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A Modern Depleted Uranium Manufacturing Facility

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INTRODUCTION

The Specific Manufacturing Capabilities (SMC) Project located at the Idaho National Engineering Laboratory (INEL) and operated by Lockheed Martin Idaho Technologies Co. (LMIT) for the Department of Energy (DOE) manufactures depleted uranium for use in the U.S. Army M1A2 Abrams Heavy Tank Armor Program. Since 1986, SMC has fabricated more than 12 million pounds of depleted uranium (DU) products in a multitude of shapes and sizes with varying metallurgical properties while maintaining security, environmental, health and safety requirements.

The SMC project began in 1983 as a 'black' project with strict national security requirements. The high level of project security and classification impacted initial facility construction by limiting communication with other depleted uranium manufacturing facilities. As a result, many aspects of facility construction were based on a best effort design that has proven over time to be successful in maintaining security, safety and radiation control.

During the time of initial facility design in the early 1980's, emphasis on employee safety, radiation control and environmental consciousness was gaining momentum throughout the DOE complex. This fact coupled with security and production requirements forced design efforts to focus on incorporating automation, local containment and computerized material accountability at all work stations. The result was a state-of-the-art (at that time), fully automated production facility engineered to manufacture DU armor packages with virtually no human contact while maintaining security, traceability and quality requirements. This hands off approach to handling depleted uranium resulted in minimal radiation exposures and employee injuries.

Construction of the manufacturing facility was complete in early 1986 with the first armor package certified in October 1986. Rolling facility construction was completed in 1987 with the first certified plate produced in the fall of 1988. Since 1988 the rolling and manufacturing facilities have delivered more than 2600 armor packages on schedule with 100% final product quality acceptance. During this period there was an annual average of only 2.2 lost time incidents and a single individual maximum radiation exposure of 150 mrem.

SMC is an example of designing and operating a facility that meets regulatory requirements with respect to national security, radiation control and personnel safety while achieving production schedules and product quality.

SMC PRODUCTION FACILITIES

SMC's facilities, located at Test Area North on the INEL site, house the DU armor rolling and manufacturing operations. All radioactive material processing areas are ventilated with high efficiency particulate air-filters (HEPA) and are maintained at a negative pressure relative to atmosphere. Production lines are installed within lexan and steel enclosures that are also HEPA ventilated. The combination of double containment minimizes employee radiation exposure and virtually eliminates any potential for environmental release.

The first operation in the manufacturing process is the rolling billets to plate. The DU workpieces are salt bath heated, rolled, sheared, levelled and cleaned prior to transfer to fabrication and final assembly operations. A process flow diagram of the rolling operations is shown in Figure 1.

