A DECONTAMINATION PROCESS FOR METAL SCRAPS FROM THE DECOMMISSIONING OF TRR

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ABSTRACT

A decontamination facility including surface condition categorizing, blasting, chemical/electrochemical cleaning, very low radioactivity measuring, and melting, is being established at INER. The facility will go into operation by the end of 2004. The main purpose is to clean the dismantled metal wastes from the decommissioning of Taiwan Research Reactor (TRR). The pilot test shows that over 70% of low level metal waste can be decontaminated to very low activity and can be categorized as BRC (below regulatory concern) waste.

All the chemical decontamination technologies applied are developed by INER. In order to reduce the secondary wastes, chemical reagents will be regenerated several times with a selective precipitation method. The exhausted chemical reagent will be solidified with INER’s patented process. The total secondary waste is estimated about 0.1-0.3 wt.% of the original waste. This decontamination process is accessed to be economic and feasible.

INTRODUCTION

The difficulty of finding a disposal site for radioactive wastes calls for the effort to reuse or release the wastes after suitable decontamination become necessary and profitable. Especially, Taiwan is a mountainous island, the high density of population further limits the available area for disposal site. Reduction of the radioactive waste is much urgently concerned.

At present about 3000 barrels of metal waste are stored in the warehouse at INER. In the near future, many nuclear facilities will be decommissioned. In order to establish the metal waste reduction technology for the deficiency of warehouse right now and for the future need of NPP decommissioning, chemical decontamination reagents and cleaning process have been investigated. Pilot tests also showed good performance. For further integrating the decontamination technology, BRC identification technology, and metal reuse technology, a decontamination center is under construction. Figure 1 shows the concept of the decontamination process.
THE DEVELOPED DECONTAMINATION METHODS

Chemical decontamination methods

Comparing to mechanical decontamination method, chemical decontamination method has the advantage of free of inaccessible area as the metal scraps is in complex shape. However, the drawback of chemical decontamination is that the secondary waste is a problem to be solved (1,2). Therefore, an effective chemical decontamination reagent should both possess good decontamination factor and generate less secondary waste. In other words, an effective reagent is capable of being regenerated several times without losing its original function.

Three kinds of chemical reagents have been investigated and tested in a pilot facility. Each reagent has its apt application target with specific merits (2). The summary is outlined in Table 1. The first is a mixture of organic acids, such as oxalic acid, formic acid, or citric acid. This reagent is suitable for stainless steel and carbon steel scraps and subsystems that can be decontaminated by a recirculation loop. Usually a large volume of chemical reagent is used for the decontamination of a subsystem. Fortunately, the organic mixture is degradable and the
secondary waste can be controlled to a limit amount (3). The next reagent developed is a mixture of phosphoric acid and additives. This formula is suitable for aluminum and copper waste. Meanwhile it is also applied in the electropolishing process that can clean all kinds of metal wastes. The reagent can be regenerated by a selective precipitation method when either the metal concentration reaches the upper limit or radioactivity exceeds the regulatory value. The third reagent is a mixture of fluoroboric acid and additives. This is especially effective for stainless steel waste, of which a rather thick contaminated layer needs removing. The regeneration method is the same as the phosphoric acid mixture.

Table 1. Chemical Reagents Used in Chemical Decontamination Process

<table>
<thead>
<tr>
<th>Reagent Type</th>
<th>Composition</th>
<th>Operation Temp.</th>
<th>Action Time</th>
<th>Dissolution Rate</th>
<th>DF</th>
<th>Application</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Acid Mixture</td>
<td>1. Organic Acid 2. Oxidant</td>
<td>90-100℃</td>
<td>1-6 hr</td>
<td>SS:0-3 μm/hr</td>
<td>2.5~1000</td>
<td>System</td>
<td>Oxidation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CS:0.5 μm/min</td>
<td></td>
<td>Decon. for SS and CS</td>
<td></td>
</tr>
<tr>
<td>Phosphoric Acid Mixture</td>
<td>1. Phosphoric Acid 2. Oxidant</td>
<td>70-80℃</td>
<td>1-10 mins</td>
<td>SS:0.5-1.5 μm/hr</td>
<td>3~1000</td>
<td>Cu, Al And CS</td>
<td>Regeneration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CS:&gt;14 μm/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cu,Al:0.5-9 μm/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoroboric Acid Mixture</td>
<td>1. Fluoroboric Acid 2. Oxidant or Reducing Agent</td>
<td>70-80℃</td>
<td>1-10 mins</td>
<td>SS:5-60 μm/hr</td>
<td>3~1000</td>
<td>SS, CS</td>
<td>Regeneration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CS:&gt;10 μm/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cu,Al:25-40 μm/min</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mechanical decontamination methods

Two types of mechanical decontamination methods for metal wastes have been developed in INER(4). The first is an ultrahigh pressure water (UHPW) jet and the other is a shot blasting system. The UHPW jet cleaning is effective for removing loose contaminants. Since only water is used, the wastewater treatment is easy.

Shot blasting is another technology to clean metal surface especially as a protective painting or debris is on the surface (5). Abrasives, such as steel shot or grit, are activated by impeller which projects abrasives through the centrifugal force.
DECONTAMINATION PROCESS DESIGN

Retrieval of Waste
Except some large items such as heat exchangers and tanks, the dismantled metal scraps to be decontaminated are stored in two types of containers. One is the traditional 55-gallon drum, the other is a specially designed box with the dimension of 2m(L) x 1.4m (W) x 1m (H) for storage of large pieces. For each retrieval, one box or six drums of metal scraps will be retrieved from the storage house with a folk lifter. The retrieval will be done once a week to avoid keeping too much waste in the decontamination center, causing the necessity of a thick shielding around the site.

