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Y-12 NATIONAL SECURITY COMPLEX U-MO FABRICATION FOR MP-1

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ABSTRACT

Y-12 National Security Complex (Y-12 NSC) participates in the Fuel Fabrication Capability (FFC) pillar of the National Nuclear Security Administration (NNSA) Office of Material Minimization and Management (M^3) Office of Conversion Pillar system. Y-12 NSC is primarily responsible for the establishment of the fabrication process for the low-enriched uranium-molybdenum (LEU-Mo) feedstock. The report will focus on the efforts and status of fabricating feedstock in support of the Mini-Plate (MP)-1 experiment.

1. Introduction

The Reduced Enrichment for Research and Test Reactors (RERTR) Program was initiated by the U.S. Department of Energy (DOE) to develop the technical means for the conversion of high powered research reactors (HPRRs) from Highly Enriched Uranium (HEU) to Low Enriched Uranium (LEU). The RERTR program cooperates with the research reactor community to achieve this goal of HEU to LEU conversion while maintaining reactor reliability and performance. The Y-12 National Security Complex (Y-12 NSC) is a participant in the NNSA NA-23, Office of Material Management and Minimization's Convert Program, also known as RERTR, by performing development activities, supporting low enriched uranium (LEU)-molybdenum (Mo) research, and performing Uranium (U)-Mo production activities in casting and machining.

2. Program Scope

The NA-23 Office of Material Management and Minimization Reactor Conversion Program funded the Y-12 NCS to fabricate DU-Mo ingots in support of the Mini-Plate-1 (MP-1) experiment. This effort consists of manufacturing DU-Mo, LEU-Mo and HEU-Mo ingots using the process of shown in Figure 1. Y-12 first acquires a U-Mo Feedstock (UMoF). The UMof is fabricated by blending a depleted uranium feed with molybdenum. This can be done by either arc melting or by a vacuum induction melting. This is typically performed at an off-site location. For the DU-Mo ingot fabrication, Aerojet provided the UMoF. For the LEU-Mo and HEU-Mo fabrication, Los Alamos National Laboratory (LANL) provided the UMoF. The UMoF is then blended with uranium feed in a vacuum induction melting process. The temperature is taken to 1400^{o}C and held for 30 minutes.

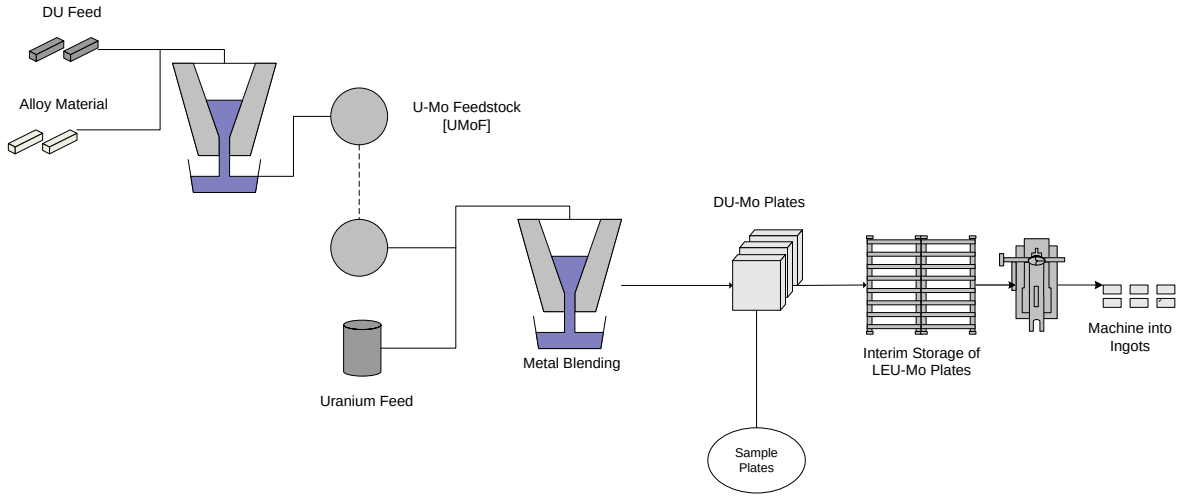

Figure 1: MP-1 Fabrication Process

3. MP-1 Fabrication Status

Y-12 NSC fabricated DU-Mo ingots as described in Figure 1. The melt temperature profile for three DU-Mo Plate castings is shown in Figure 2.

