The Development of Special ISO Freight Containers for the Transport of Low Level Radioactive Waste

G. Holt[1] and R.A. Vaughan[2]

[1]*Central Electricity Generating Board, Barnwood, Gloucestershire*
[2]*Croft Associates Ltd., Didcot, Oxfordshire, United Kingdom*

INTRODUCTION

During the operation and maintenance of nuclear power stations, and other nuclear facilities, solid waste materials such as paper, plastics, filters, clothing, wood and metallic items are produced which are lightly or potentially radioactively contaminated. These items of trash are generally classified as low level waste (LLW) which, in the UK, is defined as having a radioactivity content of not more than 12 GBq/tonne beta/gamma (about 300 mCi/t) and 4 GBq/tonne alpha (about 100 mCi/t). LLW does not normally require to be shielded during normal handling and transport.

LLW in the UK is routinely disposed at a special site at Drigg in Cumbria and until recently the disposal method used has been simple tumble-tipping into shallow trenches excavated in clay. Large re-usable tipping containers were used to transport the waste by road to the disposal site. Although various studies had confirmed the continued technical, safety and environmental acceptability of the simple disposal practices at Drigg, it was recognised that improvements would have to be made, mainly for presentational purposes.

The new disposal concept adopted at Drigg was to construct concrete lined engineered vaults in which the containerised waste would be stacked uniformly. It was therefore necessary to develop a new method of waste packaging that was compatible with the new disposal concept. A number of proposals were considered. We proposed a system that would use ISO freight containers as both transport and disposal packages. This system was adopted and has been in service since mid 1988.

The advantages perceived in using ISO containers were that they are used in vast numbers worldwide, predominantly for non-radioactive materials transport, and hence there are well developed handling and transport systems. They are relatively low cost items, were reasonably compatible with the handling systems that existed at the waste producing sites and could be readily stacked in the disposal vault. However, for this particular application it was found to be necessary to produce special designs, within the ISO container concept, and to undertake a development and proving programme.

DUTY OF PACKAGING SYSTEM

To be able to determine the size, shape and design of the transport and disposal packages, it was necessary to consider both the physical and radiochemical nature of the waste material. LLW can comprise a broad range of materials which have a wide variation in size, shape and weight. However, it was possible to group the waste into three different categories; drummed waste, wrapped waste and loose waste. The majority of LLW arising at the nuclear power stations and other sites is placed inside 200 litre capacity cylindrical steel drums. When full, these weigh on average about 80 kg. Some LLW is too large to fit into drums and this material, such as redundant plant items, is generally wrapped in plastic sheeting to prevent or minimise the loss and spread of contamination during handling. The weight of such items is variable but can be as high as a few tonnes. Finally, some trace active wastes can be handled loose. Typical materials that would fall into this category would be building rubble.

With respect to transport, the IAEA regulations are the basis for UK legislation. At present, either of two editions of these regulations may be used: the 1973 Revised Edition (As Amended) (IAEA SS6 1973) and the 1985 Edition (IAEA SS6, 1985). Under the 1973 Edition, LLW is classed as Low Specific Activity (LSA) material and hence the standard of transport packaging required is such that it need not be subjected to any impact or containment integrity tests. Under the 1985 Edition, LLW is classed as LSA II or SCO (Surface Contaminated Object). For exclusive use transport this requires packaging to Industrial Package Type 2 (IP-2) standards. The regulatory requirement for IP-2 is that it can withstand normal conditions of transport, which is usually demonstrated by an impact test during which it must maintain containment integrity. This is a more onerous standard than is required by the 1973 Edition.

As well as being suitable for transport, the package must also be suitable for disposal. Because of the ground conditions at the Drigg disposal site and the design of the concrete lined vault, it was recognised that there would be a limit to the gross weights and point loadings imposed by the waste packages.

Having identified the necessary duty of, and constraints on the packaging system, it was then possible to prepare suitable package designs.

