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REDUCED ENRICHMENT FOR RESEARCH AND TEST REACTORS

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Y-12 NATIONAL SECURITY COMPLEX U-MO FABRICATION

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ABSTRACT

Y-12 National Security Complex (Y-12 NSC) participates in the Fuel Fabrication Capability (FFC) pillar of the U.S. Department of Energy's (DOE) National Nuclear Security Administration (NNSA) Global Threat Reduction Initiative (GTRI) Convert Pillar system. Y-12 NSC is primarily responsible for developing the fabrication process of a low-enriched uranium-molybdenum (LEU-Mo) feedstock. The baseline LEU-Mo fabrication process included a two-step casting process. Y-12 NSC is examining the feasibility of transitioning to a single step casting process. This presentation will focus on the transition strategy and discuss initial results from the feasibility trials.

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-21 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.

The LEU-Mo Baseline Coupon Fabrication Process is a two-step casting process, as depicted in Figure 1. First, HEU is blended with a diluent and molybdenum in an initial cylindrical casting. The cylindrical casting is sampled and analyzed. Based on the analytical results, the feed is adjusted and recast or the alloy is then broken and recast into a single plate form. The LEU-Mo coupons are fabricated from the plate casting. This process has a large molybdenum distribution range, typically from 8% to 12%, resulting in a higher than desired reject rate. One theory is that the initial casting step has too many process variables in a one unit operation to provide a repeatable and predictable casting. Y-12 NSC is experimented with Alternate LEU-Mo Casting Process using a pre-alloyed diluent feedstock, labeled as UMoF, and a multi-plate casting form, as depicted in Figure 2.