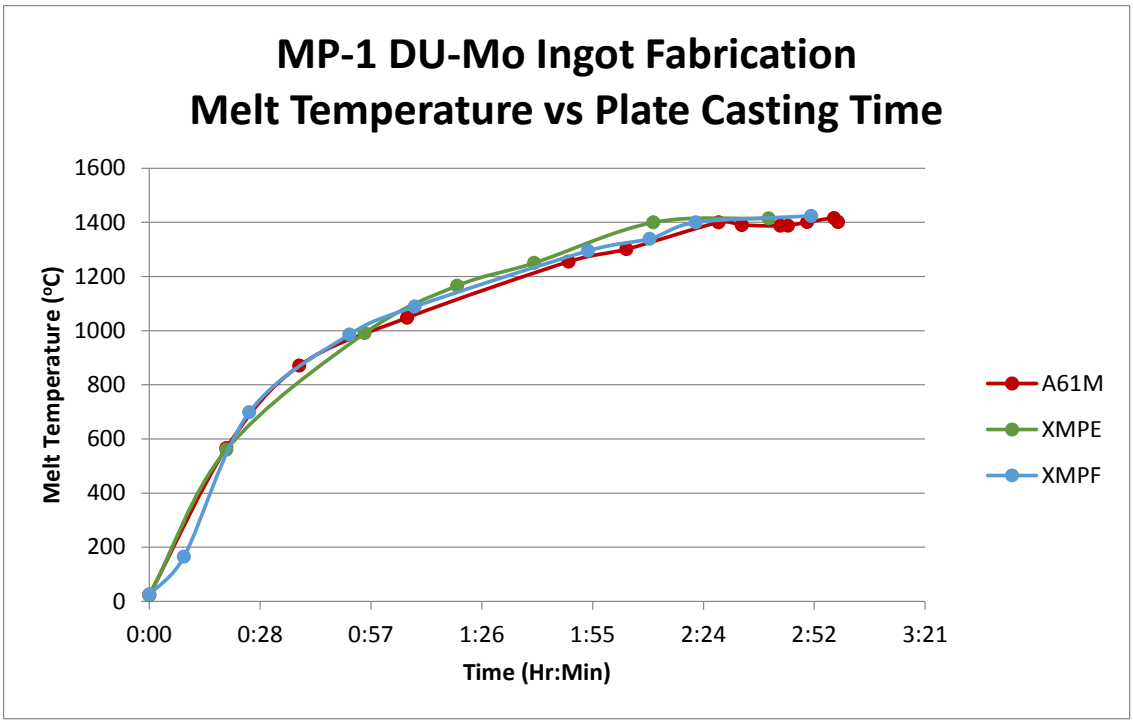

Figure 2: Nominal Melt Temperature Profile for DU-Mo Fabrication

The melted material was then poured into a multi-plate book mold, as shown in Figure 3. The melt yields three single plates that are approximately 8” by 11” by 0.2”. A representative plate with the hot top removed is shown in Figure 4.

Figure 3: MP-1 Casting Mold

Figure 4: MP-1 Cast Plate

The cast plates are then sectioned into ingots, as shown in Figure 5. The hot top is removed and a strip of cast material in the center provides material for sampling.