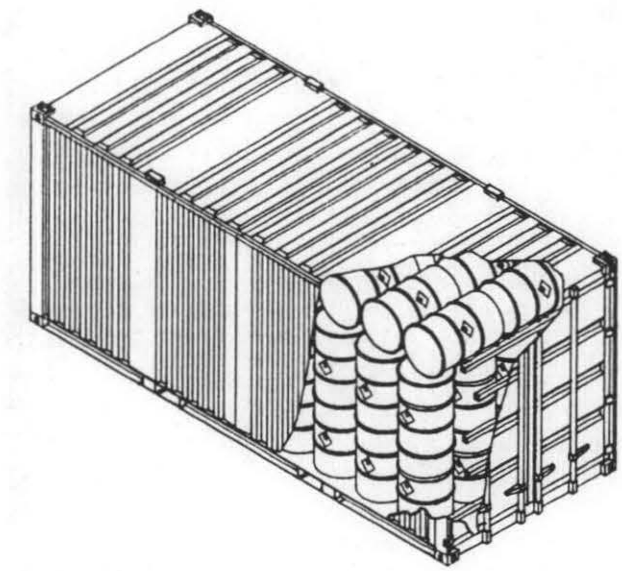
CONTAINER DESIGN

The ISO freight container system is based on a standard range of sizes. The width of containers is fixed at 8 foot but the length can be 10, 20, 30 or 40 foot. The allowable height of containers is more flexible but the most common heights are either 8 foot or 8 foot 6 inches. Having recognised the range of LLW materials needing to be packaged for transport and disposal, and the weight limitations imposed by the design of the disposal vault, two different container designs and sizes were identified as being appropriate. These containers are now commonly known in the UK nuclear industry as the full height and half height containers. Both containers are 20 foot long and 8 foot wide, but the full height is 8 foot 6 inches high and the half height container is 4 foot high.

It was considered that a full height container would be the most appropriate for drummed LLW. A container height of 8 foot 6 inches allows two layers of drums to be stacked vertically with a third layer of drums placed horizontally on top. Approximately 90 drums of 200 litre capacity can be accommodated, with some space being left which can be used for smaller wrapped items such ventilation filters. The most appropriate form of container closure for loading drums was the double rear door arrangement.

The type of container, with double rear doors, is the most commonly used for the worldwide movement of freight. As such, consideration was given initially to the use of second-hand containers as, for the particular duty envisaged, they were to be used for one journey only from the waste producing site before being buried at the disposal site. However, it was soon recognised that second-hand containers could not be used: this was principally due to the need to reduce the point loadings imposed by the container on the disposal vault floor. This necessitated the introduction of additional columns or load transfer posts in the container side walls and making the container base flat so that the load was spread more evenly. The gross container weight was also limited to 20 tonnes initially but this was later increased to 25 tonnes. There was also a concern that second-hand or standard ISO containers were not designed or manufactured in such a way that, should there be any loss of radioactive contamination from the drums or wrapped waste items, the contamination would be retained in and not lost from the container.

When it was recognised that a special design of full height ISO container would be required, consideration was given to what other design features over and above those used on standard ISO containers, could be introduced to provide a high quality container that would be appropriate for the transport of radioactive waste materials. It was found that a number of improvements could be introduced at only a small increase in container cost. The container design that resulted is of all steel construction, with the floor being steel plate rather than wood planking as is more usual for standard ISO containers. All construction joints are fully seal welded. The wall and roof panels are 2 mm thick and the floor is 4.5 mm thick, both of which are thicker than usually used on most ISO containers. Also, restraint bars are fitted between the rear doors and the stacked drums within the container to prevent the load shifting and reacting against the doors which may open up the door seals. These bars also prevent drums, particularly those positioned horizontally, from falling out when the doors are opened. The doors and door seals are similar to those used on standard ISO containers.



