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DROP TESTING REPRESENTATIVE MULTI-CANISTER OVERPACKS

Spencer Snow and Dana K Morton

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5. Purpose: The objective of the work reported herein was to determine the ability of the Multi-Canister Overpack (MCO) canister design to maintain its containment boundary after an accidental drop event. Two test MCO canisters were assembled at Hanford, prepared for testing at the Idaho National Engineering and Environmental Laboratory (INEEL), drop tested at Sandia National Laboratories, and evaluated back at the INEEL. In addition to the actual testing efforts, finite element plastic analysis techniques were used to make both pre-test and post-test predictions of the test MCOs structural deformations. The completed effort has demonstrated that the canister design is capable of maintaining a 50 psig pressure boundary after drop testing. Based on helium leak testing methods, one test MCO was determined to have a leakage rate not greater than 1×10^{-5} std cc/sec (prior internal helium presence prevented a more rigorous test) and the remaining test MCO had a measured leakage rate less than 1×10^{-7} std cc/sec (i.e., a leaktight containment) after the drop test. The effort has also demonstrated the capability of finite element methods using plastic analysis techniques to accurately predict the structural deformations of canisters subjected to an accidental drop event.

Part I of the attached report gives an overview of the testing program, summarizing the test MCOs construction, examination efforts, loading of internal components, drop testing, pressure and helium leak testing, and post-drop evaluations performed. Part II of the report provides additional details addressing the pre-drop and post-drop analytical evaluations of the test MCOs.

This document was developed and is controlled in accordance with NSNFP procedures. Unless noted otherwise, information must be evaluated for adequacy relative to its specific use if relied on to support design or decisions important to safety or waste isolation.

The NSNFP procedures applied to this activity implement DOE/RW-0333P, “Quality Assurance Requirements and Description,” and are part of the NSNFP QA Program. The NSNFP QA Program has been assessed and accepted by representatives of the Office of Quality Assurance within the Office of Civilian Radioactive Waste Management for the work scope of the NSNFP. The NSNFP work scope extends to the work represented in this report.

The current, principal NSNFP procedures applied to this activity include the following:

- NSNFP Procedure 6.01, “Review and Approval of NSNFP Internal Documents”
- NSNFP Procedure 6.03, “Managing Document Control and Distribution”
- NSNFP Procedure 3.04, “Engineering Documentation.”

TOTAL ATTACHMENTS:	**Attachment Nos.:**	**No. of pages in each:**	**Total Pages:**
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The authors would like to acknowledge the many INEEL personnel that helped with the two representative MCOs used for this drop testing effort. Special acknowledgement is given to Mr. Lyle Powell (welder), Mr. Brad Stanger (mechanic), Mr. Ed Howick (heavy equipment operator), Mr. Rex Ginn (heavy equipment operator), and Mr. Paul Southworth (machine shop) for their skills and dedication to the project, without which this effort would not have been successful.

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ABSTRACT

During fiscal year 2004 (FY2004), two test canisters were prepared to represent Multi-Canister Overpacks (MCOs). The two test MCOs, each with five modified Mark IV baskets, were assembled at the Department of Energy (DOE) Hanford Site using internal weights and simulated fuels (all carbon steel) fabricated at the Idaho National Engineering and Environmental Laboratory (INEEL) for the National Spent Nuclear Fuel Program (NSNFP). These 13.83-foot long, 24-inch nominal diameter, test MCOs weighed 17,784 and 18,247 pounds, which was less than the maximum design weight for an MCO with Mark IV baskets (20,080 pounds dry). Heavier test MCO weights could not be achieved without using undesirable denser internal weight materials (e.g., lead, uranium, tungsten).

The test MCOs were dropped onto an essentially unyielding, flat surface, one oriented vertically and dropped from 23 feet and the other oriented at 60 degrees off-vertical and dropped from 2 feet. The drop testing was performed at Sandia National Laboratories (SNL) on August 10 - 11, 2004. The 60-degree dropped test MCO had minor damage to its outer shell (in the form of small flat spots) where the vertically-dropped test MCO showed no visible signs of damage after the drop testing.

After the drop testing, both test MCOs were shown capable of holding 50 psig air pressure for one hour without loss of pressure. This pressure testing was performed at the request of NSNFP to provide consistency with the FY1999 standardized DOE SNF canister post-drop testing effort. Post-drop helium leak testing of the 60-degree dropped MCO indicated that a “leaktight” containment (defined as having a leak rate of less than 1×10^{-7} std cc/sec) was maintained. However, leak rate testing of the vertically-dropped MCO to the 1×10^{-7} std cc/sec level was not possible due to internal helium contamination (a result of Hanford’s pre-drop helium leak test check of the final closure weld). However, the vertically-dropped test MCO was shown to have a helium leak rate not greater than 1×10^{-5} std cc/sec. The post-drop pressure and helium leak testing were performed at the INEEL.

Both pre-drop and post-drop test MCO finite element (FE) evaluations were performed by the NSNFP in support of the MCO drop test program. All model evaluations were performed using the ABAQUS/Explicit software. The FE models representing the test MCOs accurately simulated the actual test MCO structural responses during the defined drop events.

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
B&PV	Boiler and Pressure Vessel
canister	a large structure (approximately 24-inch diameter) surrounding SNF or other highly radioactive components that facilitates handling, storage, transportation, and/or disposal and can be placed into a waste package or transportation cask
canister orientation	angle of canister longitudinal axis with respect to vertical
cask	a structure used for the transportation or storage of SNF and/or HLW comprised of components intended to provide radiation shielding and retention of SNF and radioactive material contents during storage or transportation that meets all applicable regulatory requirements
CFA	Central Facilities Area (at the INEEL)
CFR	Code of Federal Regulations
CGOC	center of gravity over corner
CMTR	certified material test report
containment	the retention of any substance within a closed area and no other substance may gain access inside the closed area
DOE	Department of Energy
drop height	height measured from the top of the impacted steel floor plate or other object to the bottom edge of the drop-test canister
FE	finite element
INEEL	Idaho National Engineering and Environmental Laboratory
internals	items (baskets, spacers, sleeves, dividers, impact plates, cans, etc.) placed inside the DOE SNF canister along with the SNF for supporting and positioning the SNF and to also prevent criticality when necessary
ISFP	Idaho Spent Fuel Project
ksi	thousand pounds per square inch
lbs	pounds force
leaktight	leakage rate of helium less than or equal to $1X10^{-7}$ standard cubic centimeter/second with the canister internal/external pressure differential of 1 atmosphere
LP	liquid penetrant test

MCO	Multi-Canister Overpack
NRC	Nuclear Regulatory Commission
NSNFP	National Spent Nuclear Fuel Program
OCRWM	Office of Civilian Radioactive Waste Management (DOE)
OD	outer diameter
plastic strain	(or equivalent plastic strain) refers to the integrated sum of the 3-dimensional plastic strains occurring at a finite element integration point in an analytical model
psi	pounds per square inch
psig	pounds per square inch gage pressure
QA	quality assurance
QE	quality engineer
Q-list	quality-level list of equipment that have quality-affecting and/or safety-related functions for a facility
repository	a system that is intended to be used for the disposal of radioactive wastes in excavated geologic media
sec	seconds
slapdown	secondary impact resulting from rotational acceleration imparted to the canister during eccentric primary impact
SNF	spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing
SNL	Sandia National Laboratories
SST	stainless steel
TAN	Test Area North (at the INEEL)
TIG	tungsten inert gas
TRA	Test Reactor Area (at the INEEL)
U.S.	United States
USNRC	United States Nuclear Regulatory Commission
WASRD	Waste Acceptance System Requirements Document
waste package	the container in which the DOE SNF canisters are to be placed at the geologic repository for disposal

PART I

PROGRAM HIGHLIGHTS OF THE REPRESENTATIVE MULTI-CANISTER OVERPACK DROP TESTING EFFORT

PART I CONTENTS

PART I

PROGRAM HIGHLIGHTS OF THE REPRESENTATIVE MULTI-CANISTER OVERPACK DROP TESTING EFFORT

1. BACKGROUND

The mission of the National Spent Nuclear Fuel Program (NSNFP) is to help Department of Energy (DOE) sites safely dispose of their spent nuclear fuel (SNF) at the nation's repository, currently designated as Yucca Mountain. To achieve this goal, the NSNFP has taken steps to support those sites with existing canister designs [e.g., Hanford's Multi-Canister Overpack (MCO)] by helping to gain repository acceptance of those canister designs or to develop a new canister specifically designed for interim storage, transportation to the repository, and for disposal at the repository without having to reopen that canister.