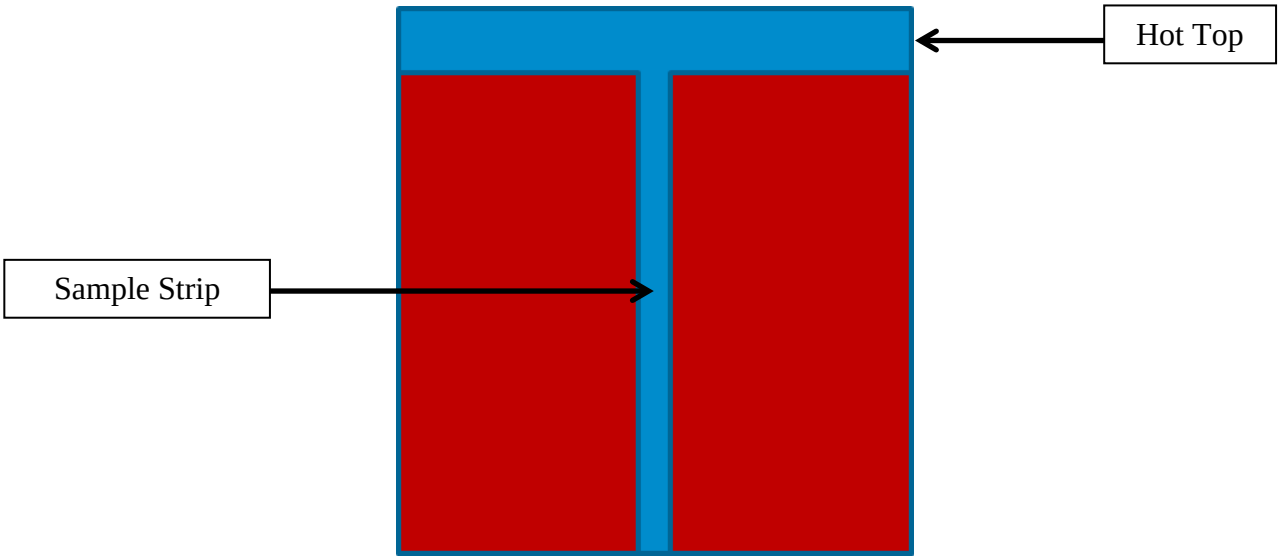

Figure 5: Ingot Sectioning Schematic

As the DU-Mo ingots were sectioned from the plates, samples were taken from the center strip, which is representative of the ingot chemical make-up. Samples were taken from the top, middle and bottom of each plate. The chemical analyses were compared to target. For molybdenum, the target was 10% ± 1%. For Uranium, the target was 90% ± 1%. Results are shown in Figures 6-11.

