Proceedings of the 15th International Symposium on the
Packaging and Transportation of Radioactive Materials
PATRAM 2007
October 21-26, 2007, Miami, Florida USA

BEST PRACTICES IN MINIMISING SURFACE CONTAMINATION: A DISCUSSION OF BRITISH ENERGY'S OPERATIONAL EXPERIENCE WITH IRRADIATED FUEL TRANSPORT FLASKS

Richard James CEng MIMechE and **Julian Robertshaw** CEng MIET
British Energy, Gloucester, UK

ABSTRACT

British Energy and its predecessor companies have been transporting irradiated fuel in specifically designed transport flasks between nuclear licensed sites within the UK since the 1960s. Minimising external contamination on fuel flasks has always been a high priority and sometimes a challenging task. This was particularly so around the turn of the century when the UK nuclear industry was tasked with addressing, and correcting, an increase in the number of flask contamination occurrences. This was tackled on several fronts, one of which was to identify and implement best practice. This has been formulated into a best practice guide, the principles of which are relevant to all fuel flasks, not just British Energy's. These principles, listed below, are discussed.

- Ensure flask surface finish is kept in good condition
- Minimise pond activity and immersion time
- Ensure the flask is physically clean before placing in the pond
- Pre wet the flask before placing in the pond
- Hand towel immediately after removal from the pond
- Wash in warm water using an approved decontaminant
- Rinse after drying and towel dry
- Minimise cross contamination possibilities
- Survey the flask prior to despatch, trend survey results
- Minimise the time between survey and despatch
- On arrival survey the flask with minimum delay
- On arrival dry swab the correct area using light finger pressure
- Investigate contamination incidents and trend near misses
- Ensure the staff are trained and familiar with the requirements
- Ensure that staff and management are clear of the priorities, standards and expectations

Operational experience since the introduction of the best practice principles has been good, with a significant reduction in the number of contamination events. The main conclusion is that "Following the agreed process and ensuring the flask is despatched clean is more important than ensuring that the flask catches the scheduled train". This needs to be the clear expectation that is set and taken into account when developing performance indicators.

INTRODUCTION

British Energy and its predecessor companies have been transporting irradiated fuel transport flasks between nuclear licensed sites within the UK since the 1960s. British Energy currently operates 7 Advanced Gas Reactors (AGRs) and 1 Pressurised Water Reactor (PWR) within the UK and generates approximately 20% of the electricity. The PWR fuel is long term stored at the station whereas AGR fuel is sent to Sellafield in Cumbria for reprocessing or long term storage. The latest design of irradiated fuel transport flask, the AGR Mk A2 design of fuel flask was introduced in 1992. To date nearly 5,000 loaded flask movements have been undertaken with this flask design together with a similar number of unloaded flask movements. The average distance of each journey is about 200 miles (320 km) and each journey takes 1 or 2 days. Thus AGR A2 flasks have been transported in total about 2,000,000 miles (3,200,000 km). The flasks are expected to remain in service until at least 2025.

Minimising surface contamination on fuel flasks has always been a high priority and sometimes a challenging task. To assist, a best practice guide has been developed, the principles of which are relevant to all fuel flasks, not just British Energy's. This best practice guidance was originally developed on the basis of research undertaken in the 1960's and 1970's but has been significantly refined as a result of operational experience.

Figure 1: Train transporting an A2 fuel flask under covered rail flatrol

The AGR Mk A2 irradiated fuel transport flask is a 50 te cuboid flask. Both the body and lid are manufactured from a single carbon steel forging. The majority of the flask surface is painted with a specially formulated paint that aids contamination control, the remainder being clad in stainless steel. A photograph is given below. There are 31 AGR Mk A2 flasks in service and they are used to move fuel from the AGR power stations to Sellafield for reprocessing or long term storage. The standard payload is 770 kg of spent fuel. The flasks are wet loaded (ie placed into a fuel pond) at 5 of the power stations and dry loaded at 2 power stations. The flasks are unloaded dry at Sellafield.

Figure 2: An AGR Mk A2 Irradiated Fuel Flask being handled at a railhead

BEST PRACTICE GUIDE TO MINIMISE CONTAMINATION

These principles of the best practice guide are listed below and are discussed in the paper together with an explanation of their importance.

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- Minimise pond activity and immersion time
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- Pre wet the flask before placing in the pond
- Hand towel immediately after removal from the pond
- Wash in warm water using an approved decontaminant
- Rinse after drying and towel dry

- Minimise cross contamination possibilities
- Survey the flask prior to despatch, trend survey results
- Minimise the time between survey and despatch
- On arrival survey the flask with minimum delay
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- Investigate contamination incidents and trend near misses
- Ensure the staff are trained and familiar with the requirements
- Ensure that staff and management are clear of the priorities, standards and expectations.