Special Full Height ISO Container

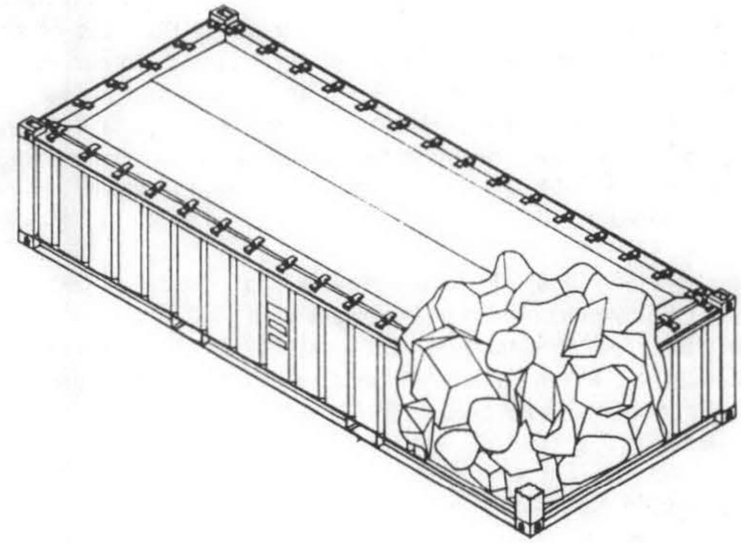
A special full height ISO container of high quality, both technically and presentationally, has been produced. This is being used for the transport and disposal of predominantly drummed wastes and also for some smaller quantities of wrapped wastes. At present this packaging arrangement has been approved and is in use in accordance with the requirements of the 1973 Edition of the IAEA transport regulations. This was because the drummed and wrapped light waste already had approval in their own right to the 1973 Edition and hence, in the tight time constraints that existed in which it was necessary to introduce the new transport and disposal system, this was the simplest and quickest approach to take. It is intended to upgrade the approval and use to satisfy the 1985 Edition but this may require some design changes.

A half height container was identified as the most suitable for loose waste materials and the majority of wrapped materials. These types of waste tend to be of higher density than drummed waste and of larger size. A top opening container would allow such waste to be loaded most easily and, within the constraint of a maximum allowable disposal container weight of 25 tonne, a container of half height and hence reduced volume would be most appropriate.

As with the full height container, it was necessary for the half height container to be a special non-standard ISO container design. A principle difference between the two types of container is the extent of containment integrity required. The full height container carries drummed or wrapped light materials which have some degree of containment integrity in their own right in addition to any integrity provided by the ISO container. The half height container, however, can carry loose radioactive materials and wrapped heavy items. The half height container must therefore provide all the necessary containment integrity to prevent any unacceptable loss of radioactive contamination from the loose materials. Even for the wrapped items it is not always possible to guarantee that the wrapping remains sound and that there is no loss of contamination, and hence the container must again provide containment integrity. Therefore, in developing the half height container design, special attention was paid to producing a high quality design that had an appropriate and demonstrable level of containment integrity or leaktightness.

The special half height ISO container is of all steel construction with all construction joints being seal welded and accessible externally for leak testing purposes. The wall panels are 4 mm thick and the floor plates are 6 mm thick. Thicker panels and plates were selected to ensure no damage by penetration occurred when waste items were placed or dropped into the containers or as a result of any movement of waste items during handling or transport. This container, as with the full height version, has additional load transfer posts on two sides and a flat base for disposal purposes. Access for loading waste into the half height container is provided by a single full aperture lid. The lid incorporates a double neoprene seal around its edge and is fastened to the container body by a bolted clamp arrangement. Both the container body and the interspace between the double seal can be leak tested.

A special half height container of high quality, particularly with respect to containment integrity, has been produced. This is being used for the transport and disposal of wrapped and loose radioactive waste materials. Because the time constraints for introducing the half height container were not as tight as for the full height containers it was intended that this container should be designed and approved to the requirements of the 1985 Edition of the IAEA transport regulations from the onset rather than initially to the less onerous requirements of the 1973 Edition as was the case for the full height container. However, due to interpretation difficulties with the 1985 Edition this did not prove possible and hence they are at present only approved and in use in accordance with their 1973 Edition.



