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Solutions to waste problems in hot cells

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Abstract

The small but significant amounts of radioactive waste arising from hot cell environments are never likely to be entirely eliminated, but with operational care, consideration of the consequences and forward planning, they can be minimised.

The application of non-destructive techniques would appear to offer one of the best solutions to minimising waste production, but where this is not possible then segregation at source helps to reduce the subsequent problems of waste management.

Agreed policies on waste treatment and the provision of standard packaging will greatly assist in ensuring that the wastes can be readily removed from the hot cells and in a condition suitable for interim storage, prior to eventual disposal.

INTRODUCTION

In the UK, radioactive waste is currently classified into 3 categories, high, intermediate or low level. These classifications have been discussed and quantified in various assessments[1,2] and their use would appear to be largely influenced by the major wastes producers, fuel reprocessing and reactor operations. The term high level refers exclusively to the highly active raffinates from fuel reprocessing which contain predominately fission products and are currently stored in special tanks at the reprocessing site. It is intended that they will eventually be vitrified for disposal.

The majority of other wastes arise as solids, albeit in a variety of chemical and physical forms, and are differentiated as being intermediate or low level by the latter having an activity limitation of 4 GBq/t α and 12 GBq/t $\beta\gamma$. Such low levels, although possibly requiring packaging, do not require shielding during normal handling and transportation. Having therefore established the higher and lower levels it is fairly obvious that the intermediate level covers a wide variety of waste, both in terms of type and activity.

Reprocessing plants and reactor sites have known waste streams with each individual waste being produced in sufficient quantities[3] to warrant the development of readily acceptable routes and techniques for handling, packaging and storage. Some typical intermediate level wastes from reprocessing and reactor operations with an estimate of their arising in 1985 are given.

Typical wastes	Arising in 1985. m^3	
	Reprocessing	Reactor
Fuel element cladding debris	350 (Magnox)	-
Sludges, resins and concentrates	450	120
Plutonium contaminated materials	750	-
Filters	-	-
Miscellaneous solid wastes	20,000	5,300
Miscellaneous redundant items	250	700
Miscellaneous irradiated components	-	230

In contrast to the above the hot cell facilities used for post irradiation examination (PIE) and chemical analysis tend to produce relatively small amounts of waste but of a wide variety and rarely on a reproducible or routine basis. Consequently the removal of waste from these hot cells can create greater problems for waste management in terms of treatment,handling and packaging, prior to storage or disposal.

Minimising waste from hot cells

The obvious solution to any waste problem is not to create it in the first instance but when such an ideal is not possible then the alternative is to minimise the production. Much of the waste from hot cells arises from the contamination of the equipment and components that are required for use in the working environment. Therefore, in addition to ensuring that the sources of radioactivity are the smallest necessary for the work, the contents of the working environment should be limited and it could be beneficial to use only the minimum volume for containment.

The minimum volume containment is advocated in order to prevent the spread of contamination and hence the production of yet more waste. Most of the existing hot cells are based on the use of standard master-slave manipulators and therefore the working volumes are relatively large. However provision can be made for additional internal containment to be accommodated. The choice of containment is not always dictated by the nature of the work being undertaken but by the availability of suitable equipment and the current state of the art in remote handling.

For at least the last two decades there has been a growing awareness of the problems that contamination can create and so a deliberate attempt has been made to develop and apply non-destructive techniques (NDT), especially for the examination of reactor fuels. As a consequence of advocating the trend in using minimum active volumes (MAV) and NDT, a recent proposal has been made for combining the two techniques into a new fuel pin examination facility. The measuring or examination heads required for NDT are incorporated in a modular structure shielded tube. The fuel pins are transported along the length of the tube by a simple magnetic drive and most of the associated equipment is located outside the shielding. Such an arrangement has become known as the MAVIS concept[4] (minimum active volume in-line system).

