

Electrochemical Decontamination of Metallic Wastes

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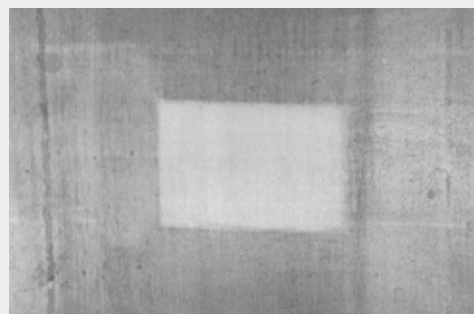
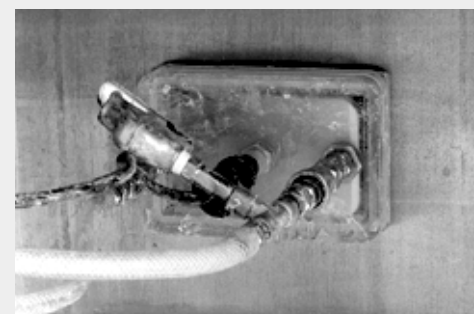
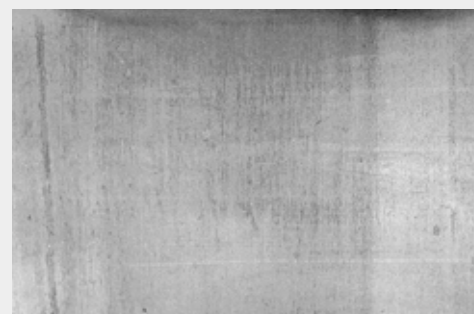
Currently, metal items such as glove boxes, tools, special nuclear material storage containers, etc. make up a significant fraction of TA-55's TRU solid waste volume. Research and development at TA-55 has led to a technique that decontaminates metal surfaces by electrochemically etching away atomic layers of the base metal. The cleaned metal can then be disposed as low-level waste.

In concept, the technique is similar to the industrial techniques of electropolishing and electrolytic cleaning. In electropolishing, the metal to be polished is made the anode (positive electrode) of an electrolytic cell. As current flows through this cell, a relatively thick viscous layer of reaction products from dissolution of the metal surface is generated. Diffusion of the dissolved metal ions through this film becomes rate limited, resulting in a microscopic smoothing of surface features. In contrast to electropolishing, electrolytic cleaning makes the surface the cathode (negative electrode) of an electrolytic cell. When current is passed through the cell, copious volumes of hydrogen gas are evolved and a highly caustic environment is created at the metal-solution interface. The caustic interface weakens the interaction between the metal surface and surface grime. The evolving gas that nucleates beneath and around surface dirt and grime aids to break it free of the surface, cleaning but without otherwise changing the surface of the metal.

The methodology developed at TA-55 for decontaminating stainless steel surfaces has features of both electropolishing and electrolytic cleaning. The electrolyte contains a moderate concentration of a sulfate salt at an elevated pH of 10 to 12. The metallic object to be cleaned is made the anode. Current sent through the cell results in water oxidation, and the evolution of oxygen gas serves to lift particulates from the surface. The generation of hydronium ions lowers the local solution pH, allowing the metallic cations to remain soluble near the interfacial region and improving the uniformity of the metal surface dissolution. Stainless steel surfaces treated in this manner are uniformly etched.

To recycle the electrolyte solution, the radioactive and other metal cations must be removed. Because both iron and nickel cations are insoluble in alkaline sodium sulfate solution, the electrolyte is maintained at a high pH through the continuous addition of small quantities of a base like sodium hydroxide. The formation of metal hydroxide precipitates is key to the electrolytic decontamination process. Not only does the precipitation facilitate the removal of these elements from solution, but the precipitate also entrains or "captures" the actinide particles that have been released from the metal surface. In a succeeding step, mechanical filtration of the electrolyte solution decontaminates the electrolyte.

Chromium is a constituent of stainless steel alloys, but unlike divalent and trivalent iron and nickel, the hexavalent chromate does not precipitate in basic solution. Chromate is removed from solution by a secondary process in which the hexavalent chromium is reduced by addition of ferrous sulfate to a trivalent oxidation state, which in turn precipitates as chromium hydroxide $\text{Cr}(\text{OH})_3$. Filtration of the electrolyte solution then provides a compact metal hydroxide residue for discard while the filtrate is returned to the process for reuse.



Electrochemical decontamination (top photo) can be used to remove actinides from metal surfaces such as glove boxes. The series of three photographs shows a contaminated metal surface before cleaning, with the portable electrolysis head attached, and after cleaning.