Development of a Large Container Cast of Low Level Radioactive Steel

M. Sappok[1] and K. Pflugrad[2]

[1]*Siempelkamp Giesserei, Krefeld, Federal Republic of Germany*
[2]*Commission of European Communities, Brussels, Belgium*

INTRODUCTION

High waste storage and disposal costs prevailing in Europe are an incentive to decontaminate thoroughly redundant components for metal recycling, in order to reduce the radioactive waste volume. Experience has shown that the objective of a substantial reduction of the overall waste volume may be missed in practice, as a result of large amounts of secondary waste. It is important, therefore, to have containers which allow the transport and/or storage of larger components and/or are made by using low-level radioactive steel originating from nuclear installations.

The Commission of the European Communities has carried out assessments on large containers within the frame of two (1979-83 and 1984-88) programmes of research on the decommissioning of nuclear installations, carried out by way of cost-sharing contracts with organisations and companies in Member States, the results of which were presented at the 1984 Luxembourg Conference /1/ and in the Annual Progress Reports /2/3/4/5/. A third five-year research programme (1989-93) is starting this year.

The budgets of the programmes are shown in Table 1. The 1984-88 programme comprised 76 research contracts, three of which are devoted to large containers. Apart from the promotion of useful research, they were intended to create a close cooperation between concerned parties thereby trying to economise on the workload.

The Commission contributes to the total budget in the contracts with an amount which generally is in the range of 40 to 50%. Table 2 shows the areas in which contracts have been concluded in the framework of the 1984-88 programme.

NOTE: Figures and tables are available from the authors.

The work progress is presented and discussed at twice yearly evaluation meetings, composed of national experts, concerned contractors and Commission staff. Freely available information is published at Conferences (e.g. Pittsburgh/-USA 4-8/10/87) and in Annual Progress Reports giving summarised presentations of work programmes and obtained results. The progress report on the 1988 activities is in preparation. Results obtained and conclusions are presented in final reports, generally published as unrestricted available EUR-Reports.

NUCLEAR METAL WASTE RECYCLING

The Community's technological research aims at catalysing the setting up of regulatory frameworks within which industrial activities can develop. An example where particular efforts are undertaken, is the re-use/recycling of nuclear metal waste /6/. One of the possible recycling routes is the use of containers for final disposal cast of low-level radioactive waste. Large packages reduce cutting work considerably and, consequently, radiation exposure of the work force. The use of nuclear steel waste for manufacturing transport and disposal containers saves high cost disposal volume and, at the same time, the consumption of raw steel. This route is strongly considered by PTB (Physikalisch-Technische Bundesanstalt, the federal institute for science and technology, i.e. the highest technical authority under the auspices of the Federal Ministry of Economy), and BAM (Bundesanstalt für Materialforschung, the federal institute for material research) for the proposed German Konrad disposal site where packages of up to $10.9 m^3$ disposal volume of a maximum total weight of $\leq$ 20 Mg, may be disposed. Large container developments are underway at UKAEA - Windfrith (M. S. T. Price) and the Société Générale pour les Techniques Nouvelles, France. Before casting large containers, knowledge was needed with respect to specific problems occurring in the presence of radionuclides.

TREATMENT OF CONTAMINATED STEEL BY MELTING

Melting of contaminated steel has essentially been studied by the British Steel Corporation and Siempelkamp Giesserei, Krefeld. Experiments at British Steel Corporation confirmed the possibility of retaining radio-caesium in the slag, through the use of acidic slag.

Siempelkamp Giesserei has developed and tested a melting facility in the framework of previous investigations involving the melting of 2000t of scrap with an average radioactivity level of 1.5 Bq/g. This facility (Taurus II) had then been used for various test series. It comprises a 20t capacity induction furnace and is authorised to process scrap with activity levels up to 74 Bq/g.

Three series of specific melting tests have been performed until now. In particular:

- In the first series of tests, 35t of mixed steel scrap with an average activity level of about 7 Bq/g was melted to produce shielding plates (the high chromium content excluded other uses).

- In the second series, 30t of carbon steel scrap (activity: 5 Bq/g) was melted to produce high-quality castings such as type-A and type-B waste containers.
- In the third series, 34t of austenitic steel (activity: 12 Bq/g) was melted to produce bars for recycling later.