Ensure flask surface finish is kept in good condition

The majority of the AGR Mk A2 flask surface is painted with a 6 coat paint, the top 2 layers being polyurethane based. It is these top 2 layers which provide the majority of the protection and minimises contaminants, particularly soluble radionuclides such as caesium, being absorbed into the paint as fixed contamination. Such radionuclides can potentially become loose contamination if they are subsequently leached out of the paint by water. This can be a particular problem with discharged flasks because there is no heat load and condensation can readily arise during transport. Damage to the paint finish can occur as a result of handling the flask and it is important that any damage is promptly rectified. Wear to the top coats of paint also occurs over time, mainly from the repeated washing and swabbing. Operational experience has shown that each flask requires the paint to be completely removed, which is done by grit blasting, and repainted every 3 years. This period represents about 30 to 40 loaded flask movements and a similar number of unloaded movements.

The stainless steel surface on the fuel flask also needs to be kept as smooth as possible because very small scratches and other features can act as traps for contamination.

Minimise pond activity and the immersion time

The main source of contamination on irradiated fuel transport flasks is from pond water. It is thus extremely important to maintain the ponds as clean as possible. Typically the activity in the AGR ponds is between 50 and 200 MBq/m^3, the main radionuclides being similar to those found in PWR ponds (Cs 134, Cs 137, Co 60, Mn 54). The pond activity needs to be frequently monitored because if the pond activity is high then extra cleaning operations may need to be undertaken on the fuel flask.

The immersion time in the pond is equally important. AGR power stations have a target maximum immersion time of 4 hours. This is more reliably achieved if the flask is only loaded into the pond when all the resources to load the fuel and remove the flask from the pond are in place. Typically flasks are only handled on “day” operations and thus the target time is more likely to be achieved if the flask is loaded at the start of a shift. If the target time is exceeded then extra cleaning operations are undertaken.

Ensure the flask is physically clean before placing in the pond

A physically clean flask will pick up significantly less contamination when placed into a fuel pond compared to a dirty or grimy flask. The flask should therefore be washed clean to remove any road and rail grime before being placed into a fuel pond.

Pre wet the flask before placing in the pond

Pre-wetting a flask can significantly inhibit the take up of contamination into / onto a flask when it is immersed into a fuel pond. During pond immersion the clean water tends to stay within any microscopic scratches in the stainless steel and contaminated pond water absorption into damaged areas of paint is minimised. To maximise the benefit of pre-wetting the flask should be wet when loaded into the pond, this is why this recommendation is not the same as cleaning the flask before being placed into the fuel pond.

Hand towel immediately after removal from the pond

The surface of a loaded fuel flask is usually fairly warm, typically 35°C – 50°C. If the flask is allowed to stand the pond water on the wet fuel flask will evaporate off leaving the contaminants behind on the dry fuel flask. Immediate hand towel drying of the flask removes the pond water with the associated contaminants.

Wash in warm water using an approved decontaminant

Extensive studies have been undertaken on the decontamination factors of various decontaminants. The performance varies depending of the nature of the contamination eg whether it is alkali or acidic based, however all commonly used decontaminants work significantly better compared to demineralised water. The temperature of the water is also important. Washing in warm water (40°C to 45°C) will typically double the decontamination factor of a decontaminant compared to washing in cold water (15°C to 20°C).

Rinse after drying and towel dry

It is important to rinse a flask after cleaning in order to remove all of the decontaminant from the flask. If decontaminant is left on a flask it may continue to turn fixed contamination, which is absorbed into the paint, into loose contamination on the surface. The flask is therefore rinsed with clean water.

Minimise cross contamination possibilities

Cross contamination, particularly after the flask has been radiologically monitored needs to be prevented. There are many cross contamination possibilities. Two of particular note are:

(i) The crane bale arms, grapple and rope which are immersed in the fuel pond to remove the flask from the pond but are also used to load the flask onto the rail or road transporter after final monitoring. Cross contaminations from the crane is often associated with contaminated crane lubrication oil.
(ii) Any surface which the flask is placed upon prior to final despatch, the flask feet being particularly prone to cross contamination.

In recognition of the fact that the flask feet can be a potential source of cross contamination to the conveyances on which the flasks are transported footplates are used, and they in turn are enclosed within a disposable polythene wrapper – a simple bag that is monitored and renewed after each journey.

Survey the flask prior to despatch, trend survey results

Within British Energy flasks are despatched only when the loose contamination is less than 50% of the IAEA limits. Reviews have shown that:

(i) The lower the level of loose surface contamination on a flask prior to despatch the less likely it is to arrive with enhanced levels of contamination.
(ii) The easier a flask is to clean to pre-despatch levels of loose contamination the less likely it is to arrive with enhanced levels of loose surface contamination.
(iii) Trending the pre-despatch levels of contamination can be used to reveal any shortfall in the flask handling process, allowing remedial measures to be undertaken before the deficiency leads to a contamination occurrence. The trending takes the form on summating the activity on each of the final pre-despatch monitoring swabs and trending in chronological order. Examples of shortfalls identified this way have been: insufficient water temperature; insufficient decontamination agent; and, insufficient cleaning prior to ponding.