The NSNFP first funded a demonstration drop testing effort for the standardized DOE SNF canister in 1999 (Reference 1). A major goal of that drop testing effort was to demonstrate the robust design of the 18-inch standardized DOE SNF canister and to demonstrate the canister's ability to maintain containment after an accidental drop event. At that time, the 18-inch diameter standardized DOE SNF canister was the only size anticipated to be used by the DOE SNF sites, with the exception of the MCO at Hanford. That drop testing effort helped gain repository acceptance of the standardized DOE SNF canister design.

Since the completion of the 1999 drop testing effort, the repository has altered its surface facility design concept to rely on DOE SNF canisters (both the standardized DOE SNF canisters and the MCO canisters) to not breach during an accidental drop event. This change places the DOE SNF canisters on the Q-list for the repository surface facility. This designation places additional significance on drop testing representative examples of the DOE SNF canisters to determine their ability to withstand a severe accident load and still perform their containment function. In addition, the use of a modified version of the 24-inch standardized DOE SNF canister has been identified. Therefore, during 2004 and 2005, the NSNFP funded a drop testing effort to evaluate the performance of the modified version of the 24-inch standardized DOE SNF canister and the MCO. This report addresses the drop testing effort for the MCO canister. Reference 2 addresses the drop testing effort for the modified version of the 24-inch standardized DOE SNF canister.

2. TEST CANISTER DESIGNS

Although somewhat similar, the modified 24-inch standardized DOE SNF canister and the MCO canister designs and their loaded weights are sufficiently different to require separate test specimens to evaluate their respective drop performance. Additional information provided below discusses the significant design features of the canisters involved in the drop testing effort discussed herein.

2.1. MCO Canisters

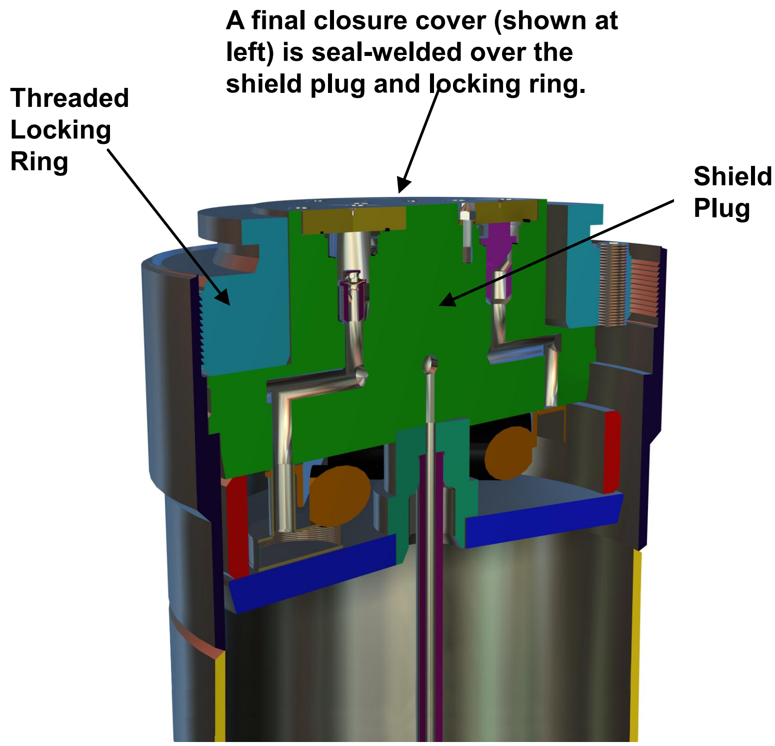
During the late 1990s, the Hanford site developed the Multi-Canister Overpack (MCO) (References 3 and 4), a SNF canister to be used for moving N Reactor and other Hanford SNF from older storage facilities near the Columbia River to safer, interim storage facilities away from the river at Hanford. Over 400 of these MCOs have been loaded (to date) and moved to the newer canister storage building at Hanford. The MCO's initial design purpose was to only move the Hanford SNF away from the Columbia River and place it in temporary storage. However, DOE wants to evaluate if the MCOs could also be used to transport the SNF to the repository and be disposed at repository, without having to reopen or repackage the MCOs. Due to this identified repository use, the NSNFP decided to pursue a drop testing effort to demonstrate the structural response of a typical MCO and to gain insights into the ability of a dropped MCO to maintain its containment system. (Fluor Hanford was the M&O contractor at the DOE Hanford Site during this effort. In this report, all work will be referred to as having been performed at or by "Hanford.")

Figure 1 illustrates the configuration of a typical MCO. The MCO is a stainless steel (304L) cylindrical vessel approximately 24 inches in diameter and 166 inches long. SNF is placed into one of four types of baskets (either an intact SNF or a scrap fuel basket for either Mark 1A and Mark IV fuel). Structural integrity is required for the Mark 1A baskets for criticality control whereas the Mark IV baskets do not require structural integrity for criticality control. A fully loaded MCO holds five or six baskets (depending on type) and a shield plug fixed in place with a locking ring. A cover cap is welded on to the top-end to complete the package. Over 300 of the existing MCOs have had this cover welded on (to date). A fully loaded MCO can weigh as much as 10 tons.

Since a large number of MCOs have already been loaded with DOE SNF and placed into storage at Hanford, the remaining significant future MCO uses are transportation to the repository and disposal at the repository. Issues associated with the transportation of the MCOs to the repository will be addressed at a later date. Regarding repository disposal use, Table 1 summarizes the analytical evaluations completed in fiscal year 2003 and reported in EDF-NSNF-029 (Reference 5). That analysis effort used the two repository surface facility defined drop events specified in the Waste Acceptance System Requirements Document (WASRD) (Reference 6). Those drop events were defined to be a 23-foot flat bottom drop (representing a vertical drop back into a transportation package or into a repository waste package) and a 2-foot worst orientation drop, both onto an essentially unyielding surface. The EDF-NSNF-029 strain predictions are below the maximum strains predicted in the 1999 drop testing effort but another full-scale drop testing effort was still considered necessary due to a number of dissimilarities, including the MCO's different design, different materials, and significant weight increase.

Table 1. Equivalent Plastic Strain (Percent) Analytical Predictions for the MCO Canisters

Canister	Strain Location	Strain Predictions From Repository Drops	
		23-Foot Vertical	2-Foot Worst Orientation
MCO	Outer Surface	5	22
	Middle	4	7
	Inner Surface	5	20



Closure Head

Mark 1A Fuel and Scrap Baskets

Figure 1. MCO Canister and Baskets

3. OBJECTIVES

The primary objective of the NSNFP was to demonstrate the MCO's robust design and determine its ability to maintain containment by drop testing two test MCOs considering the two defined repository drop events, as specified in the WASRD. The desire was to challenge the containment capability of the test MCOs and to develop insights into the response of internal baskets. Mark 1A baskets have a very robust design and are not expected to deform significantly during the repository-defined drop events. On the other hand, the Mark IV baskets are similar yet less robust. Significant deformations are expected from the Mark IV baskets, making them a much more interesting subject for drop testing. This drop testing effort was not developed to provide specific deformation guidance (i.e., canister or internals deformations) with respect to SNF criticality, shielding, or other related safety issues. However, drop response insights can be realized from this effort when properly evaluated in relationship to the specific safety issue.

A goal of using as many actual MCO components as possible was established to provide meaningful insights. Since hundreds of MCOs have already been fabricated to ASME Boiler and Pressure Vessel (B&PV) Code, Section III, Subsection NB criteria (with Code Case N-595-3, Reference 7), actual spare N-stamped MCO canisters were provided by Hanford and used as the test MCOs. In addition, actual spare Mark IV scrap baskets (later modified) were made available by Hanford for the test MCO contents. Post-drop helium leak testing to determine the leakage rates of the test MCOs was to provide containment insights.

The secondary objective of the drop testing effort was to determine the ability to adequately predict the structural responses of the test MCOs and internals due to the drop testing. Using finite element methods and fully plastic analyses, pre- and post-drop test analysis predictions were completed and comparisons made to the actual test MCO responses (Part II of this report). This effort not only provides validation insights of the unique computer models developed but also allows for increased confidence in the analytical predictions of canister responses to situations not specifically tested.