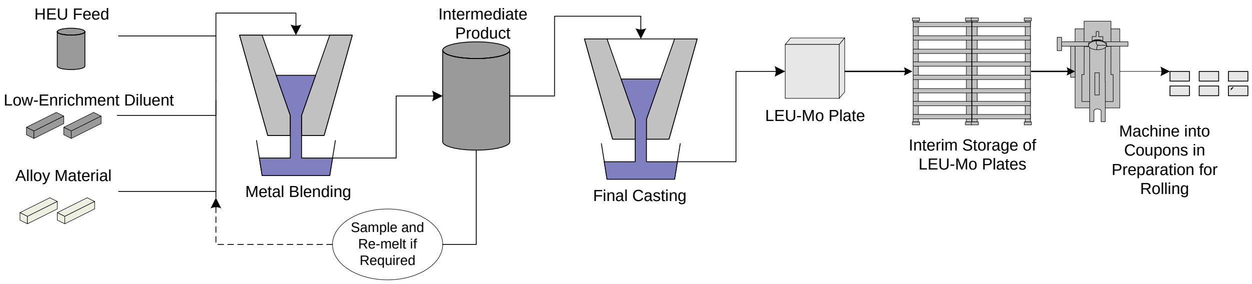

Figure 1: Baseline Coupon Fabrication Process

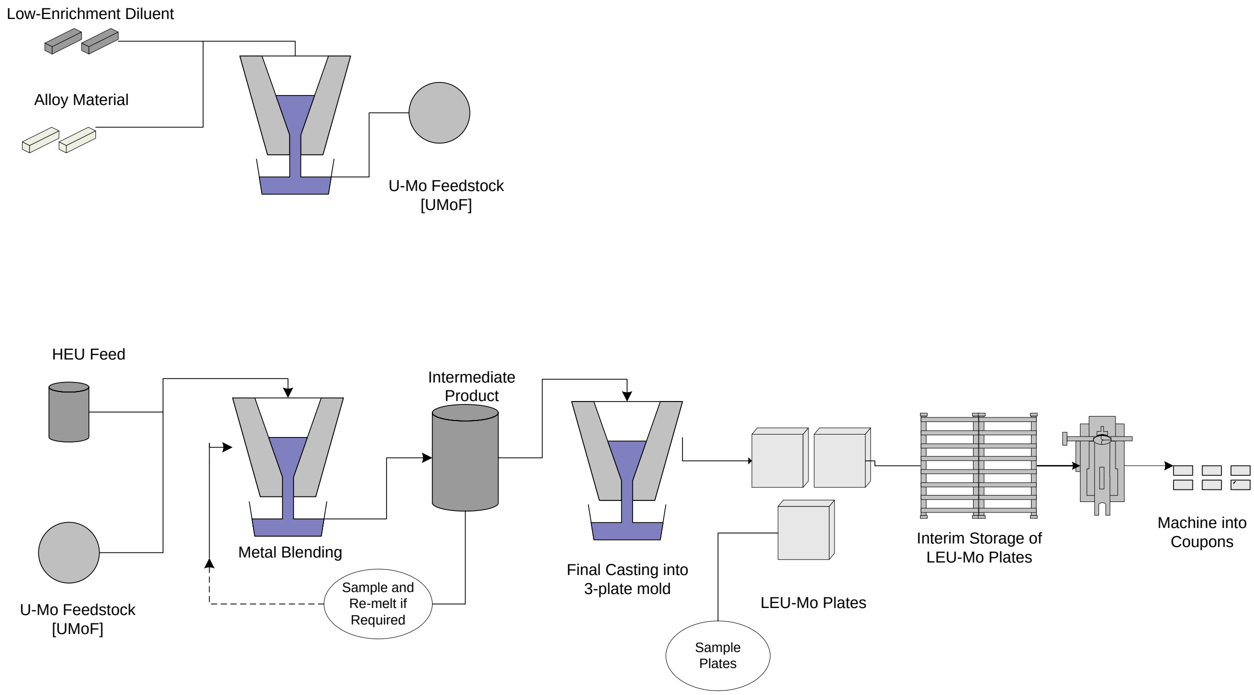

Figure 2: Alternate LEU-Mo Casting Process

Previous trials of the alternate casting process indicated there was a greater control of process parameters by pre-alloying the diluent. The alternate casting process also indicated that the Mo and uranium-235 (U235) distribution throughout the casting were more uniform, indicated a tighter process control of material constituents. In addition to using a pre-alloyed diluent, the alternate casting process indicated that a multi-plate mold could be used to increase throughput of material.

In an effort for continuous improvement in both cost reduction and scrap reduction, Y-12 NSC experimented with a Proposed Optimized Casting Process, as shown in Figure 3, based on promising results from the alternate casting process. A series of castings were performed by eliminating the intermediate cylindrical casting step.

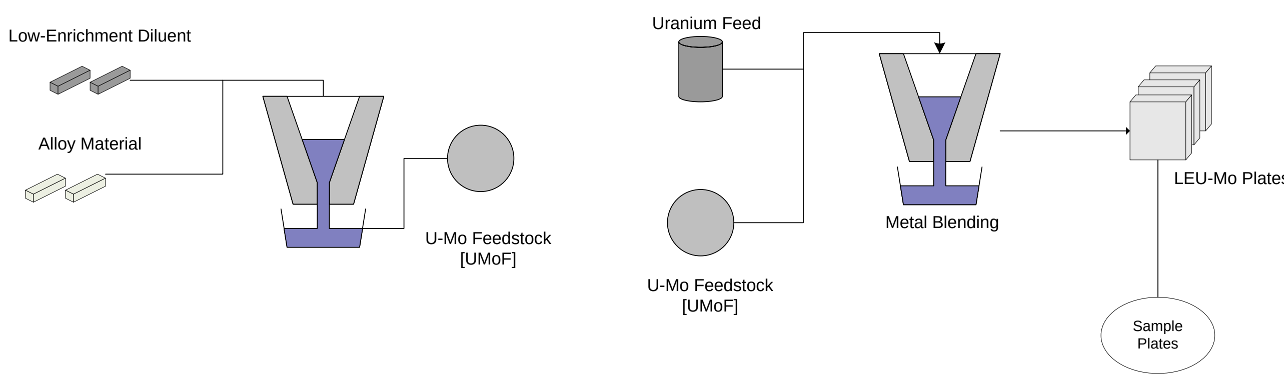

Figure 3: Proposed Optimized Casting Process

2. Description of Trial Campaign

As part of the trial campaign, Y-12 fabricated DU-Mo plates in accordance with Figure 3. The plates were sectioned and machined into coupons as previously performed in the Baseline

Coupon Fabrication Process. The trial campaign consisted of five castings. A sixth casting was performed to account for fabrication attrition. This trial campaign assumed there was no attrition for cast surface defects. The intent of assuming no attrition was to allow the final fabricator to process all of the coupons and provide feedback to determine the true defects of coupons that lead to foil failures during the fabrication process.

