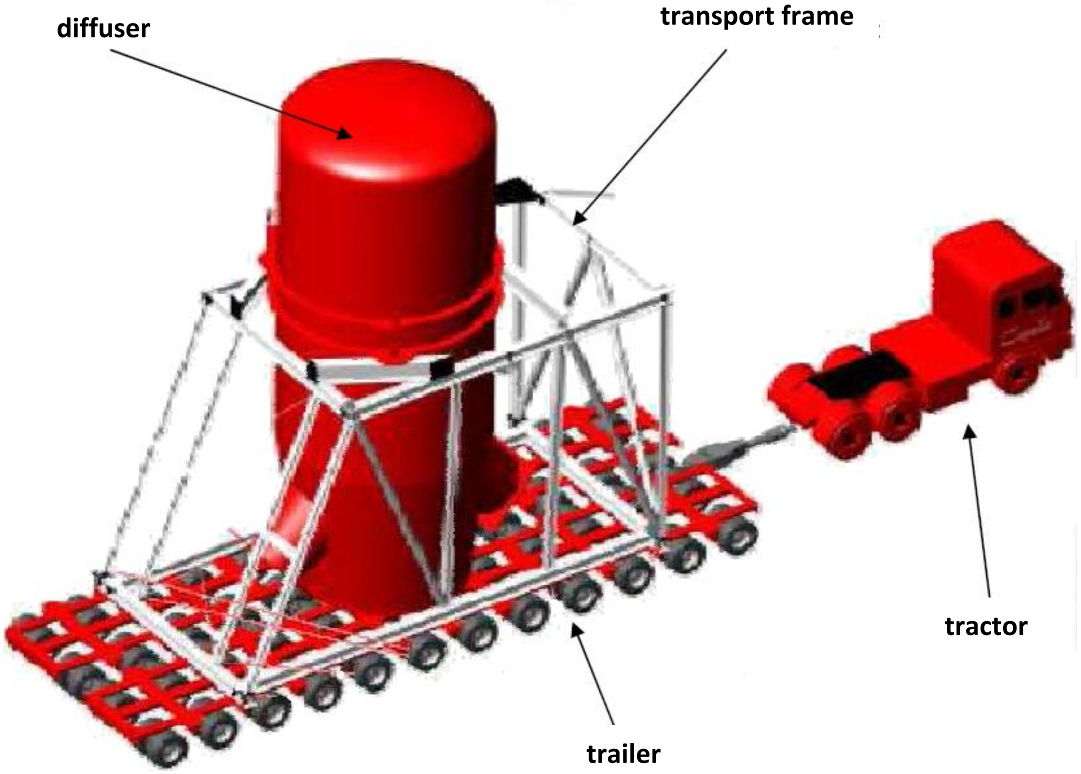

Figure 2. Equipment used for the transport of diffusers.

CONCLUSIONS

The issues raised by the transport of large components from decommissioning operations are clearly explained. With the changes to the regulatory framework underway, some of the criticality issues will be resolved soon. With regard to characterisation and classification, new techniques and new controls are proposed to overcome some of the difficulties. Special arrangements will be used more commonly which should improve their public perception. On-site transports are a viable option to gain valuable experience for future developments. The involvement of WNTI has been essential in obtaining the current results and its future involvement will be crucial for the nuclear transport industry in order to promote safe and efficient transports.

ACKNOWLEDGMENTS

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REFERENCES

[1] Regulations for the Safe Transport of Radioactive Material (2009 edition), TS-R-1, IAEA, Vienna.

[2] Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, TS-G-1.1 (Rev. 1), IAEA, Vienna.