Table 2 lists the test MCO labeling, desired drop height, desired drop orientation, and the primary reason for that particular drop test (beyond compliance with repository defined drop events). The basis for each "Reason for Test" can be found in EDF-NSNF-029. This test matrix information was developed in order to achieve as much insight as possible into the structural response of the test MCOs subjected to the identified accidental drop events. Insights gained from the 1999 drop testing were considered and these additional drop orientations were chosen to validate and build upon those insights.

Table 2. Test MCO Drop Information

Test MCO Label	Drop Height	Drop Orientation	Reason For Test
MCO-00-1	23 feet	Vertical (0-degree)	Significant basket deformation
MCO-60-2	2 feet	60-degree	Highest predicted canister strain

4. SCOPE OF WORK

In order to achieve the program objectives, many activities had to be accomplished before and after the actual drop testing occurred. At the INEEL, these activities included purchasing proper materials for the internal weights, fabricating the internal weights, and shipping the weights to Hanford. At Hanford, those activities included preparation of the spare MCO canisters for loading, loading the test MCOs with their modified baskets and the weights supplied by the INEEL, and performing final closure welding on the test MCOs. [It should be noted that certain components of the test MCOs (the shield plugs) were slightly contaminated (1500 dpm/100 cm^2 or less beta-gamma and less than 20 dpm/100 cm^2 alpha) and so work on the test MCOs had to be performed under proper radiological controls.] After receiving the loaded test MCOs from Hanford (as a radioactive material shipment) at the INEEL, additional activities included preparing (measuring, marking, and labeling) the test MCOs for drop testing, and shipping the test MCOs to the drop test site at Sandia National Laboratories (as a radioactive material shipment). After completion of the drop tests, the test MCOs were shipped back to the INEEL (as a radioactive material shipment) for post-drop test examinations and measurements, pressure testing, and helium leak testing. Quality assurance related activities that could not be performed under the NSNFP QA Program at the INEEL were typically performed by INEEL personnel, per the requirements of Task Management Agreement TMA-005 (Reference 8). For the activities associated with loading the MCOs at Hanford, those requirements were identified in Task Management Agreement TMA-012 (Reference 9). The approach to the drop testing effort is discussed in a NSNFP test plan document (Reference 10). The drop testing effort followed the requirements of NSNFP 11.01 (Reference 11).

The scope of work necessary to achieve the desired qualified drop test data results considered the following seven phases:

1. Phase I was the procurement of materials for the internal weights and obtaining the test MCOs,
2. Phase II was the fabrication of the internal weights at the INEEL and shipment of the weights to Hanford,
3. Phase III was the assembly of the test MCOs, the MCO modified baskets, and the weights at Hanford and the shipment back to the INEEL of the completed test MCOs,
4. Phase IV was the preparation of the test MCOs for drop testing,
5. Phase V was the actual drop testing performed by SNL,
6. Phase VI was the post-drop examination and measuring efforts, pressure testing, and helium leak testing activities that occurred once the test MCOs were shipped back to the INEEL.
7. Phase VII was the generation of the final report that documents all of the activities, provides insights into the prediction capabilities of the finite element analyses performed, and provides the INEEL work packages, the Hanford documentation, and the SNL documentation to the NSNFP to complete the task activities.

5. PHASE I – MATERIAL PROCUREMENT AND OBTAINING THE TEST MCOS

5.1. Material Procurement

Of course, actual SNF or scrap SNF pieces could not be loaded into the test MCOs for drop test purposes. Various pieces of carbon steel bar material were needed to represent the SNF. Carbon steel was chosen rather than ductile stainless steel to increase possible damage to the test MCO containment boundary. Therefore, the first phase was to procure the materials necessary to fabricate the internal weights that were to represent the SNF inside the test MCOs. In order to gain as much weight as possible (since SNF is denser than carbon steel), solid carbon steel bar stock (ASTM A-576) was procured for eight of the ten total basket loads (total of five baskets per test MCO). These eight solid bar pieces were a nominal 22-inch diameter and 27 inches in length (as purchased). The two remaining baskets were to be filled with 2-1/2-inch diameter carbon steel bar stock (ASTM A-36) so approximately 240 linear feet was procured. Under the INEEL Quality Assurance (QA) Program (Reference 12), the weight materials were purchased using Quality Level 4 (consumer grade) requirements.

Figure 2. Solid Bar Stock Procured for Large Internal Weights

5.2. Test MCOs

In order to get as representative a structural response as possible from the test MCOs, it was decided to use spare MCOs available at Hanford. These spare MCOs were N-stamped (Figure 3) and fabricated from Class 1 material (Figure 4). Since these were N-stamped components, there is little need to justify the fabrication process herein. The Hanford documentation package (submitted to NSNFP Document Control) (Reference 13) contains the MCO manufacturer's (Joseph Oat Corporation) data package along with basket assembly documentation, loading procedures, closure weld data, etc. Table 3 indicates the MCO serial numbers referenced for the two test MCOs.

Table 3. MCO Serial Numbers

Test MCO Label	Joseph Oat Corp. Serial Number	Hanford MCO Serial Number
MCO-00-1	2591-005	H-005
MCO-60-2	2591-014	H-014