At the other extreme, NDT is being applied to the examination of complete fuel assemblies, which because of their size require the use of large 'open' cells[5]. Open in this context means freedom of movement and handling but with assured containment of radioactive material. Obviously contamination control in a large volume can be difficult and so in principle the application of NDT probably affords the best approach to minimising waste from a PIE facility. Fuel pins examined in this way can be ultimately sent for reprocessing.

In situations where NDT cannot be applied, and it is not practicable to use a minimum working volume, then every precaution must be taken to control the spread of contamination. Eventually there is the dilemma of using decontamination with the advantages and disadvantages for waste disposal that this may bring. However, the use of modern materials and the application of coatings can play an important part both in contamination control and in ease of decontamination. Electropolished stainless steel can be readily decontaminated and suitable coatings can be applied which are strippable. The coatings readily protect surfaces and structures from contamination and if a final layer is deposited, just prior to the coating being removed, then it will seal in the contamination. In addition to the precautions that can be applied, the containment should be smooth and non-porous and to aid decontamination there should be an absence of protrusions and crevices.

Segregation of waste

In addition to the general classification of radioactive waste as being intermediate or low level there can be a further division according to the presence or absence of fuel or the actinides. In the consideration of any waste disposal scenario it is the presence of the actinides that causes the greatest concern. If there is an absence of fuel then it is possible that the waste contains only induced activities. In terms of decay most of the likely induced activities, that may create a handling problem, are relatively short lived and so an interim period of storage for no more than 50 years, to cover such nuclides as Co-60 ($t_{1/2}$ 5.2 years), could eventually qualify the waste as being low level. This would then provide the option for disposal at a shallow land burial site.

When the presence of fuel is unavoidable then the problems of waste disposal must be addressed in the planning stages of the work and if it appears to be difficult the validity for doing the work must be questioned. Apart from segregating the waste according to whether or not fuel is present it can be accumulated in separate containers according to type. Some typical hot cell wastes are:-

Loop components from test reactors
Fuel pin sections from metallurgical and chemical examination
Fuel cladding waste from dissolvers
Various acid and alkali solutions
Various organic solvents
Plastics
Glassware
Various metals
Analytical reagents
Tissues
Filters
Miscellaneous solids
Miscellaneous equipment

The quantities of the individual wastes arising in the hot cells are not necessarily recorded but the total amount of waste produced in these facilities at Harwell averages 20-30 $m^3.y^{-1}$.

Clearly there is a diversity of wastes some of which are likely to be limited according to whether the hot cells are used for engineering, metallurgy or chemistry requirements. Very few hot cells attempt to cover all three areas and most tend to prefer to segregate the chemistry and with it the problems of handling the noxious chemicals that add further to the waste problem. Such a segregation tends to ensure that wastes from engineering and metallurgy hot cells are principally assorted metals, sections of fuel and miscellaneous equipment.

The greatest variety of waste probably arises in the chemistry hot cells for in addition to the various solids there are also liquid wastes. The methods and techniques for handling all of these wastes in the hot cells depend greatly on their rate of production and the criteria being applied for treatment before removal to storage. Perhaps the most difficult waste problem is the handling of organic solvents and oils which, because of their nature, do not readily lend themselves to simple treatment methods.

Possible methods of waste treatment

It has already been suggested that waste segregation at source can greatly simplify the subsequent needs for handling and possible treatment. Segregation can be according to the type and nature of the waste (metal, plastic, glass, liquid etc.) or as combustible and non-combustible.

Apart from short cooled induced activities, the highest levels are likely to arise from pieces of fuel that have been sectioned for metallurgical or chemical examination. Further treatment of this fuel is unlikely to aid disposal, therefore from the outset, adequate packaging for long term storage should be comtemplated.

The majority of other wastes are classified as being radioactive through becoming contaminated and some consideration could be given to decontaminating the waste prior to disposal. Unfortunately decontamination merely converts the activity from one waste form to another, it does not remove the need for eventual disposal. The option for undertaking decontamination must therefore be evaluated against the benefits that can be accrued and unless it readily changes the category of the waste, it is debatable whether it should be done.

The real necessity for decontamination is in the recovery of plant and specialised equipment or to effect man-entry into an active environment for whatever reason. In such cases the volumes of waste can be relatively large and further treatment for disposal are likely.