Minimise the time between survey and despatch

Within British energy final pre-despatch monitoring is required to take place within 96 hours of the flask being sent off-site. This is important to minimise the time for any residual fixed contamination to become loose contamination. It is also difficult to demonstrate compliance with IAEA regulations if the pre-despatch survey is undertaken many days prior to off site despatch. In practice most British Energy flasks are surveyed the day before site despatch.

On arrival survey the flask with minimum delay

The arrival survey must be carried our as soon as practicable, failure to do so potentially results in enhanced levels of surface contamination being discovered that were not actually present in the transport period. Within British Energy the transport duration is typically 1 or 2 days. Thus if the arrival survey is delayed for a week, say, and moisture is gradually causing fixed contamination to become loose contamination, then there is a potential for reporting higher levels of contamination that actually existed during the period of shipment.

On arrival dry swab the correct area using light finger pressure

Observations have been made on operators undertaking swabbing as part of arrival surveys for determining levels of loose contamination. Typically an operator swabs a considerably larger area than the specified 300 cm^2, sometimes up to double. Also the assumed “pick-up” factor is based upon light finger pressure and some operators have been observed to use considerably higher levels of pressure.

Clearly both the above will result in recording higher than actual levels of loose surface contamination. This is highly undesirable because it is important to manage by fact, and it could result in investigating and reporting a contamination event that never actually occurred.

Investigate contamination incidents and trend near misses

All contamination events must be investigated. This involves recording the radionuclides involved, undertaking a more comprehensive survey of the whole flask, and examining the flask for any evidence that may explain the contamination event. Examples of evidence are: moisture, oil staining, road / rail grime, poor paint condition. The investigation must also review the pre-despatch documentation, for example, to determine if all the best practice recommendations had been followed at the despatching site.

Ensure the staff are trained and familiar with the requirements

It is essential that all personnel working on fuel flasks have been trained and are familiar with the requirements for minimising loose surface contamination. This is particularly so after changes are made to the flask handling process. It is equally important to accurately document the procedure; within British Energy the requirements are documented in the package operation and maintenance manual for the fuel flask.

Ensure that staff and management are clear of the priorities, standards and expectations

This is one of the most important recommendations. The management expectations need to clearly identify that minimising loose surface contamination is the main priority and to ensure that this is clearly communicated to all staff. More importantly management need to ensure that no other edict, initiative, or key performance indicator inadvertently undermines this message.

Within British Energy, shortly after privatisation, the organisation became more commercially focused. As a result of this one of the performance measures for the despatching site was whether the flask was despatched on the planned train slot, because each cancelled train slot cost incurs a financial penalty. At the time flasks contamination was well controlled and so not considered an issue. Consequently the personnel involved in flask handling at the despatching sites had mixed messages: one part of the company was measuring flask train cancellations and another part of the company was measuring flask contamination events. Given that an individual flask contamination event was very unlikely this led to a temptation to focus more on catching the train and less on flask cleanliness. This was rectified but the message is beware of how your key performance indicators interact with each other.

Other operational experience

A number of other interesting findings or observations have been made which are worthy of reporting:

- The 2 dry loading stations (where the flasks are not placed in the fuel ponds) have lower levels of contamination but cleaning is still needed.
- Discharged flasks (flasks empty of fuel being returned to the power station) are still as prone to surface contamination as fuelled flasks. Indeed discharged flasks, which are cold, are more prone to condensation which can act as a mechanism for causing fixed contamination to become loose surface contamination.
- There is no significant variation in contamination performance over the calendar year (ie no seasonal variation).
- It is of benefit to protect the road transporters and rail flatrols from direct contact with the flask feet. Steel plates covered with disposable or washable bags are used to form a barrier between flask and conveyance.

- Regular and open communication with the competent authority (regulator) based upon the principal of "no surprises" is beneficial to promoting a culture of trust when solving any problems.
- Peer reviews by flask operators from one station on another are very useful in highlighting best practices and areas for improvement.
- Good facilities and maintenance of the plant involved in flask handling make it easier for the operators to perform their job requirements and reinforces management expectations in this area.

FLASK DESIGN

When designing a new radioactive materials transport package, particularly a package such as a fuel flask which will be placed into fuel ponds, place a high priority on eliminating features that may cause problems in minimising surface contamination. The AGR fuel transport flask primary design aim was to survive accident conditions considerably greater than the IAEA regulatory limits (a 36 metre drop test onto a regulatory target and 60 minute, 925^{o}C fire) and to minimise operator dose rates. Whilst highly laudable these design aims, in conjunction with the available package envelope (to fit on the rail network and in the existing pond handling facilities), led to features on the flask which are not conducive to minimising surface contamination. Examples of such features are: a recessed lid, cavities just under the flask surface (containing thermal insulation and neutron shielding), exposed or recessed features such as lid chocks, and various bolts.

CONCLUSIONS

It is concluded that following the best practice guidelines does significantly assist in minimising loose surface contamination on fuel flasks. The most important factor is ensuring that the management expectation of "Following the agreed process and ensuring the flask is despatched clean" is maintained and is not diluted by other initiatives or key performance indicators.