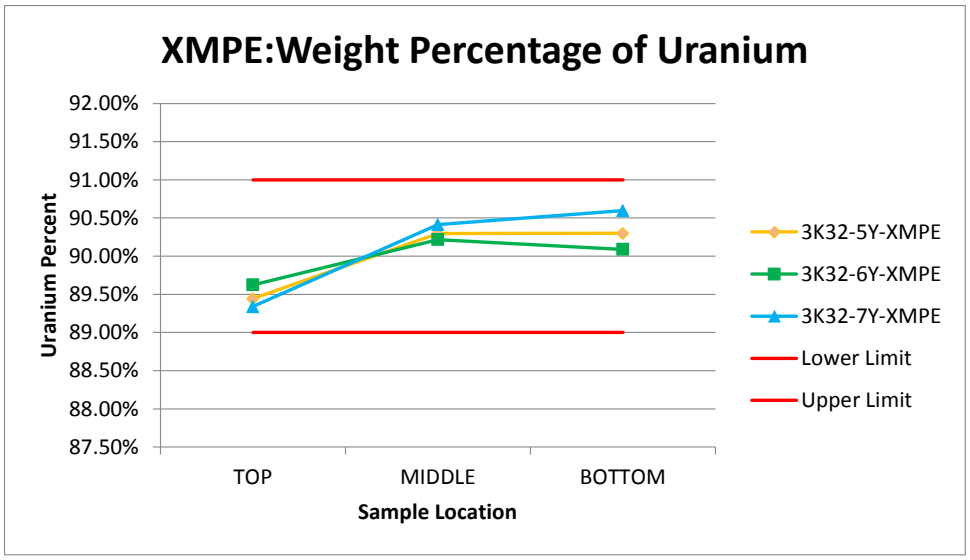

Figure 6: Uranium Weight Percentage in Plate Group XMPE

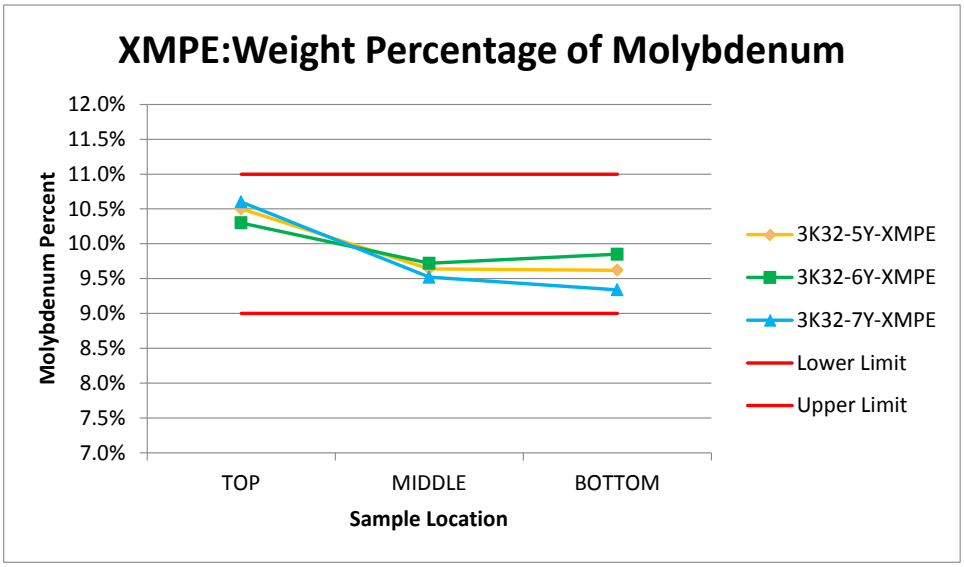

Figure 7: Molybdenum Weight Percentage in Plate Group XMPE

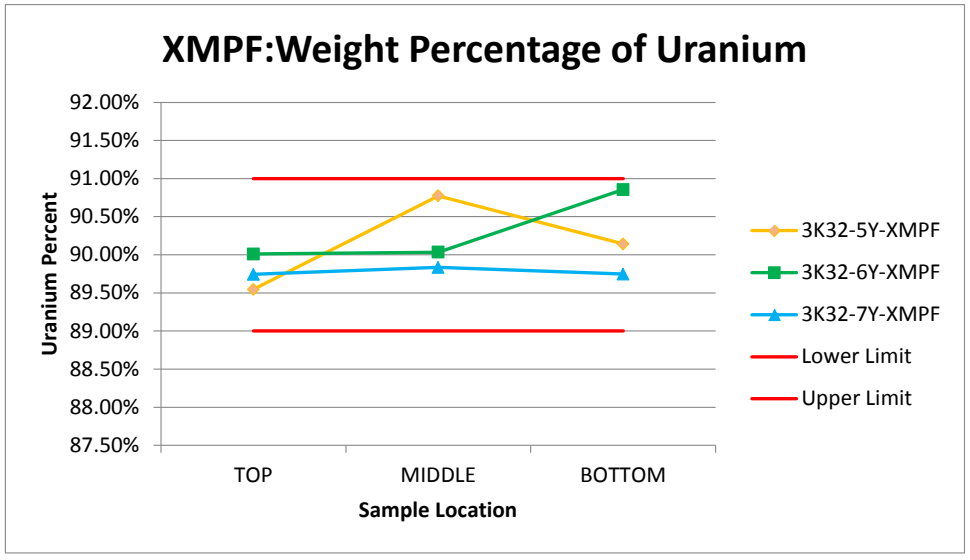

Figure 8: Uranium Weight Percentage in Plate Group XMPF

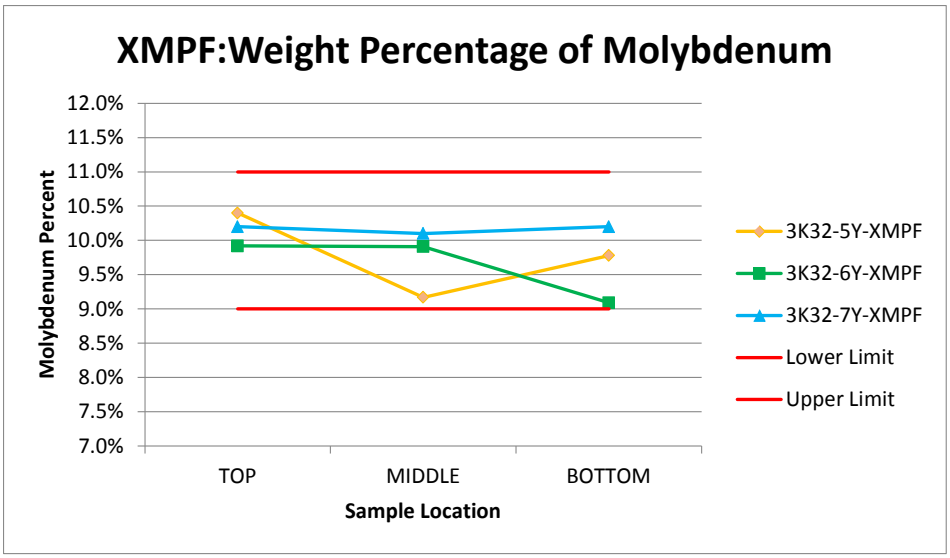

Figure 9: Molybdenum Weight Percentage in Plate Group XMPF

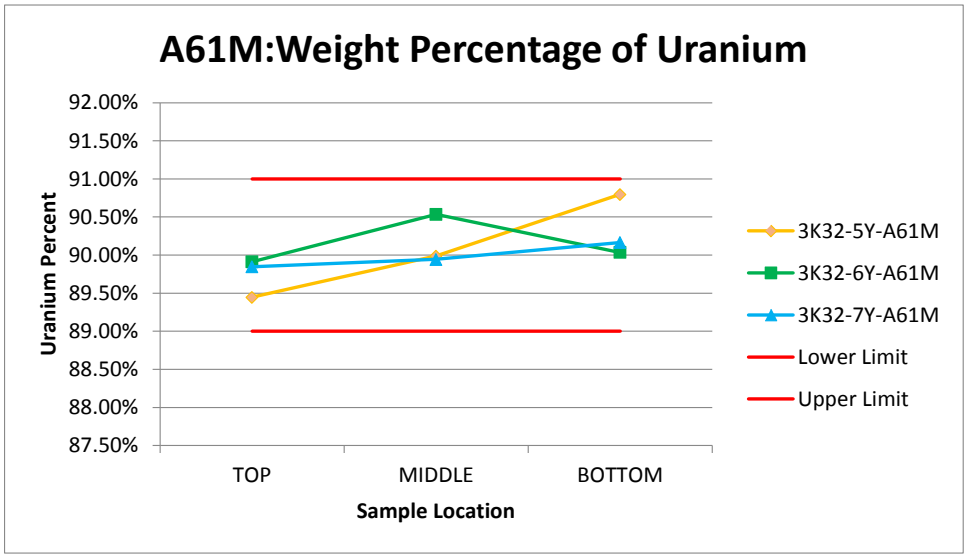

Figure 10: Uranium Weight Percentage in Plate Group A61M

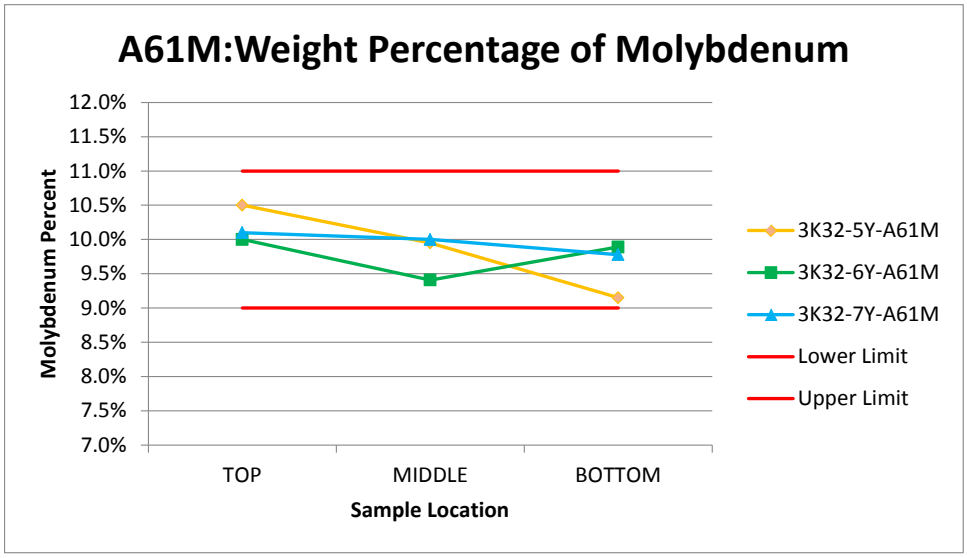

Figure 11: Molybdenum Weight Percentage in Plate Group A61M

The material fabricated in the trial campaign was planned at 10% molybdenum and 90% uranium. All castings were within the target molybdenum and uranium ranges.

4. Process Loss Information

	Average Unit Operation Loss
Plate Casting	3.8%