Having segregated the waste there may be an incentive to reduce the volume. The volume of combustible material can be reduced by incineration, non-combustibles by melting or compaction and liquids by evaporation. A more concentrated waste form can produce a greater radiation source which may result in a more difficult handling and storage problem than for the original more dispersed form. It may therefore be more beneficial to store certain wastes in their original form for periods awaiting decay before further treatment is undertaken for disposal.

The further conditioning of waste for disposal may also need to be assessed since although there can be a saving in volume the actual method of reduction may produce additional waste. For example incineration is undertaken in a closed system and the off-gases are scrubbed before being discharged to the atmosphere. The liquid waste from scrubbing is therefore produced as a secondary waste and may need to be treated before disposal.

Various options are available for the treatment of non-organic solutions. Those containing high levels of activity in a fairly concentrated form, such as dissolved fuel solutions, can be neutralised if acidic and immobilised in a cement matrix. If the volumes of solution are large but relatively low in activity there is some advantage in using evaporation to reduce the bulk for disposal. Alternatively the activity may be removed by precipitation or ion-exchange and the resulting solution treated at low level. However, secondary wastes such as sludges from precipitation or ion-exchange materials are also produced for disposal.

Waste removal from hot cells

Some of the problems associated with waste handling arises because of the lack of a standard and site compatible transfer system. The size of the radioactive sources posted into a hot cell rarely bares any relationship to the volume of waste that is created and has to be removed. Both types of transfer require to be done in shielded flasks but because of the differences in sample sizes and activity levels it is necessary to have a range of flasks which can be used for the appropriate application. In many hot cells another limitation that may exist is the size of the posting ports which are installed in the biological shielding.

A current trend in active transfers is to use a container which operates on the double lidded principle. The container normally resides in the transfer flask but for the purpose of posting it can be attached to the active containment of the hot cell through an arrangement of seals and the mating of two lids. The principle avoids the need for the container being taken into the active environment and consequently the outer surface is kept free from contamination. This in turn ensures that the internal volume of the flask is kept clean. A range of container sizes and suitably shielded flasks are available commercially and with the use of combination lids it is possible to establish a standardised posting or transfer system.

A more recent development in the use of double lidded containers has been in the introduction of 200 litre drums for waste disposal. They are ideally suited for use in the bigger hot cells where the means to handle such large containers are available. The current regulations in the UK permit a gamma dose of 200 mR/hr at the surface of such containers for handling purposes.

With an established transfer route it is possible to provide a compatible system for accumulating and segregating the waste at source. Many hot cells use the equivalent of 'paint or oil cans', to accumulate the waste, which are relatively cheap and easy to obtain. Normally when the cans are full they are simply sealed and transferred to storage inside the double lidded container which in this instance provides secondary containment. On receipt at the storage area, the can may be removed and placed in a more appropriate container for storage. It is also possible for the double lidded container to be used for storage purposes although there may be long term limitations due to seals degrading through radiation dose.

The option for re-packaging should be at the discretion of the store operator who may wish to add cement to the final product before it is acceptable for long term storage. The addition of cement in the actual hot cells could significantly increase the weight of the waste package beyond the lifting capability of the manipulators and consequently further handling aids may be required.

Conclusions

1. The handling of radioactive materials invariably leads to the production of waste which can cause problems in waste management and disposal.

2. The application of non-destructive techniques is likely to offer one of the best solutions to minimising waste production.

3. Waste can be minimised by working in minimum volume containment, retaining only essential components in the active environment and applying safeguards that limit the amount and spread of contamination.

4. The handling of waste can be simplified by segregating it at source, using standard containers and means of transfer and having an agreed policy on waste treatment.

5. Decontamination and volume reduction are options which are available to assist disposal, but the benefits obtained must be evaluated against the costs for doing it.

6. Greater consideration must be given to the waste problem at the planning stages of the work and unless an appropriate route to disposal can be identified then the validity for doing the work should be questioned.

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