Sorting and preconditioning
Waste containers will be opened and dumping out metal scraps on a sorting conveyer. Operators manipulate the conveyer on one side and separate the scraps into different categories for subsequent suitable decontamination. A ventilation system fixed on the other side of the conveyer can protect both the operators and the working environment from contamination. The sorted metal scraps will be sent to the decontamination unit by a crane system or a folk lifter.

Mechanical decontamination
Two operation types of shot blasting will be established. One is a rotating drum type. The treating capacity is about 600kg per batch with an effective volume of 200 liters. The limitation is that each piece to be treated should be lighter than 35kg and shorter than 40cm. A 22hp impeller ejects the steel grit, in size of 2 mm diameter, into the rotating drum chamber to polish the contaminated metal surface. The used steel grit will be recycled, and both the dust and debris will be collected by a bag filter to the bottom of the filter. The other is a still chamber type in which the treated metal scraps are suspended by a rotating device. The crane on the rotating device can hold metal scraps of weights less than 2500kg. The working chamber is with a size limitation of 2m length and 1m width. More than two impellers will be set to activate the steel shot.
After blasting decontamination, blowing air will be used to remove fine particles sticked on the metal surfaces. In addition, following steps of rinsing and drying are still necessary. These steps share the equipment of the chemical decontamination process described in the next section. The schematic diagram is shown in Figure 2.
Other than shot blasting, an ultrahigh waterjet has been established in the existing decontamination site, which will be an alternative for large contaminated metal piece.
confined booth equipped with specially designed nozzles and a turntable is used to clean metal scraps which are lighter than 500kg and smaller than 100cm(L) x 100 cm(W). Larger pieces could be treated by a lane within a temporary tent. An UHPW generator, supplied by Asia Flow, can supply UHPW 4.5 gpm with a pressure of 35,000 psi. After mechanical decontamination either by blasting or waterjet rubbing, the metal scraps will be inspected immediately by a handy type dosemeter. If the metals meet the cleaning criteria, they will be rinsed and dried. Otherwise the chemical decontamination will be followed.

![Diagram of mechanical decontamination](image)

### Chemical decontamination

An integrated equipment including degreasing, chemical polishing, electropolishing, rinsing, and drying is set up for chemical decontamination. Metal scraps will be fixed on the rack and transferred to each step by a PLC controlled overhead crane if the electropolishing process is required. Otherwise if the chemical polishing is in use, the metal scraps will be put in a basket. The tanks used in each step are of same size, 2.5m (L) x 1.0m (W) x 1.2m(H), but the tank materials are different depending on the operation temperature and the chemicals in them. On the cells side of chemical polishing and electropolishing step, air suction will be provided to prevent from acid-contaminated air pollution. Furthermore, the integrated equipment will be covered with a booth to enhance the removal of acid-contaminated air. The air drawn will go through a scrubber, in which a diluted sodium hydroxide solution is circulated. The exhausted
air from the scrubber will be dried and conducted to a main exhaust system. The schematic diagram is shown in Figure 3.

Regeneration of the decontaminating reagents

Either the metal ions in the decontaminating reagent accumulated over the predetermined concentration or the tank surface dose exceeding the set value of 0.1mSv/h, the solution needs regeneration. The limit of metal ion concentration in decontaminating reagent is about 180g/l for phosphoric acid solution and about 90g/l for fluoroboric acid. An ion selective precipitation method is adapted to regenerate the acid solutions. According to the metal concentration, a specific ratio of oxalic acid will be added. Most of the iron, cobalt and nickel ions will be
removed as metal oxalate. Radioactive nuclides such as cobalt and cesium are removed together with the precipitated sludge. The radionuclide removal efficiency is excellent for cobalt but is only 10-20% for cesium. If the radioactivity exceeds 1 mSv/h and the contribution is most from cesium, the solution will be discarded and solidified with cement. The entire decontaminating solution will be solidified finally after regeneration several times, as the decontamination efficiency is obviously decreased.

In addition, the rinsing water will be collected and neutralized first, then sent to the liquid waste treatment plant for further polishing. The effluent from the liquid waste treatment plant can be recycled back to the decontamination center for reuse in some decontamination processes. The treatment process of the used decontaminating solution is shown in Figure 4.

**Figure 4. Treatment of the spent decontaminating reagents**

**BRC WASTE IDENTIFICATION**

There is a BRC Waste Measuring Center under planning for construction. The radioactivity of metal scraps will be roughly checked in-situ after decontamination. If the activity still exceeds the BRC limit after cleaning twice, the metal scraps will be returned to the storage house and be categorized as the low-level waste. The cleaned metal scraps will be sent to the BRC Waste
Measuring Center for further identification. If the activity is proved over the regulatory value, the metal scraps will be also sent back to the storage house as low-level waste. The identified RBC wastes with required documents will apply to the government authority for the final check before reuse or release.

FUTURE WORK

The detail design of decontamination process and civil engineering is being executed. The facilities will be established within two years. After obtaining the facilities operation permit from the government authority, metal scraps will be decontaminated and melted for further reuse. If the public acceptance for BRC waste is still questionable, the cleaned metal scraps will be melted for volume reduction and stored in a site with a little guard. All experiences will be a valuable reference for dealing the NPP decommissioning metal wastes in the future.

REFERENCES