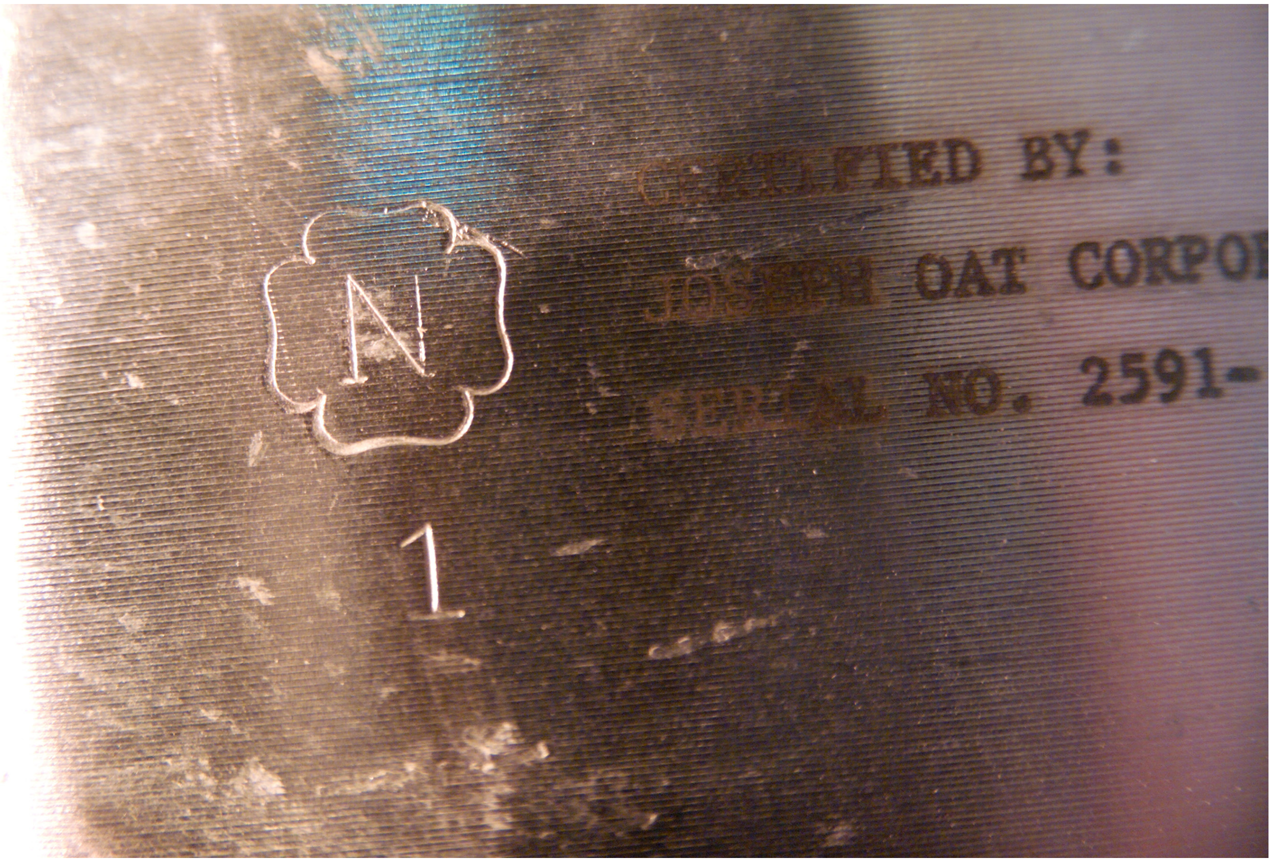


Figure 3. ASME B&PV Code N-Stamp on Test MCO

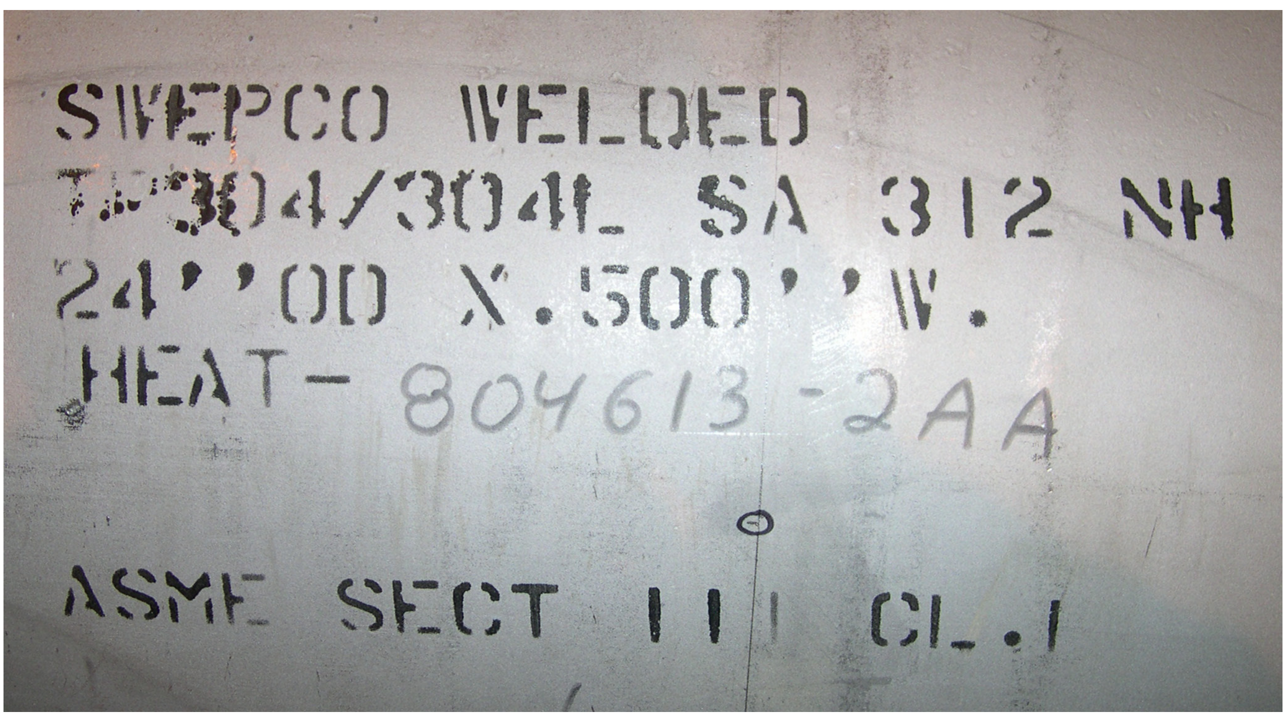


Figure 4. Material Labeling From Test MCO Shell

6. PHASE II – FABRICATION OF INTERNAL WEIGHTS AT INEEL

Of the five MCO baskets to be loaded into each test MCO, four of the baskets were to be loaded with a solid steel bar approximately 22-1/4 inches in diameter and 26.7 inches in length (finished dimensions), machined with a 3-inch diameter center hole to fit over the center post of the basket. The fifth MCO basket was to contain fifty-four 2-1/2-inch diameter steel bars, representing a fuel basket filled with individual SNF elements. These smaller diameter bars were cut to different lengths to permit different insights per drop test. Part II, Appendix A contains the detailed design sketches used to fabricate the internals.

Figure 5 shows the large 22-inch nominal diameter bar stock being machined at the INEEL's Test Reactor Area (TRA). NSNFP test personnel qualified under the NSNFP procedure NSNFP 2.04 (Reference 14) recorded a number of dimensional and weight measurements, obtaining basic "as-built" information about the internal weights (Figure 6). This information was recorded on data sheets (Part II, Appendix B) that identified each component by number. In order to aid in the handling of these large weights, they were placed in a wooden cradle (Figure 7) so that could be easily lifted with a fork lift.

INEEL Test Area North (TAN) personnel fabricated the remaining 2-1/2-inch diameter internal weights by cutting (Figure 8) the bar stock to either a 21-inch or a 26-inch length, 54 pieces each length. Again, in order to make handling easier, the smaller diameter bar stock was loaded into separate wooden boxes (Figure 9) for shipment to Hanford. In addition to the smaller diameter bar stock, the wooden crates also included foam filler pads and a flat plate.

On April 12, the internals fabricated at the INEEL were loaded onto a flatbed truck (Figure 10) and shipped to the Hanford site, where they arrived the next day.

Figure 5. Large Diameter Weight Being Machined

Figure 6. Large Diameter Weight Being Measured.