3. Progress of Trial Campaign

Y-12 completed the casting activities as described in Figure 3, which yielded eighteen plates. As the DU-Mo coupons were sectioned from the plates, samples were taken from the milled plate, which is representative of the coupon 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 for each casting batch are shown in Figures 4-15. Summary charts are shown in Figures 16 and 17.

Date of Casting	Identification
8/20/13	W7RP
8/26/13	W7RT
12/9/13	WCRJ
12/17/13	WDCM
12/19/13	WDCN
12/26/13	WDCP

Table 1: Casting Dates

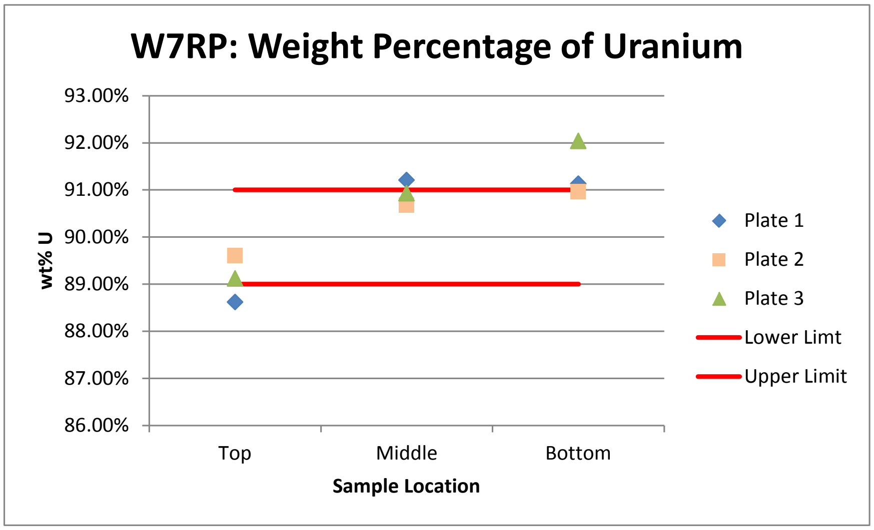

Figure 4: Uranium Weight Percentage in Plate Group W7RP

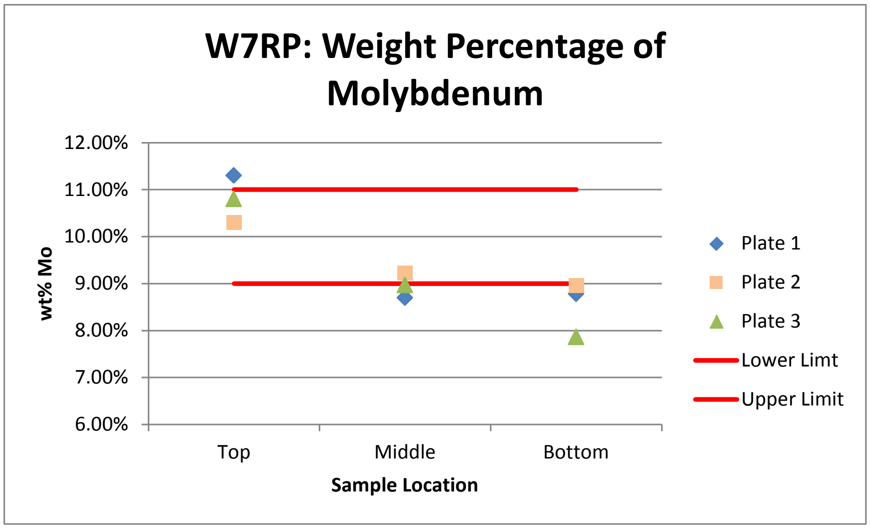

Figure 5: Molybdenum Weight Percentage in Plate Group W7RP

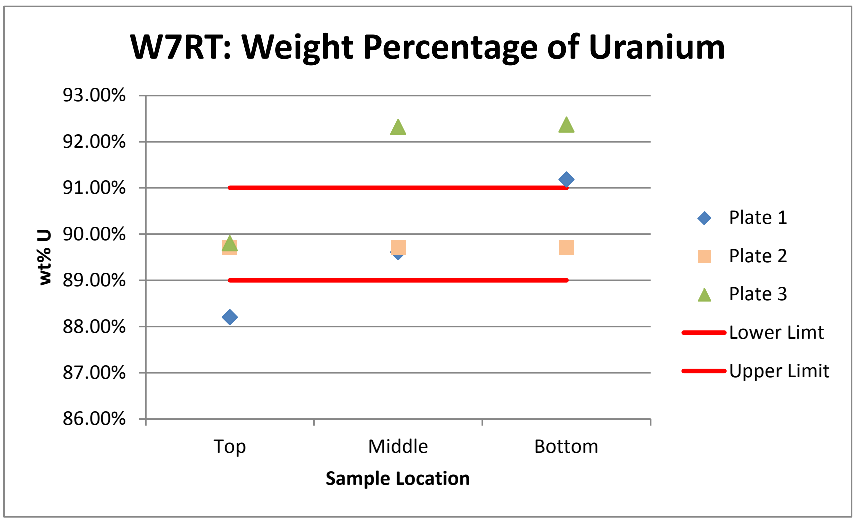

Figure 6: Uranium Weight Percentage in Plate Group W7RT

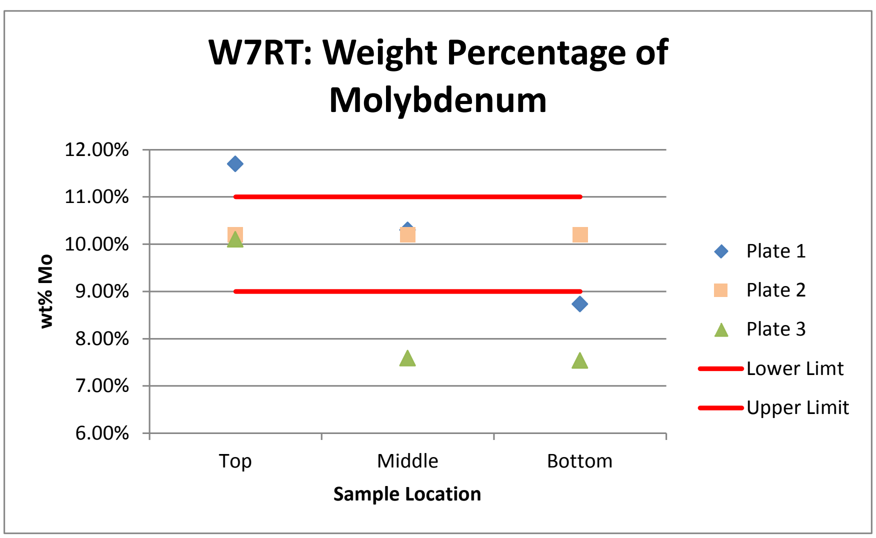

Figure 7: Molybdenum Weight Percentage in Plate Group W7RT

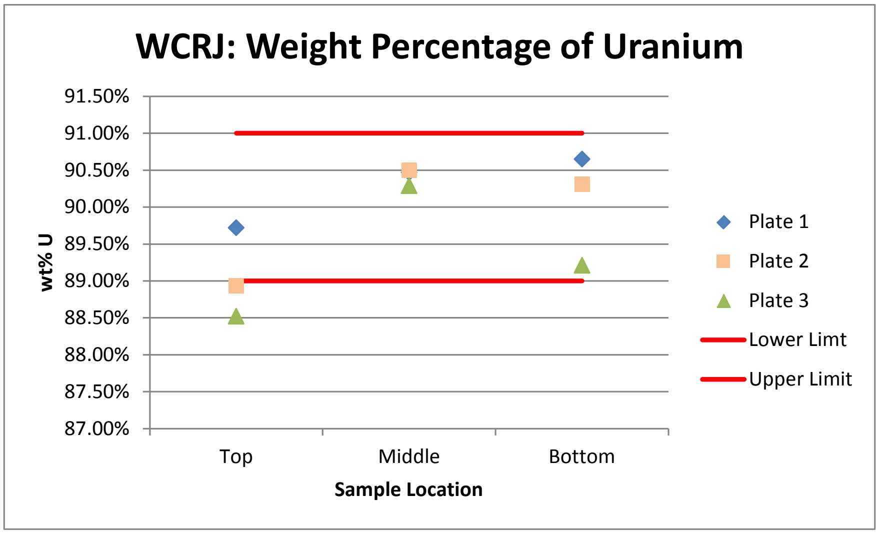

Figure 8: Uranium Weight Percentage in Plate Group WCRJ

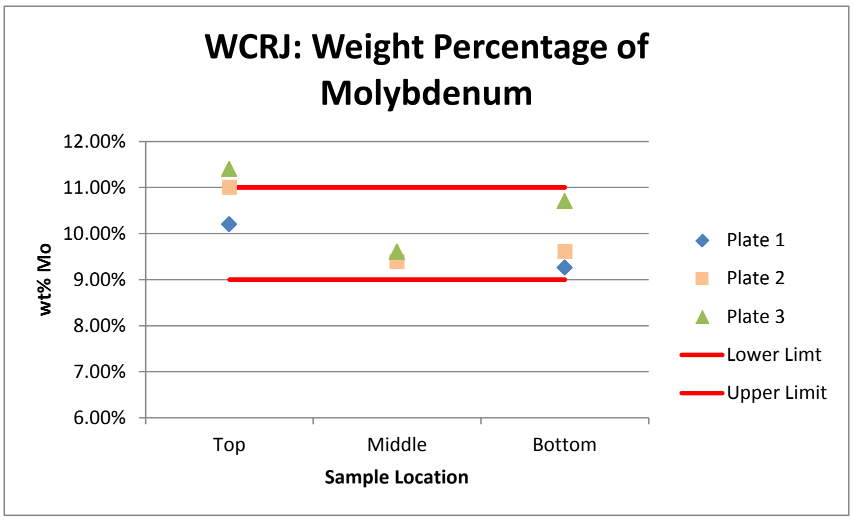

Figure 9: Molybdenum Weight Percentage in Plate Group WCRJ

