Decontamination of Uranium Contaminated Metals – 15 Years of Experience - 15528

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ABSTRACT

Uranium contaminated waste is somewhat of a special case among radioactive waste as the uranium, if enriched, also is a valuable asset.

Incineration and pyrolysis of uranium contaminated dry active waste (DAW) was covered during WM'14. Uranium contaminated metals is however somewhat different when it comes treatment and recovery of uranium. Since the late 1990s the Metals Treatment and Recycling Facility in Studsvik Sweden has treated approximately 1500 tonnes of metals contaminated by uranium. Depending on the metal, melt-decontamination may or may not be a way of salvaging metals if the pre-treatment was not enough. The only metals that currently are subject to melt decontamination are iron based materials as well as lead. Other metals such as aluminium, brass and copper must all be cleaned prior to melting.

Recovery of uranium from the secondary waste is most likely economically feasible only from the first step, the pre-melting decontamination, as the slag is just that, a slag, which is molten at a high temperature, and thereafter cooled under non-controlled conditions so uranium is trapped inside in an unspecified chemical form.

This paper will describes experiences and lessons learned from 15 years of treatment, including melt-decontamination, of uranium contaminated metals.

INTRODUCTION

Materials and waste from facilities governed by a nuclear license like nuclear fuel factories need in at least most countries either to go through a clearance and exemption process or be disposed as radioactive waste.

Proper treatment of metals contaminated with uranium may usually give an opportunity to separate the uranium to such an extent that the metals can either be subject to general or conditional clearance or volume reduction combined with reclassification of LLW to VLLW. The target is in most cases to meet the criteria for conditional clearance followed by recycling back to the conventional metal industry.

Recycling of metals from the nuclear industry is in many countries common practice and in other countries not. Decontamination of metals is a necessity before any metal contaminated above the threshold values can be recycled. In some cases, with some nuclides, waiting is a form of decontamination as the radioactivity decays. For long-lived nuclides like uranium awaiting decay is not an option.

Most nuclides has to be removed from the metals before melting but some nuclides, among them uranium in steel, can be removed from the metals during melting.

THE STUDSVIK MELTING FACILITY

Treatment of metals by melting started in Studsvik in 1987 as a joint initiative by Studsvik and the regulators in Sweden. However, uranium contaminated metals was not the main target. The overall aim of the treatment was do recycle metals from nuclear installations instead of disposing of them in the final repository and use space that could be utilised better for other wastes. Later on environmental and sustainability aspects governed by the Waste Hierarchy has been added.

During the years the facility and the operations has developed by extending the facility with cutting and sorting halls, a new and large furnace hall, installation of decontamination units as well as advanced cutting equipment for large components. Treatment methods as well as the number of different metals possible to treat for clearance has also developed over the years. The installation of advanced decontamination technology in year 2000 increased the potential for clearance of metal after treatment significantly.

According to the permit for the metals treatment facility Studsvik can only accept metals with uranium contamination with enrichment up to 5% U-235.

PROCESS DEVELOPMENT – TREATMENT OF URANIUM BEARING METALS

In the early days treatment of uranium contaminated metals only included cutting, melting, casting, sampling and measurement of said samples for analysis and calculation of the total uranium content. This was fine as long as the contamination was low enough to make the metals released from regulatory control with just limited separation of the uranium elements.

When the market interest for treatment of uranium contaminated metals start to grow a research and development program was started within the Studsvik group. The theoretical studies by experts combined with laboratory tests and later on full scale tests resulted in a method for treatment of uranium contaminated steel orders of magnitude higher than the clearance levels. The new method was taken into operation in the late 1990s.

The full attention has been on steel based materials as those metals are the dominating metals in the actual segments within the industry which generate uranium contaminated metals.

A proper combination of the available methods can, more or less, guarantee that the radiological release levels can, independent of incoming specific activity, be reached for uranium contaminated steels.

REGULATORY FRAMEWORK

The regulatory framework for the metal treatment has to large extent remained the same even though stricter requirements has been introduced over time. This applies to all types of regulatory requirements including nuclear, workers safety and environmental protection.