Figure 7. Placing Large Diameter Weight Into Wooden Cradle

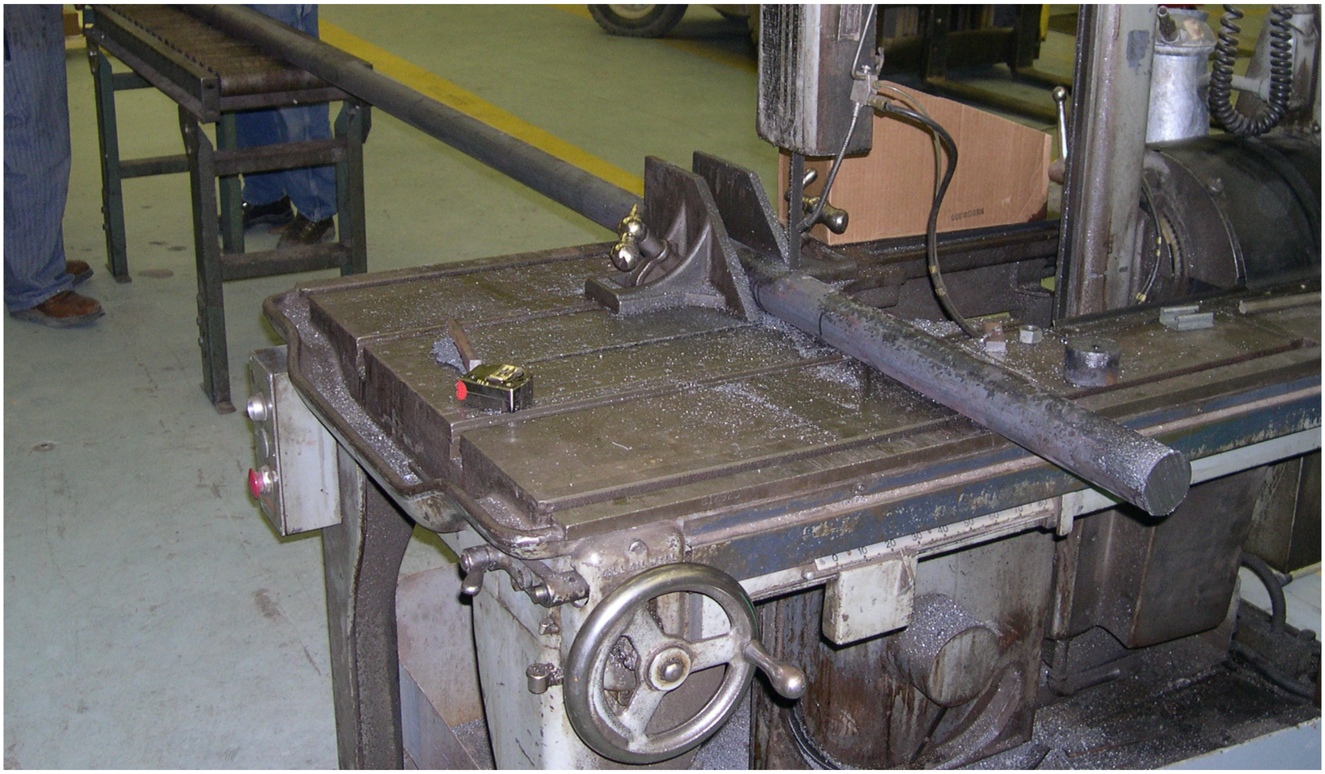


Figure 8. Smaller Diameter Bar Stock Being Cut to Length

Figure 9. Smaller Diameter Bar Stock Loaded into Boxes for Easier Handling

Figure 10. MCO Internal Weights Loaded Onto Truck for Shipment to Hanford

7. PHASE III – TEST MCO ASSEMBLY AT HANFORD

Hanford was tasked with loading the test MCOs with their modified baskets and the internal weights supplied by the INEEL. Figure 11 illustrates how MCO-00-1 was to be loaded and Figure 12 illustrates how MCO-60-2 was to be loaded. As explained earlier, each test MCO had one representative SNF fuel basket and four large diameter weight baskets. The representative SNF basket for MCO-00-1 was loaded into the bottom position to maximize its axial deformation, much like that anticipated for an actual Mark IV scrap or SNF basket after an accidental vertical drop. The representative SNF fuel basket for MCO-60-2 was loaded at the top position to have that basket respond much like an actual Mark IV fuel basket would during a slapdown impact event. Note that both Figures 11 and 12 identify not only the type of basket but also the contents for each loading position.

Hanford provided ten Mark IV scrap baskets to be used for this drop testing effort. Eight of these Mark IV scrap baskets were modified (copper shroud subassembly and perimeter posts removed) in order to accept the large diameter steel weight (Figure 13). The remaining two Mark IV scrap baskets were slightly modified (copper shroud replaced with a new stainless steel 0.047-inch thick shroud and added the aluminum storage rack and screen present in the Mark IV fuel baskets) so that fifty-four 2-1/2-inch diameter steel bars could be inserted, representing a Mark IV fuel basket filled with intact SNF (Figure 14).

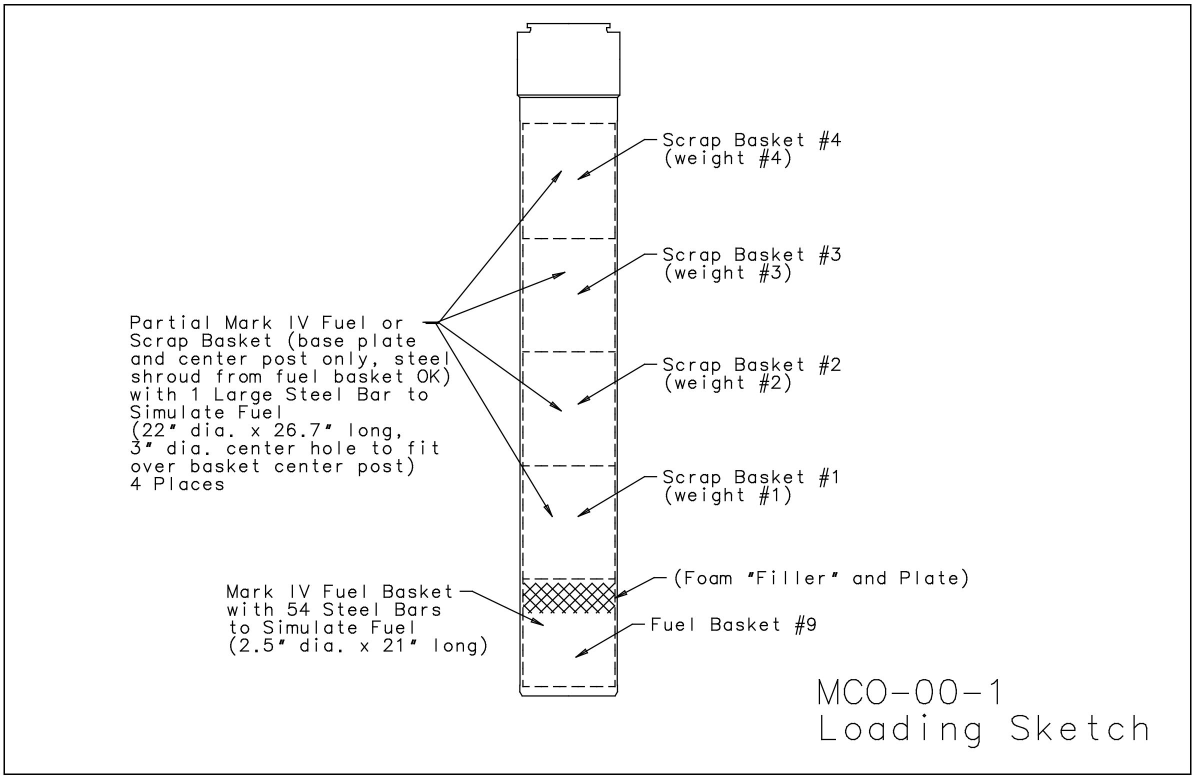


Figure 11. Loading Sketch for MCO-00-1

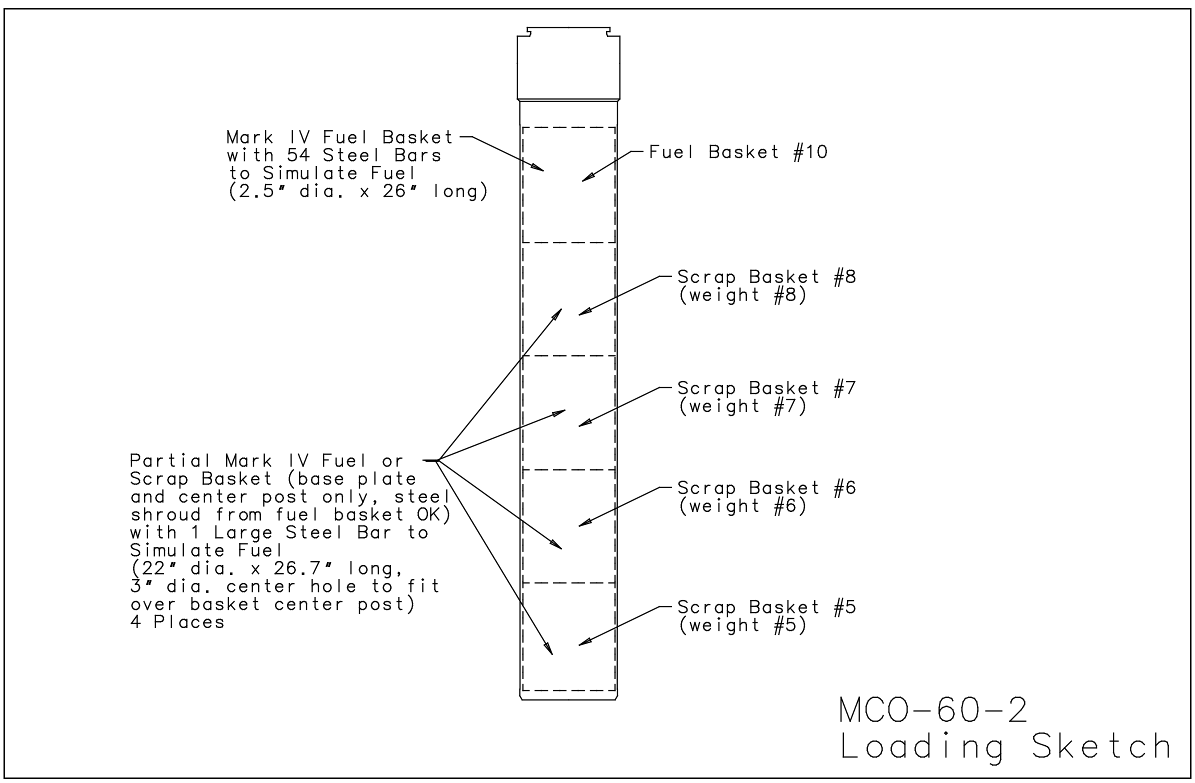


Figure 12. Loading Sketch for MCO-60-2

Figure 13. Modified Mark IV Scrap Basket

Figure 14. Representative Mark IV Fuel Basket

Figure 15 shows a large diameter steel weight being positioned onto a modified Mark IV scrap basket while Figure 16 shows completed baskets ready to be loaded into a test MCO.