Special Half Height ISO Container

The principal parameters for the two designs of special containers are as follows:-

	Full Height Container	Half Height Container
Length	6058 mm (20 ft)	6058 mm (20 ft)
Width	2438 mm (8 ft)	2438 mm (8 ft)
Height	2586 mm (8 ft 6 in)	1219 mm (4 ft)
External Volume	38.3 m^3	18.0 m^3
Internal Volume	32.8 m^3	14.1 m^3
Tare Weight	2680 kg	2450 kg
Gross Weight	25 tonne	25 tonne
Closure	Double end doors	Top lid

REGULATORY REQUIREMENTS AND INTERPRETATION DIFFICULTIES

In the early stages of the development of the designs of the special ISO containers, it was recognised that there were interpretation difficulties with the 1985 Edition of the IAEA transport regulations. The containers were required to be to IP-2 standards and as such two alternative regulatory requirements could be applied.

The first alternative that could be used was para 519 which specified the generic requirements that could be applied to any form of IP-2, eg drums, boxes or freight containers. This paragraph requires that the package can withstand a free drop test and a stacking test without the loss or dispersal of the radioactive contents or a shielding integrity loss of greater than 20%. In interpreting this regulatory paragraph, questions were raised as to whether the free drop test was relevant to a large ISO freight container. The purpose of the regulatory tests is to represent normal conditions of transport and not accident conditions. The usual means of performing a free drop test is to drop the package on to an unyielding target in its most vulnerable attitude. In the case of a drum this would be a top edge impact, local to the drum lid and body interface, and such a situation could be imagined as a result of a minor mishap during normal transport should a drum fall off a transport vehicle. In the case of an ISO container, the most vulnerable impact test attitude would be an inverted corner drop. There is no conceivable possibility that such an impact attitude could occur under normal transport conditions; it would clearly be a severe accident situation. Even though the regulations (para 622 and Table XIV) specify a lower free drop test distance for heavier packages, this did not reduce the concern about para 519 and our conclusion was that it should not be applied to the special ISO freight containers.

As an alternative to para 519, there is para 523 which is specific to ISO freight containers. Para 523 states that freight containers can be classed as IP-2 provided that they satisfy the requirements of an ISO Testing Standard (ISO 1496/1-1978) without a loss of shielding integrity greater than 20%. Taken at face value, this alternative regulation would appear to overcome the difficulty identified with para 519. However, a closer assessment of para 523 also revealed a problem.

The ISO Standard quoted in para 523 requires the freight container to be subjected to a series of overload static tests which are designed to represent certain handling and transport conditions, eg loads imposed by shipboard movements and stacking. These tests certainly demonstrate the structural integrity of an ISO freight container. However, there is no specified requirement to maintain containment integrity within the ISO Test Standard or written into para 523. We considered that it was essential that during normal conditions of transport there was no loss or dispersal of radioactive contents from the container. Recognising that radioactive materials could be carried loose in ISO containers, we considered that the lack of a containment integrity requirement in para 523 was an unacceptable omission. This concern was raised with the UK Competent Authority who sympathised with the views being expressed. It has now been input as part of the IAEA Continuous Review process and the outcome of these deliberations is awaited. A secondary concern was raised, and that was that the quoted ISO Test Standard includes static and not dynamic testing. Historically, the IAEA transport regulations have included dynamic testing.

As a result of the interpretational difficulties experienced with the 1985 Edition of the 1985 transport regulations, it has not proved possible to qualify the special ISO container designs to these regulations. However, as this edition of the regulations is due to come fully into force within UK legislation in January 1990 it has been necessary to make some progress. Although there are unresolved difficulties with the regulations as they are presently written, it is quite clear what the basis or spirit of the regulations is for an IP-2. An IP-2 must withstand normal conditions of transport with no loss or dispersal of the radioactive contents and a loss of shielding integrity no greater than 20%. Normal transport is defined as the conditions likely to be encountered in routine transport in incident free conditions and during minor mishaps. No loss or dispersal of radioactive contents does not mean zero loss but that the radioactive content of the package cannot escape in sufficient quantities to create a radiological or contamination hazard. To enable a good understanding of the structural and containment integrity of the special ISO container designs to be determined, and hence how they relate to the spirit of the 1985 Edition of the IAEA transport regulations, a substantial container development and proving programme was implemented.