The only area in which the regulatory requirements have been somewhat released if for clearance. This applies mainly to certain alpha emitting nuclides as the uranium elements and to some pure beta emitters. This is due to that the initial domestic clearance criteria was replaced by the implementation of a license based on EC recommendation RP-89 [1]. RP-89 clearance criteria is based on a nuclide specific system in which each nuclide is given a specific clearance level. If there are more than one radioactive nuclide in the material, the nuclides are added together as fractions of their specific clearance level.

The current license is based on conditional clearance which means a controlled reuse. The specific conditions requires that the cleared material –in the form of ingots – must be mixed or alloyed with metals not origin from cleared metals from the nuclear industry.

SAFEGUARD

All material containing uranium has to, in accordance with Swedish and European legislation, be registered as Safeguard materials. Studsvik will as nuclear licence holder be responsible for the fissile material as long as it is within the Studsvik site.

As the uranium concentration increases during treatment, due to the transfer of the uranium to the secondary waste, and by then the precision in the measurements, the inventory values may change in the treatment process even though the real inventory remains the same.

PURPOSE WITH TREATMENT OF URANIUM CONTAMINATED WASTE

Treatment of contaminated metals can have many different purposes. The obvious one is the recovery of the metals for reuse inside or outside the nuclear industry. Another is that treatment of uranium contaminated metals can make it possible to recover the uranium removed from the surfaces.

Other purposes could be and which may apply to uranium contaminated non-iron metals is to reduce the volume and by then the surface of the waste or to bind the uranium in the metallic structure of any purpose.

The primary reason to reduce the volume is normally to reduce the storage and disposal costs. Reduction of surface is more related to gas generation and release or radioactivity due to corrosion.

TREATMENT RESULTS

In total approximately 1500 tonnes of uranium contaminated metals have been treated. Approximately 90% of the metal has been subject for conditional clearance. Considering only the iron based metals which is the main portion of the material treated the clearance ratio is close to 100%. Even lower uranium concentrations can be achieved at the cost of increased secondary waste volumes. The average secondary waste is in the order of 5% on weight.

Taking benefit of the rich experience a graded approach has been implemented which has reduced the generation of secondary waste.

By certain pre-treatment a significant percentage of the uranium can be removed in a form which opens up for recovery and recycling of the uranium.

It must be underlined that failures in the segregation of the materials prior to melting can eliminate the attempts to separate the uranium from the metal.

RADIOACTIVITY DETERMINATION

Determination of uranium content on equipment is usually is a fairly imprecise and time consuming operation. To be on the safe licensees implement safety margins which reduces the clearance possibility.

By melting the uncertainties can be reduced significantly as the metal bath, after the completion of the melt decontamination process is completed is homogenised. A sample taken in the melting bath according to the established procedures is proven to be representative of the full melting batch.

The samples taken are sent for gamma analysis after preparation. In parallel samples are taken for alpha spectroscopy analyses. Normally will collective samples be fine for metals coming from the nuclear fuel chain.

An important part of the determination of the nuclide specific radioactivity content is to verify or define the nuclide vector. For uranium waste the enrichment is of prime interest. For other contaminants than uranium every melt is measured for gamma nuclides with a standard detector. In order to measure low concentrations of uranium correctly long measurement times are needed. For the secondary waste full drum scanning for gamma emitting nuclides combined with sampling for determination of alpha emitting nuclides other than uranium. The uranium content is calculated using the enrichment value.

SECONDARY WASTE MANAGEMENT

The inventory of fissile radionuclides, in this case U-235, put certain requirement on the secondary waste management as criteria apply on either total of amount of U-235 per package or the maximum concentration of U-235 inside a package.

For conventional packages the limitations put quite a lot of restrictions on how the secondary waste can be packed. This impact increases with the uranium concentrations in the material sent for treatment.

CONCLUSION

The technology for separation of uranium from steel and steel alloys is today well established and well proven. The successful treatment of steel, i.e. to meet the clearance conditions for recycling, can today almost be guaranteed.

Very low uranium concentrations can be reached but at the cost of an extended processing and an increased amount of secondary waste.

Taking benefit of the experience and the process knowledge built up the process has been possible to optimise based on a graded approach.

REFERENCES

[1] COMMISSION OF THE EUROPEAN COMMUNITIES
Recommended radiological protection criteria for the recycling of metals from the dismantling of nuclear installations, Radiation Protection No. 89, 1998.