Figure 17 shows Hanford personnel loading the 21-inch long, 2-1/2-inch diameter bars into a modified Mark IV scrap basket (or representative Mark IV fuel basket). Figure 18 shows the basket with all of the 2-1/2-inch diameter bars loaded. This basket (with the 21-inch long bars) was to be loaded into the bottom position of MCO-00-1, the vertical drop canister. In order to maximize the deformation to this basket, the bars were purposely cut to a shorter length than the maximum SNF length (26.1 inches). This would reflect either shorter fuel elements, SNF elements that potentially could not withstand the anticipated axial compression loading, or scrap SNF that may also not provide vertical restraint, thereby shifting the axial compression load to the perimeter bars. Since these shorter 2-1/2-inch diameter bars could potentially displace during multiple handling processes prior to drop testing, it was decided to lightly restrain the bars so that they would not move out of the aluminum rack but would also not adversely affect the basket response during the drop test. Therefore, onto the top of the 21-inch bars, a thin, flat 19-inch diameter plate (with a 3-inch center hole) was positioned and then two 3-inch thick layers of foam placed on top (Figure 19). The plate was intended to keep individual bars from penetrating the foam too much and displacing themselves from the aluminum rack while the foam occupied the remaining space, keeping the bars properly positioned prior to drop testing. Any movement of the baskets above this representative Mark IV fuel basket would easily displace the foam.

The actual loading of the baskets into the test MCOs took place in a methodical and controlled fashion. Due to the importance of knowing the orientation of the two representative Mark IV fuel baskets with respect to the desired impact point (for analysis predictions), discussions (between the Hanford personnel and NSNFP test personnel) were held at the Hanford site during initial loading efforts to assure that the perimeters bars on each of the two representative Mark IV fuel baskets were symmetrically positioned on each side of the shell longitudinal weld (the specified impact orientation for test MCO-60-2). This allowed the computer predictions to correctly position (on a rotational basis) the representative Mark IV fuel baskets within each test MCO. One could say this orientation would not matter for MCO-00-1 (the vertical drop test) but there were no guarantees that the test MCO would not fall over after initial impact. Therefore, basket orientation was still important for MCO-00-1 from a contingency perspective. Due to the full symmetry of the eight baskets with the large diameter weights, position controls were not necessary for their loading.

Figures 20 through 29 show additional pictures of the vertical loading platform used at Hanford, various baskets being placed inside the test MCOs, installing a shield plug, a picture of the locking ring, installation of the cover, and final closure weld pictures.

Hanford completed their activities and shipped the two test MCOs to the INEEL (as a radioactive material shipment) on June 28, 2004 where they arrived the next day.

Figure 15. Loading of Large Diameter Internal Weight Onto Modified Mark IV Scrap Basket