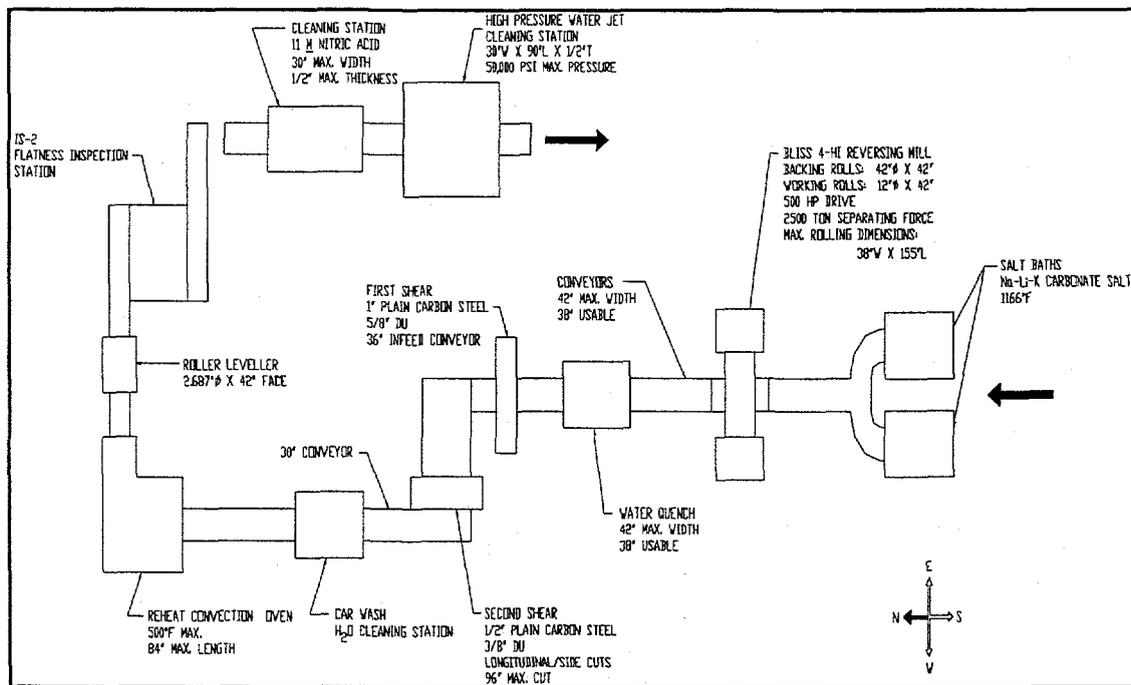


Figure 1. SMC Rolling Operation Flow Diagram

Depleted uranium workpieces are salt bath heated in dual Ajax Electric 375 kW, 2400 pound salt baths operated at 1166°F utilizing the triple carbonate eutectic salt with a nominal composition of 65% K_2CO_3 , 25% Li_2CO_3 and 10% Na_2CO_3 . Material handling is accomplished with an enclosed and ventilated billet loading station and computer controlled hoists. Billet containers are loaded into the enclosed salt bath loading station, removed with a grapple and

conveyed into salt bath baskets. Individual PLC controlled salt bath hoists load the baskets into the south end of the salt bath and index them to the north end at an operator determined time step such that billets have attained minimum required soak time prior to exit. After exiting the salt bath, the hoist transfers the basket to an unloading station and the part is loaded onto a conveyor and transferred to the rolling mill feed conveyors.

A computer controlled Bliss hydraulic four-high reversing rolling mill converts billets and slabs to plate stock. The mill is driven by a 500 horsepower motor and a Brad Foote Gear speed reducer. The 12" diameter forged steel work rolls are backed by 42" diameter back-up rolls and has a maximum rating of 2500 tons separating force. The mill is equipped with state-of-the-art controls and data collection. Some of the key features are described as follows:

1. Automated side guides align the part along the centerline of the feed conveyors. A retractable turning pin allows for part rotation during cross rolling applications. The sculptured feed tables are designed to square the leading edge of the part to the work rolls.
2. Hydraulic roll gap and roll bending control enables ± 0.003 " gage control.
3. Entry and delivery optical pyrometers monitor part temperature during the rolling process.
4. Entry and exit cesium-137 radiation thickness gages monitor and record real time part thickness and are accurate to ± 0.0005 ".
5. Computer controlled rolling schedules allows for fifty different schedules to be pre-loaded and called up by the mill operator. Rolling parameters controlled by the stored schedule are roll gap, roll bending and part entry temperature.
6. Computerized data collection records: roll gap, entry and exit temperature, separation force, conveyor speed (work roll sfpm), roll bending.
7. Computerized material control system allows for 100% traceability and material accountability.

This combination of computer process controls, automation and data collection is unique to depleted uranium manufacturing facilities in that a controlled and repeatable process has virtually no operator interaction with the workpiece. The rolling mill enclosure and ventilation is shown in Figure 2.