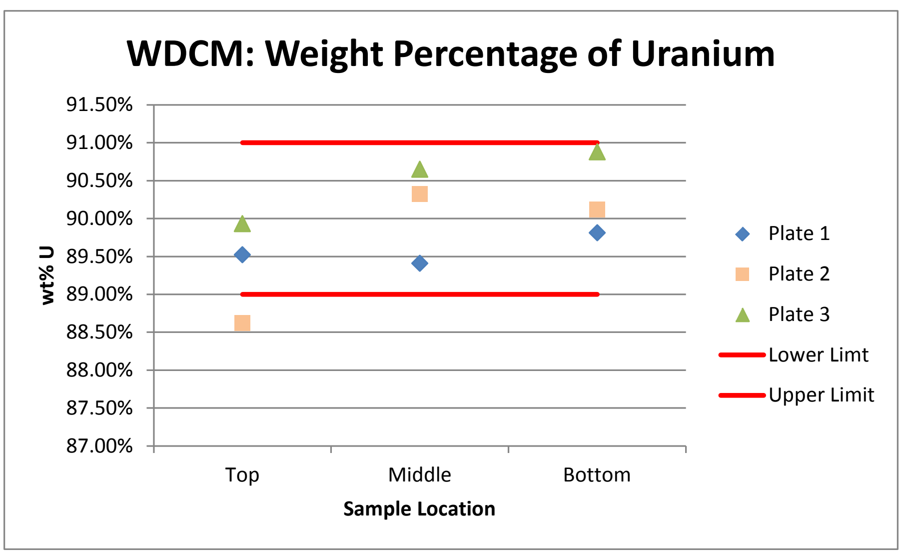

Figure 10: Uranium Weight Percentage in Plate Group WDCM

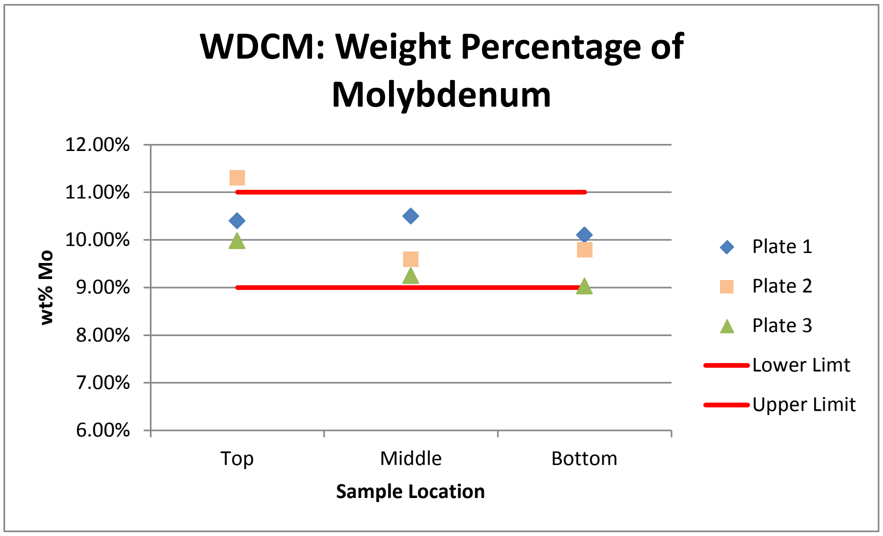

Figure 11: Molybdenum Weight Percentage in Plate Group WDCM

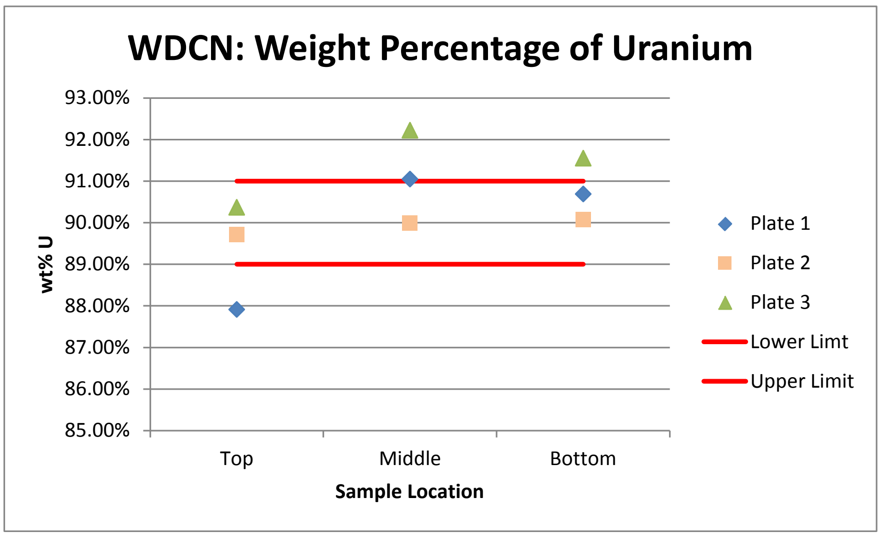

Figure 12: Uranium Weight Percentage in Plate Group WDCN

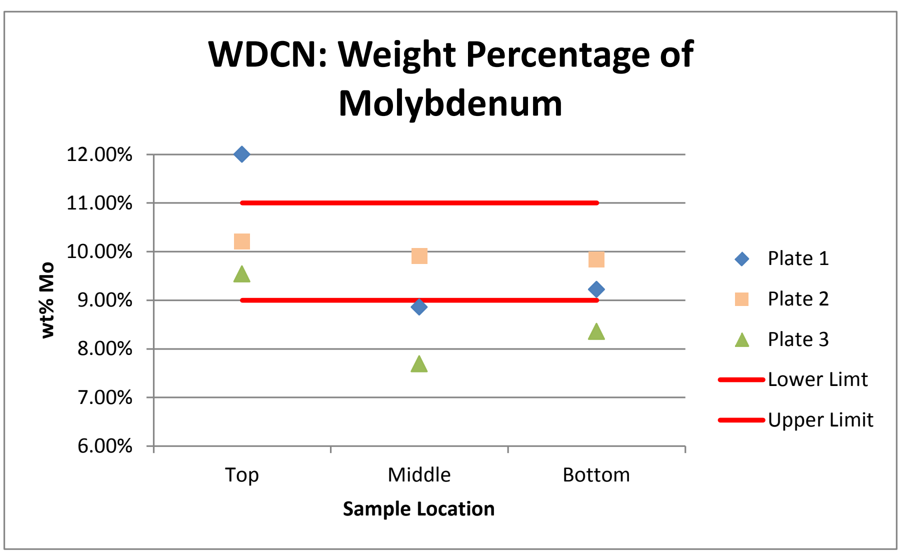

Figure 13: Molybdenum Weight Percentage in Plate Group WDCN

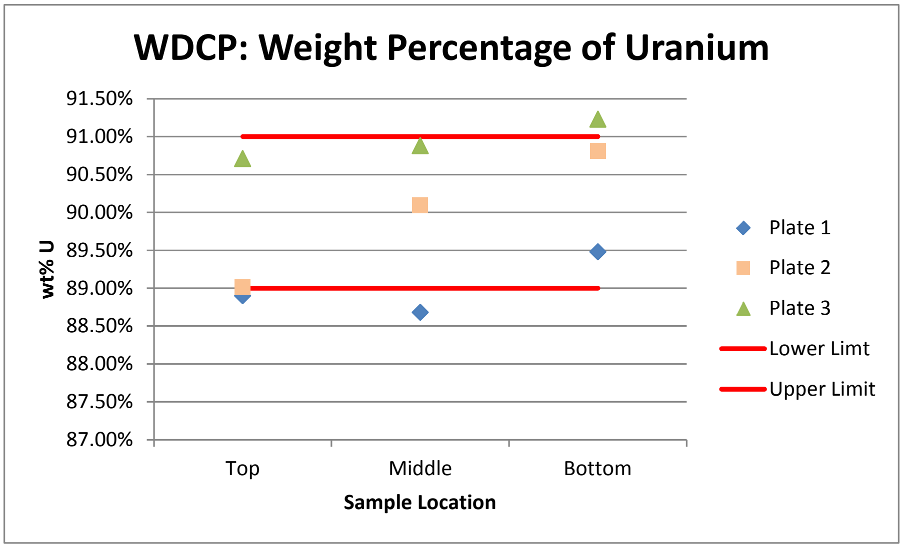

Figure 14: Uranium Weight Percentage in Plate Group WDCP

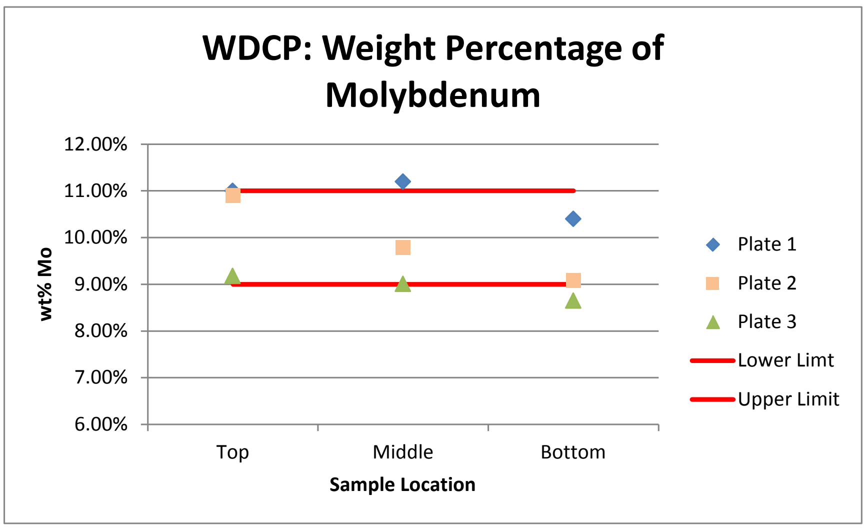