Figure 16. Baskets Ready for Loading Into Test MCO

Figure 17. Placing 2-1/2-inch Diameter Bars Into the MCO-00-1 Bottom Basket

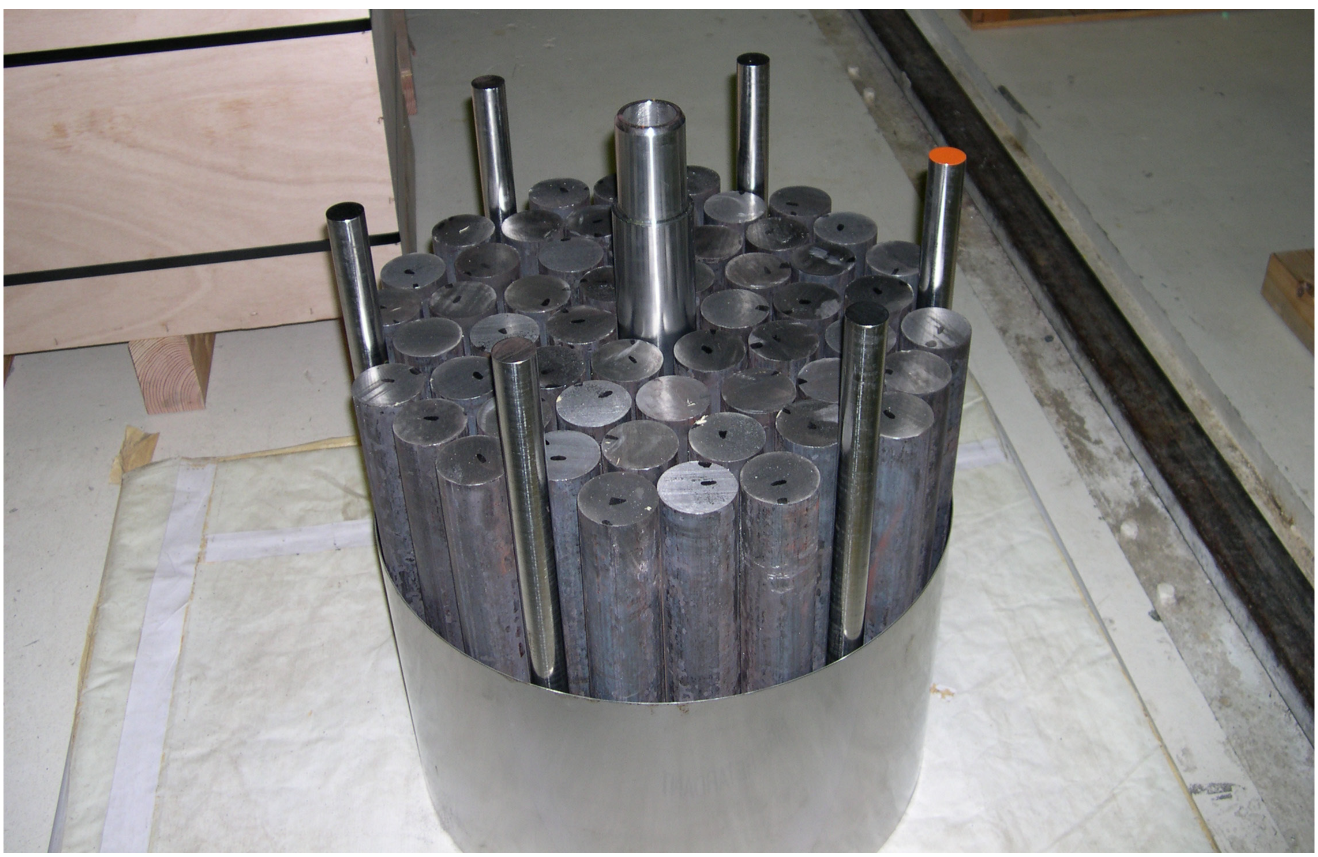


Figure 18. MCO-00-1 Bottom Basket Loaded With Smaller Diameter Bars

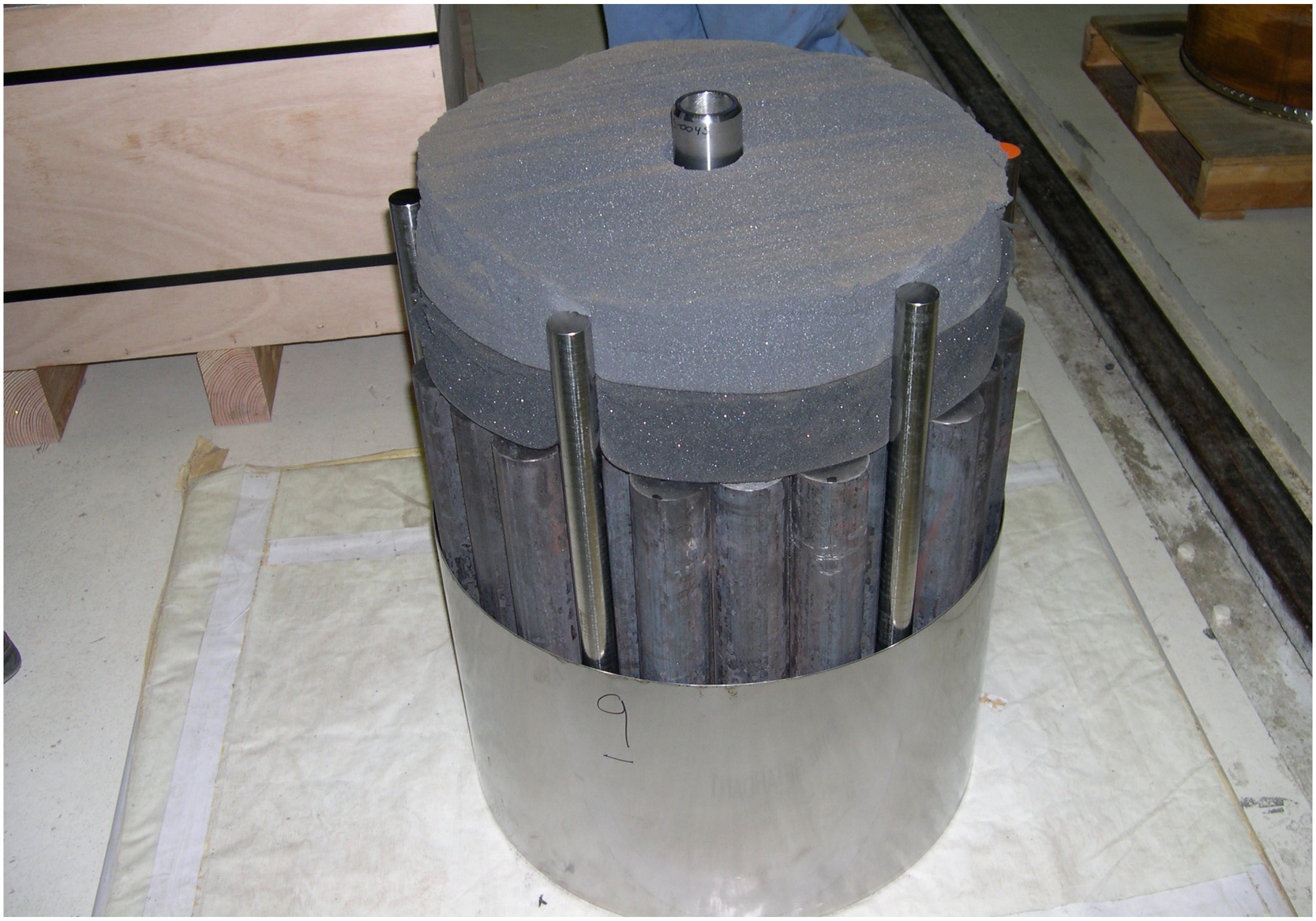


Figure 19. Completed Bottom Basket for MCO-00-1

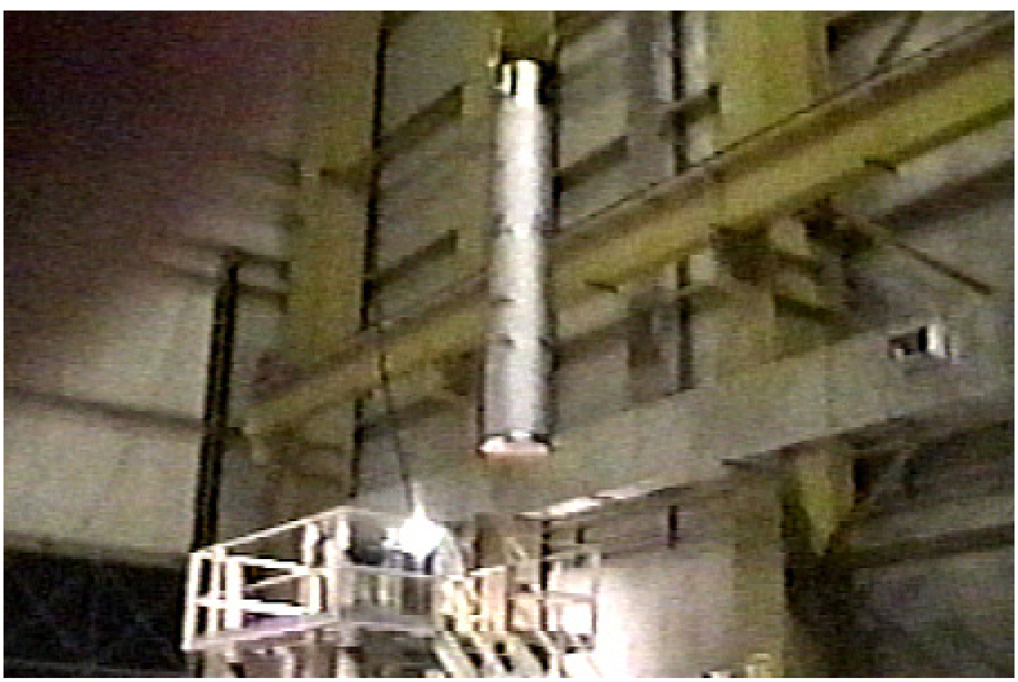


Figure 20. Placement of Lower MCO Shell Assembly Into the Loading Platform (picture from video provided by Hanford)

Figure 21. Loading of Bottom Mark IV Fuel Basket into MCO-00-1 (picture from video provided by Hanford)

Figure 22. Loading of Mark IV Scrap Basket and Large Diameter Weight Into Test MCO (picture from video provided by Hanford)

Figure 23. Loading of Shield Plug (picture from video provided by Hanford)