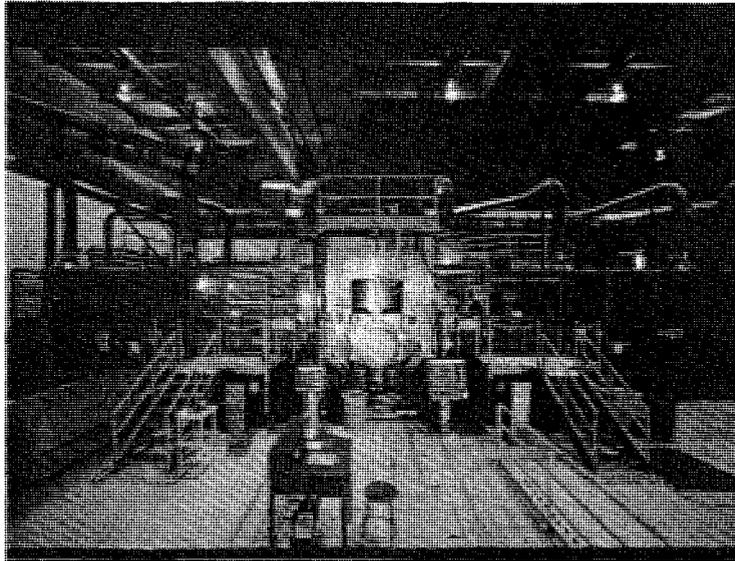


Figure 2. SMC's Bliss rolling mill and radiation enclosure.

Rolled plates are sheared on two in-line Pacific process shears. The first process shear, rated for 1" A36 carbon steel and 0.625" DU, is used for trimming the leading and trailing edges of the as-rolled workpiece. The second process shear, rated for 0.5" A36 steel and 0.375" DU, is used to size the rolled plate to width. Both shears are equipped with CNC back gage controls, centering side guides, automated scrap collection, material handling transporters and turning tables that allow for 180° part rotation.

Following rolling and shearing, plates are pre-heated in a 500°F radiant heated oven and levelled in a Herr-Voss roller leveler. The roller leveler is configured in an eight-over-nine design with 2.687" diameter work rolls and roll bending capability. Attainable flatness is 0.032" per foot and 0.25" per eight feet.

To minimize contamination in down-stream manufacturing operations and allow for surface defect inspection, plates are cleaned to remove oxide and mill scale prior to being off-loaded from the rolling facility production line. Until recently, all depleted uranium parts were pickled in 8-10 molar nitric acid. Nitric acid is very effective in removing uranium oxide and mill scale but generates an undesirable mixed hazardous waste by-product. A high pressure water jet (HPWJ) cleaning system was installed in 1994 and began operation in early 1995 that effectively removes oxide and mill scale while totally eliminating the generation of mixed hazardous waste. A second benefit of the HPWJ is the elimination of the safety hazards associated with the storage and handling of large volumes of nitric acid on site. Following HPWJ cleaning, parts are off-loaded into pallets via vacuum transporters and transferred to the fabrication operations. The end of the line part off-load station is shown in Figure 3. The cleaning operation is so effective that the external surfaces of the transfer pallets are surveyed clean and interim pallet storage is in non-radiation controlled warehouse areas.

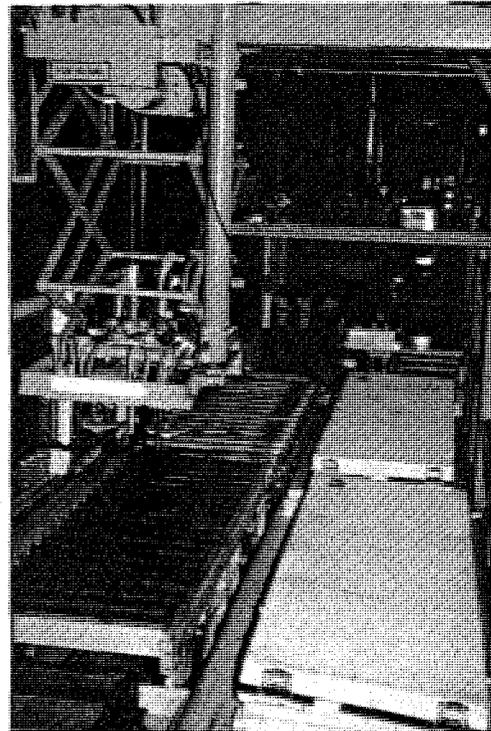


Figure 3. Part off-load station.