Figure 15: Molybdenum Weight Percentage in Plate Group WDCP

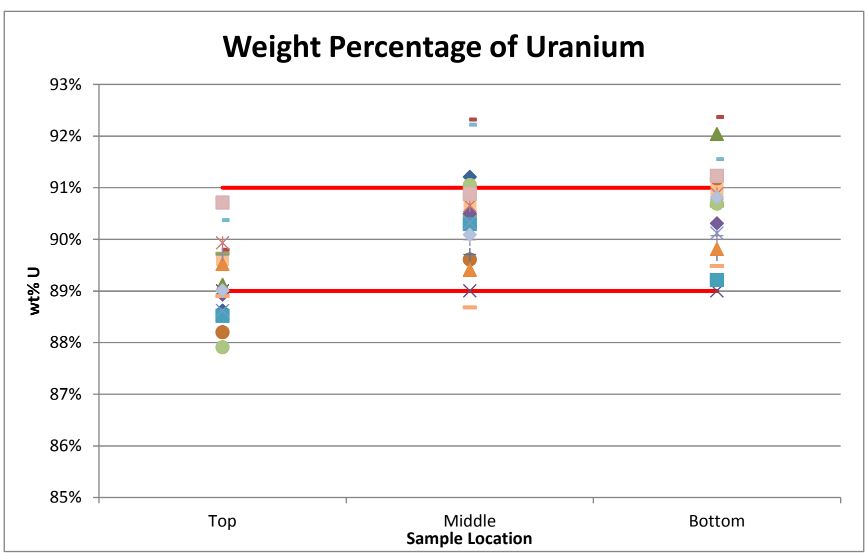

Figure 16: Uranium Weight Percentage Summary

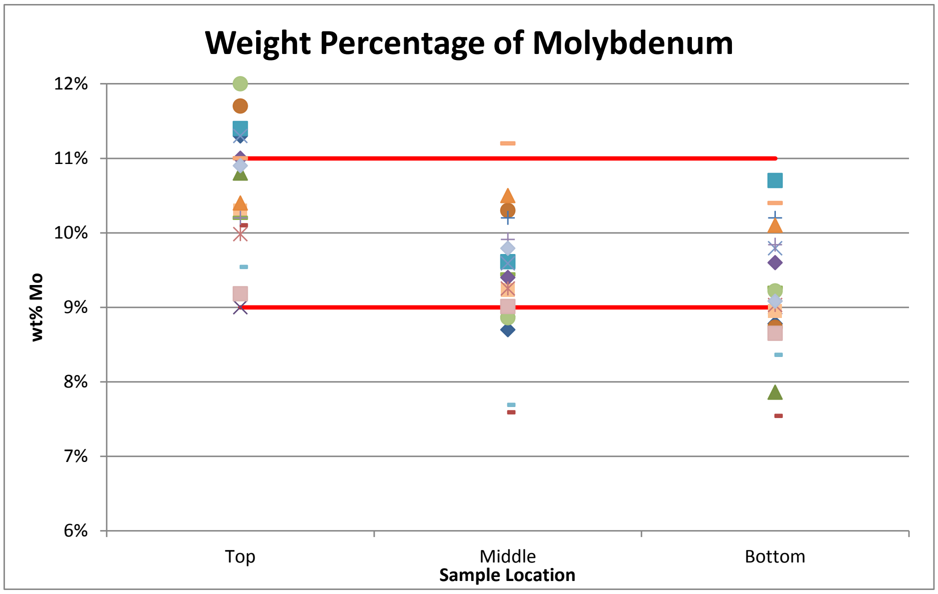

Figure 17: Molybdenum Weight Percentage Summary

The material fabricated in the trial campaign was planned at 10% molybdenum and 90% uranium. There were other minor constituents and impurities found in the product. However, as seen in the Figures above, when molybdenum percentages were high, the uranium percentage was lower. On the samples taken, the chemistry was out of the target range 33% of the time. Further analyses indicate that the first two castings, performed in August, were out of the target range 44% of the time. The remaining castings, performed in December, were out of the target range 28% of the time. The decrease may be indicative of proficiency gained in the new process. Since this is the first time this single step casting was tested, achieving the target in over 65% of the trial campaign is promising. This indicates that the single step casting process is viable and may improve with process adjustments.

4. Summary

Y-12 fabricated DU-Mo coupons using a pre-alloy diluent feedstock and a single step casting process. The trial campaign also included a multi-plate mold. Based on the results, single step casting process is a viable process. The results indicate that some process adjustments should be made to accommodate better material mixing in a single step casting, such as temperature or time at temperatures. Additionally, changes to the mold design, in collaboration with Los Alamos National Laboratory, may provide better homogeneity.