Machining	25.6%
Total Loss	**29.4%**

Table 1: Operational Loss information from DU-Mo Ingot Fabrication

Y-12 NSC was able to monitor process losses throughout the DU-Mo fabrication. The total fabrication losses averaged 30%, as shown in Table 1. Casting losses, such as skull loss and leakage, accounted for approximately 4 % of the loss. Machining losses from hot top removal, deburring, sectioning and the sample strip accounted for approximately 26% of the loss.

In reviewing the process losses, Y-12 NSC estimates that 26% of the fabrication losses can be recycled. The hot tops, which are approximately 14% of the fabrication loss, and the sample strips, which are approximately 10% of the fabrication loss, may be recycled into the casting stream. The saw fines, which are approximately 2% of the fabrication loss, may be consolidated, melted and then recycled.

With information gained on the DU-Mo ingot fabrication, Y-12 NSC began casting activities for the LEU-Mo ingot fabrication, which is currently in progress. Based upon knowledge gained during the DU-Mo fabrication, Y-12 NSC is collaborating with LANL to optimize the multi-plate book-mold to improve casting properties. Y-12 NSC is also examining the shearing process as an alternate method of sectioning. The shearing process would eliminate saw fines and provide fabrication efficiencies.

5. Summary

Y-12 NSC completed fabrication of DU-Mo ingots in support of the MP-1. Based on the result of the fabrication, Y-12 NSC obtained information needed for transferring process activities to LEU-Mo production facility. Y-12 NSC began the LEU-Mo ingot fabrication which will continue in the fourth quarter of CY 2015.