Several capital equipment upgrade projects are currently in progress designed to improve maintenance, capacity and efficiency. A new Pacific 1.5" shear is being procured to replace the first and second process shears combining both the length and width cuts, allowing for improved material handling, scrap collection and automated blade changes. The existing dual shear system has historically been one of SMC's largest maintenance nuisances due to tight personnel access for blade changes, scrap collection and repairs. The new shear will eliminate the need for worker entry into the enclosure for scrap box removal and shear blade rotation and change-out. This new design eliminates one more potential personnel injury hazard.

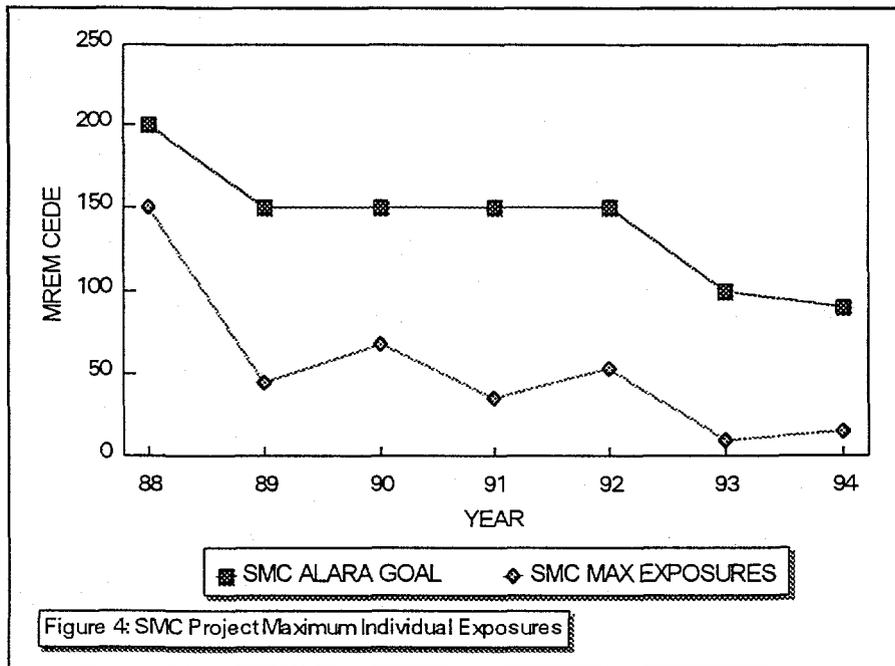
A new Wisconsin Oven radiant heater pre-heat oven and a Monarch/Stamco 3" roller leveler will replace the current preheat oven and Herr-Voss leveler. The existing preheat oven has been a high maintenance item, causing a loss of production time and unnecessary personnel radiation exposure. The new oven design improves access to heating elements and relocates rotating components out of the hot zone thus reducing personnel radiation exposures during maintenance activities.

Completion of the capital upgrade projects planned for FY '95 and '96 will decrease employee radiation exposure and minimize the risk of injury by improved equipment design, capability and location.

The fabrication facility consists of an Amada totally integrated flexible manufacturing system. This allows for receipt of a cleaned plate from rolling operations and fabrication and assembly of a final armor package with minimal personnel exposure. This is accomplished by CNC controlled equipment, automated storage and retrieval systems and computer driven 100% part traceability and quality inspection records. The manufacturing line contains enclosed and ventilated lasers, shears and punches.

HEALTH, SAFETY AND ENVIRONMENTAL ISSUES

SMC's low exposure levels to employees attest to the safety features of the production lines accomplishing the desired effect by minimizing "hands-on" contact with radioactive material.



Each piece of production equipment utilizes material handling devices such as hoists, transporters, conveyors and location sensing transducers. Equipment control for automatic feed and delivery as well as process parameter set point inputs are by computer numeric or programmable logic control. These controls allow process parameters to be stored and recalled as needed depending upon product being manufactured. The most noticeable result is two separate periods of 1 million man-hours without a lost time accident since 1988, the most recent in the last quarter of 1994.