Further meltings carried out related to 139t of mixed steel scrap. Thus, a large mass of results and experience is supporting the casting of waste containers suitable for transport and final disposal in the Konrad mine.

Melting was demonstrated to be an efficient procedure for the release measurements which can be done in a safe and fast way because of the perfect homogeneisation of the radioactivity in the ingot retaining the bulk of the Co-60 activity whereas the volatile cesium activity is retained in slag and filters. Fig. 1 gives a schematic view on the melting facility. Melting campaigns for scrap up to 500 Bq/g in a controlled area will soon be undertaken in cooperation with KRB Gundremmingen (FRG), in a specially designed melting shop under construction, Fig. 2. First melts in this melting shop are foreseen in the last quarter of 1989.

LARGE STEEL CONTAINER SUITABLE FOR THE KONDRAD MINE

This paper gives results from R&D work sponsored by the Commission of the European Communities and carried out by Siempelkamp Giesserei, Krefeld, in the frame of the 1984-1988 five-year programme.

Research work undertaken related to design and evaluation of large containers for decommission waste, cast of low-level radioactive steel. Essential progress has been achieved in the development of a prototype container for disposal in the Kondrad mine with a loading capacity of 14t (5.4 m^3) cast of low-radioactive steel (<10 Bq/g).

The main steps undertaken relate to:
- Technical optimisations based on Konrad type VI steel container (1600 x 2000 x 1700 mm high, total weight 20t) taking into account all relevant requirements for safe transport and disposal in the Konrad mine; a stability calculation showed that the container can withstand shocks resulting from normal transport and handling.
- Design and casting of a prototype container using 20% (4.22t) of contaminated steel (<10 Bq/g) and its successful testing under conditions as required by IAEA and the German authorities (PTB, Physikalisch-Technische Bundesanstalt and BAM, Bundesanstalt für Materialforschung).
- Establishment of a radiological measurement programme for radioactivities occurring before and during the manufacturing of the finished container, showed gamma dose rates of 2 mSv/h at surface and 0.1 mSv/h at 1m.
- Testing of the prototype container with representative loading materials and the development of concepts to repair an accidentally damaged container, with a particular view to tightness and handling.

MATERIAL SPECIFICATION

As mentioned above, it was the major target of this project to demonstrate that steel waste from nuclear installations can be used to produce containers suitable for transport and final disposal of radioactive waste. For this purpose, a defined quality of the original material must be ensured, which means that the chemical composition must be specified with limits which cannot be exceeded. Table III shows the mechanical properties for the material and of major interest is the limit for elements, which can cause a disturbed structure accompanied by a decrease of the mechanical properties. Generally, there are difficulties with the elements Cr, Ti, Pb, Mn, and Cu.

These elements usually come from stainless steel and impurities, so it is an essential task of the dismantling crew to separate carbon steel from stainless steel. It can be easily done by using a small magnet.

To be sure that a container will meet the regulations for transport and storage, the mechanical properties are specified on a data sheet. Due to the lower loads a container has to withstand under type-A conditions, it is sufficient to specify a yield stress of $>250\ N/mm^2$, a tensile strength of $210\ N/mm^2$ and an elongation of $\geq 3\%$.

The production of the prototype container WACO I for the tests was made under conservative conditions, that means that the chemical composition was chosen to be at the upper limit - as it can be seen in Table IV. Consequently, the mechanical properties are at the lower band of the specified values.

Of major importance is the ultrasonic test, which makes sure that no allowed shrinkage within the wall either reduces the shielding effect of the container or reduces the strength of the wall to withstand accidents. Fittings are also of major importance for handling the container corner. A dye-penetrant test can make sure that no cracks are present in this highly forced area.

The container is presently tested in the frame of the licensing procedure for agreement by PTB/BAM (licensing affiliates for the Konrad mine).