CONTAINER DEVELOPMENT AND PROVING PROGRAMME

The two special designs of ISO containers used for the transport and disposal of LLW have been subjected to a series of mechanical and leaktightness tests. The continuing programme includes analytical assessments and full scale impact testing.

Both designs of container have been subjected to the structural or mechanical tests specified in the ISO Test Standard. These have proved that the containers are sufficiently robust to readily withstand the stacking, loading, handling and transport conditions that could be considered to be more onerous than the routine conditions experienced during road, rail or sea transport.

Both containers have been subjected to leaktightness testing which has included such techniques as helium leak testing, bubble testing, pressure testing and smoke tests. Particular attention has been paid to the half height container design as this can be used to transport loose radioactive material and hence requires a higher containment integrity than the full height container. The leak testing, as well as indicating the containment integrity of the container, was also a useful check on manufacturing quality and techniques. For example, it was found that where construction weld runs come together, the manufacturers butted the welds up to each other to produce a smooth weld bead which enhanced its presentational appearance. This practice resulted in leaks at most points where welds joined which could be eliminated by overlapping welds.

Each special half height ISO container manufactured is subjected to leak testing. With the container lid fitted and clamped down fully, the container is pressurised internally with air and a bubble testing technique applied to all the construction seal welds on the container body and lid. The double seal arrangements on the lid is also subjected to an interspace pressure test. This has demonstrated that a leaktightness better than 0.1 bar cm^3 s^{-1} SLR (Standardised Leak Rate) (AECP 1068 1985) for the body and lid and 1 bar cm^3 s^{-1} for the lid closure seal can be readily achieved. The leak testing has also been undertaken whilst a container is being subjected to the structural loading tests during which there has been no noticeable increase in leak rate.

Leak testing of the production special full height ISO containers is not carried out routinely but tests have been performed on a small number of units. In comparison with the double seal on the half height container, the seal on the doors of the full height container is simpler and the same as on standard ISO containers and, as would be expected, the degree of leaktightness is less. However, during a test in which a full height container was filled with smoke under a slight overpressure, although there was some visual trace of smoke leakage at a few points around the doors, the seals held some internal pressure even after the pressurising source was disconnected. The level of leaktightness attained for the full height container is quite acceptable when carrying packages such as drums which themselves have some containment integrity. Should the container be used for wrapped contaminated items for which the],z containment integrity of the wrapping cannot be guaranteed, then a higher degree of leaktightness and hence an improved door seal design may be necessary.

As the spirit of the IAEA transport regulations requires an IP-2 to withstand normal c nditions of transport, a study is being undertaken to determine what can be considered to be normal handling and transport conditions for ISO freight containers. Contact has been made with those bodies associated with general freight movements, such as ports, railways, road hauliers and container suppliers and repairers, so that the methods of handling and transport of ISO containers in the UK can be assessed and the minor mishaps and accidents that do occur to containers, can be identified. This should allow these situations and incidents to be identified which, like heavy handling or minor impacts, can be considered to be part of normal handling and transport. Having identified the normal conditions of transport, including minor mishaps, that apply to ISO containers, the two special designs of ISO containers will be assessed analytically to determine the effects on container structural and containment integrity under such conditions. As final confirmation of the assessment work it is proposed that each container design be subjected to full scale dynamic tests that fully represent the identified normal conditions or minor mishap situations.

Upon completion of the above container development programme, which is expected before the end of 1989, it should be possible to determine whether the existing special ISO container designs meet the spirit of the 1985 Edition of the IAEA transport regulations, and whether or not any design changes, either up-grading or down-rating are appropriate.

CONCLUSIONS

A new system for the transport and disposal of solid low level radioactive waste has been introduced in the United Kingdom. This utilizes two designs of special ISO containers which are considered to be of a high quality appropriate to the transport of radioactive materials. A container development and proving programme is in progress and is expected to conclude shortly with some full impact test work. This programme is confirming the structural and containment integrity of the containers and it is hoped that it will assist in the resolution of a number of interpretational difficulties that have been experienced with the 1985 Edition of the IAEA transport regulations.

REFERENCES

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