All production lines are installed within lexan and steel enclosures that are maintained below ambient pressure. The enclosures utilize time, distance and shielding to minimize personnel radiation exposure. Time in the radiation area is reduced by requiring radiation work permits to enter enclosures. This forces effective planning and communication between safety, radiation control and maintenance personnel prior to initiating maintenance activities resulting reduced time in the radiation area and minimal personnel exposures.

The enclosure incorporates distance and shielding by increasing the distance between the worker and the DU and shielding beta radiation. The DU workpiece generates a beta/gamma radiation field of 85-100 mR/hr which is reduced to a working field of <2 mR/hr gamma by the enclosure. Finally, the enclosure contains any airborne contamination within the production line and filters it through a bank of HEPA's.

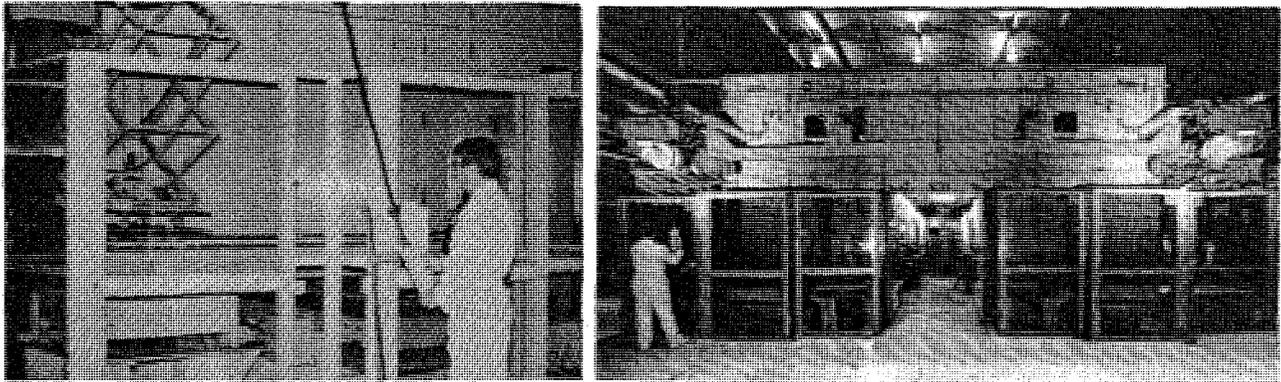


Figure 5. Operator transferring DU part into salt bath loading basket (left) and south view of salt bath enclosure (right).

SMC's production operations produce solid and liquid radioactive waste streams. Non-acidic liquid rad wastes are processed through evaporators, fractionators and calciners to remove solid particulates such as uranium oxide. The collected solids are packaged and disposed of at the INEL's low level rad waste landfill. Water recovered from the non-acidic waste stream is reintroduced into the facility as process water.

The HPWJ, a self-contained, closed-loop system, has eliminated the generation of mixed hazardous waste from the nitric acid cleaning station. However, an inventory of acidic waste from acid cleaning remains on site. It is currently being processed through the acidic waste stream calciner for removal of solids and acid recovery. The treated nitric acid will be transferred to the Idaho Chemical Processing Plant for use at that facility. The calcine generated is a mixed hazardous waste that is treated by stabilization in concrete and disposed of in the INEL low level rad waste landfill.

SMC's depleted uranium feed stock is also a closed-loop, recycled system. Initially, all project DU feed stock was cast from virgin derby material. Derby is the term for uranium metal reduced from UF_4 . After consumption of the initial DU procurement, a recycle effort was initiated to reprocess usable DU scrap into feed stock. DU process scrap was segregated and shipped to a commercial vendor for remelting and casting. Presently, all DU feed stock billets at SMC are second generation recycle with no virgin derby additions. It is anticipated that all of the U.S. Army's armor requirements can be accomplished with third generation recycled depleted uranium.

CONCLUSION

In today's environment of increased safety awareness, our experience indicates that proper planning for radiation control and personnel safety can create a work atmosphere free from hazards while maintaining large production capacity and national security requirements. Nine years of operations at the SMC has demonstrated that the time and money spent on initial design and construction activities can eliminate cost and schedule impacts of responding to future regulatory requirements.

ACKNOWLEDGEMENTS

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