PROTOTYPE TEST PROGRAMME AND RESULTS

The tests were planned with respect to relevant transport and storage regulations. While the IAEA regulations for the transport of type-A packages are well known, the storage regulations for the Konrad mine are in draft form at present. Over the next few years, this situation may be improved. At present, IAEA type-A regulations require a drop test from a height of 0.3m, whereas the Konrad conditions require for 0.8m drop tests. Konrad requires a fire test, which is not in the IAEA regulations; IAEA requires a waterspray test, which is not needed for Konrad (requiring tests of the corner fittings for loads on top of the container and, for special purposes, the tightness of the container must demonstrated).

For the prototype, all items were covered by choosing the harder conditions in every case, i.e.
- drop test from a height of 0.8 m
- fire test at 800°C for one hour
- staple test by loading (60 t) on top of the container (20 t)
- spreader test to check the corner fittings (Tables V and VI).

The prototype under testing conditions is shown in the following situations:

Fig.3 shows the container ready for the drop test.
Fig.4 shows preparation for the fire test.
Fig.5 shows it under the load of 60 t and finally during the
Fig.6 test of the corner fittings.

The tests demonstrated that the requirements of the IAEA regulations were met completely. Also the drop test results under "Konrad" conditions, as well as the staple tests and the tests of the corner fittings were satisfactory. After these tests a leakage test was made to demonstrate the tightness and a dye penetrant test was performed after the last test to ensure that no cracks were present.

A problem arose with the seals after the fire test (for "Konrad" all containers have to resist against a fire for one hour). This problem arose because of the high temperature in the seal area. As shown in Fig.7, this temperature increased above 300°C. That means that synthetic seals like viton and teflon fail. Tests with seals on a graphite base, which are resistant up to 800°C, did not give the required tightness of 10^{-5} mbarl/s. The only solution to this problem seems to be metallic seals of an aluminium or a silver base, i.e. costly items. It has therefore to be decided whether a container needs tightness and, if yes, at which level.

CONTAINER REPAIR CONCEPTS

After having qualified the container, with respect to the various regulations, additional special repair concepts had to be carried out. Two items have been assessed:
- repair of a corner fitting during a transport/handling hazard
- tightness welding between the lid and the container.

It cannot be ensured during the handling and transport of the container that a corner fitting will not break. This means that a repair concept is necessary to be able to handle the container without unloading. In fig.8 the proposed solution is shown. In a machine shop the defect corner could be ground out. On the machined surface, a new steel plate is fixed by screws and the new fitting - made out of cast steel - is welded against the base plate. Another solution to make the container tight is to weld a seam between lid and container as can be seen in fig. 9 (in this case, the lid is not removed) reducing exposure of the worker. Dye penetrant tests showed no cracks in the seam after detailed checking.

CONCLUSIONS

The research work finished in May this year. As regards the industrial aspect of the project, it may qualify as one of the most successful with EC participation. Until now, 12 containers of this type have been produced and shipped to the customer, and another 23 are under construction.
Is this not a clear indication that useful recycling of nuclear waste, is one of the realistic routes for reducing the radioactive waste volume and to save steel resources which concerns steel waste?
The main conclusion of the assessments carried out is that the quality of the material to be recycled is of paramount importance. Therefore a qualitative selection of the material on the decommissioning site is the easiest way to obtain well known material categories allowing the casting of quality items.

REFERENCES

1. Schaller, K.H., and Huber B. (ed). Decommissioning of nuclear power plants. Proceedings of a European Conference held in Luxembourg, 22-24 May 1984. Graham & Trotman Ltd., London, EUR 9474.

2. The Community's research and development programme on decommissioning of nuclear installations. First annual progress report (year 1985). EUR 10740, Commission of the European Communities.

3. The Community's research and development programme on decommissioning of nuclear installations. Second annual progress report (year 1986). EUR 11112, Commission of the European Communities.

4. The Community's research and development programme on decommissioning of nuclear installations. Third annual progress report (year 1987). EUR 11715, Commission of the European Communities.

5. The Community's research and development programme on decommissioning of nuclear installations. Fourth annual progress report (year 1988). In preparation, Commission of the European Communities.

6. Commission of the European Communities, Radiation Protection no. 43, Radiological Protection Criteria for the Recycling of Materials from the Dismantling of Nuclear Installations. Recommendations from the Group of Experts set up under the terms of Article 31 of the Euratom Treaty. Luxembourg, November 1988.