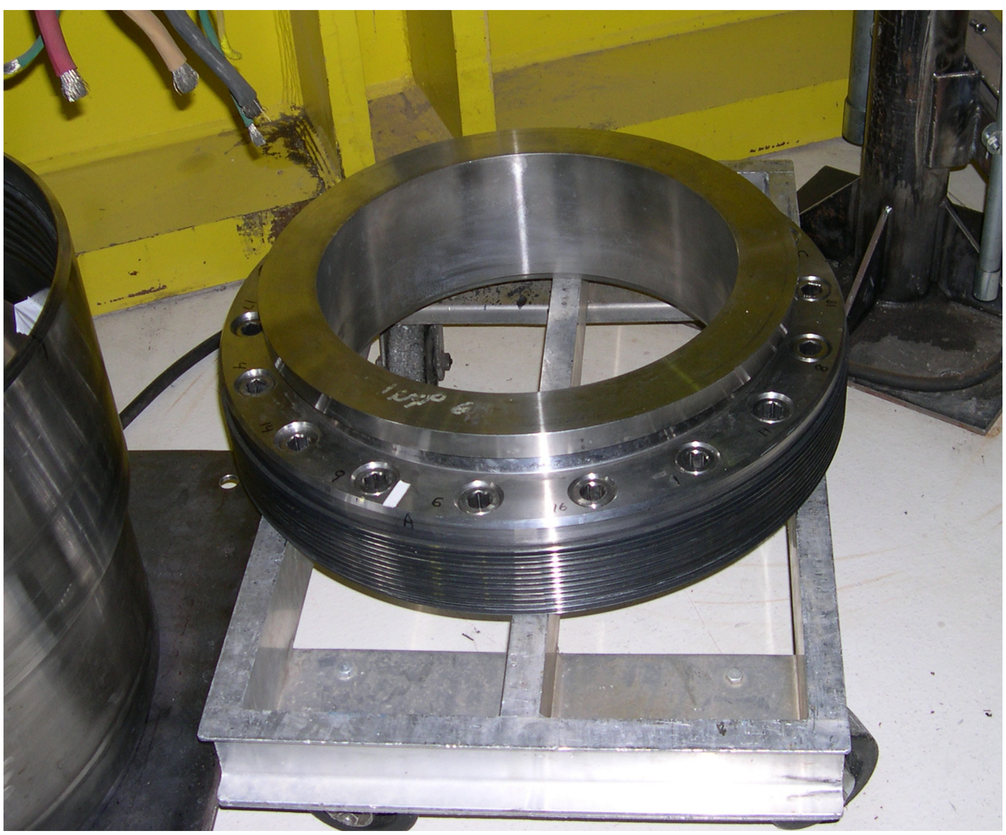


Figure 24. MCO Locking Ring

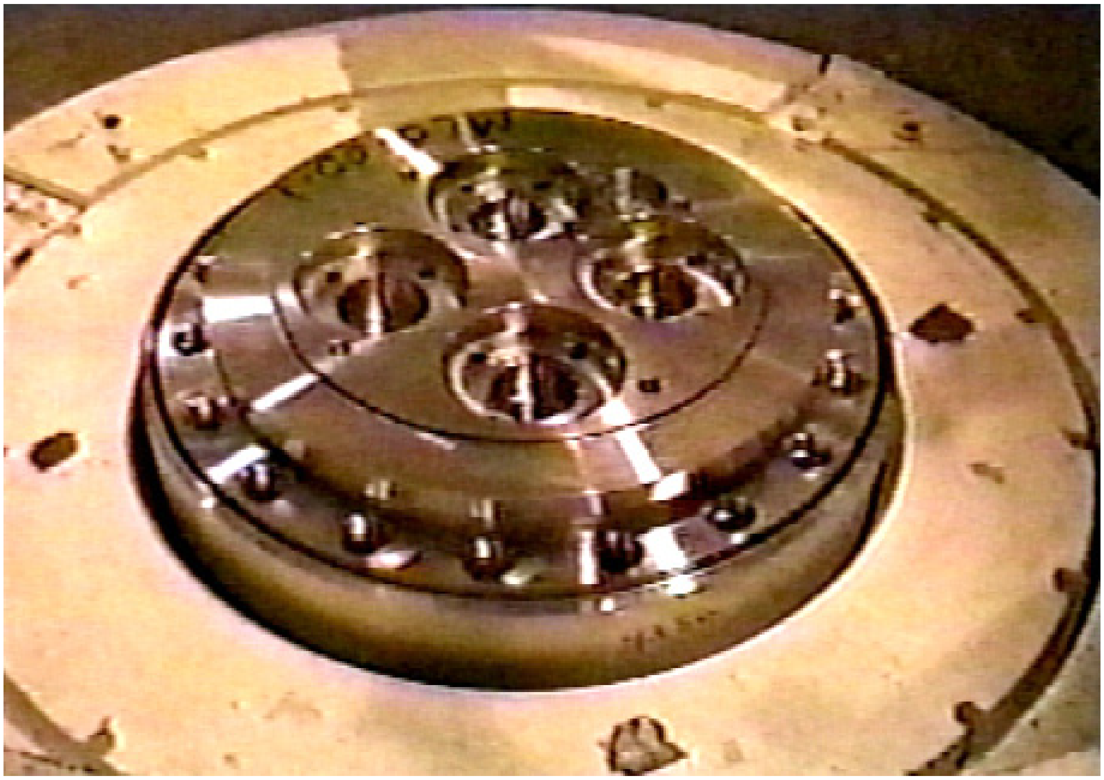


Figure 25. Test MCO Top Prior to Placement of Cover (picture from video provided by Hanford)

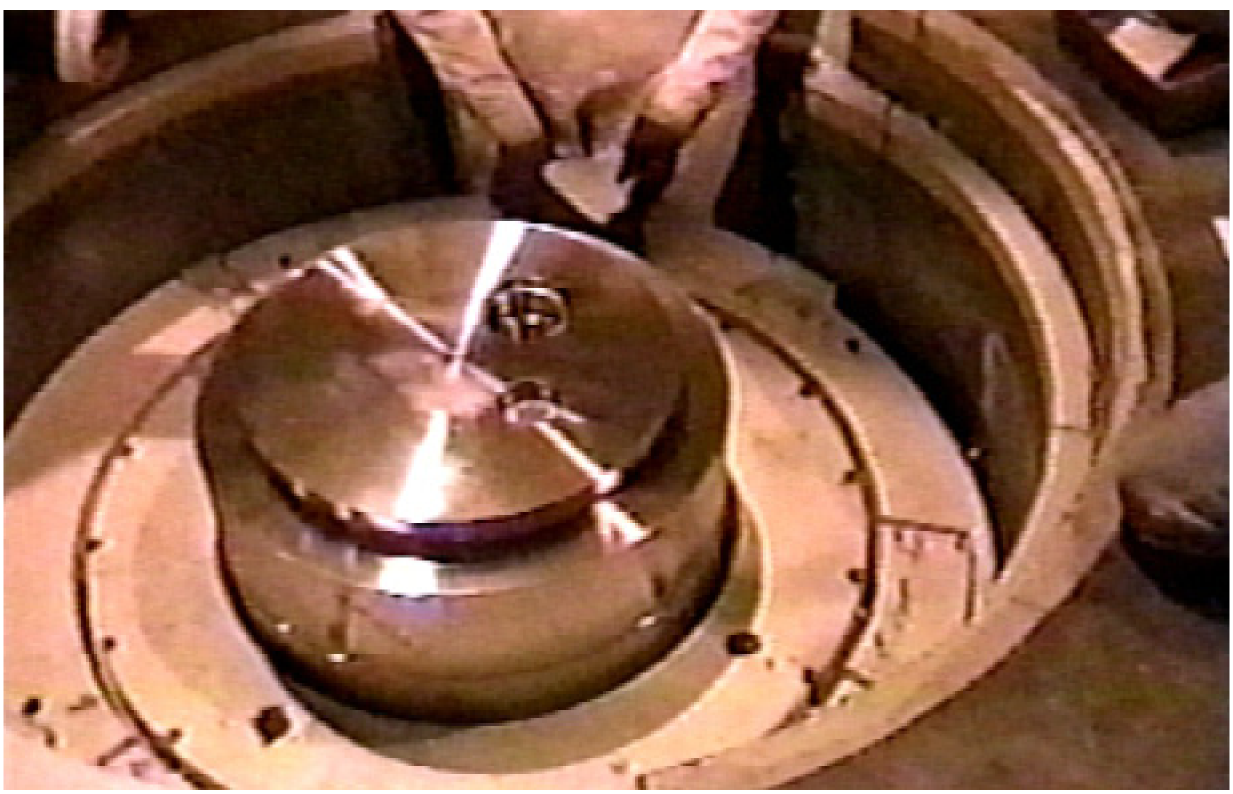


Figure 26. Placement of MCO Cover (picture from video provided by Hanford)

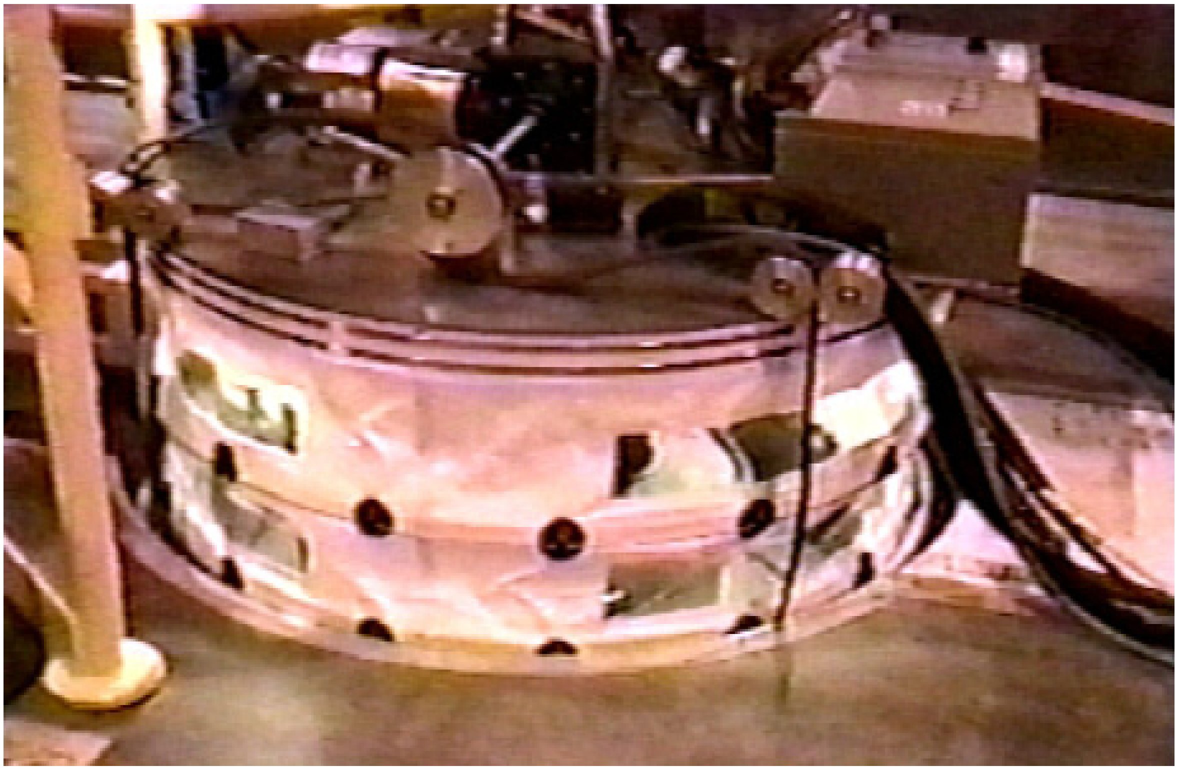


Figure 27. Welding Machine Positioned for Final Closure Weld (picture from video provided by Hanford)

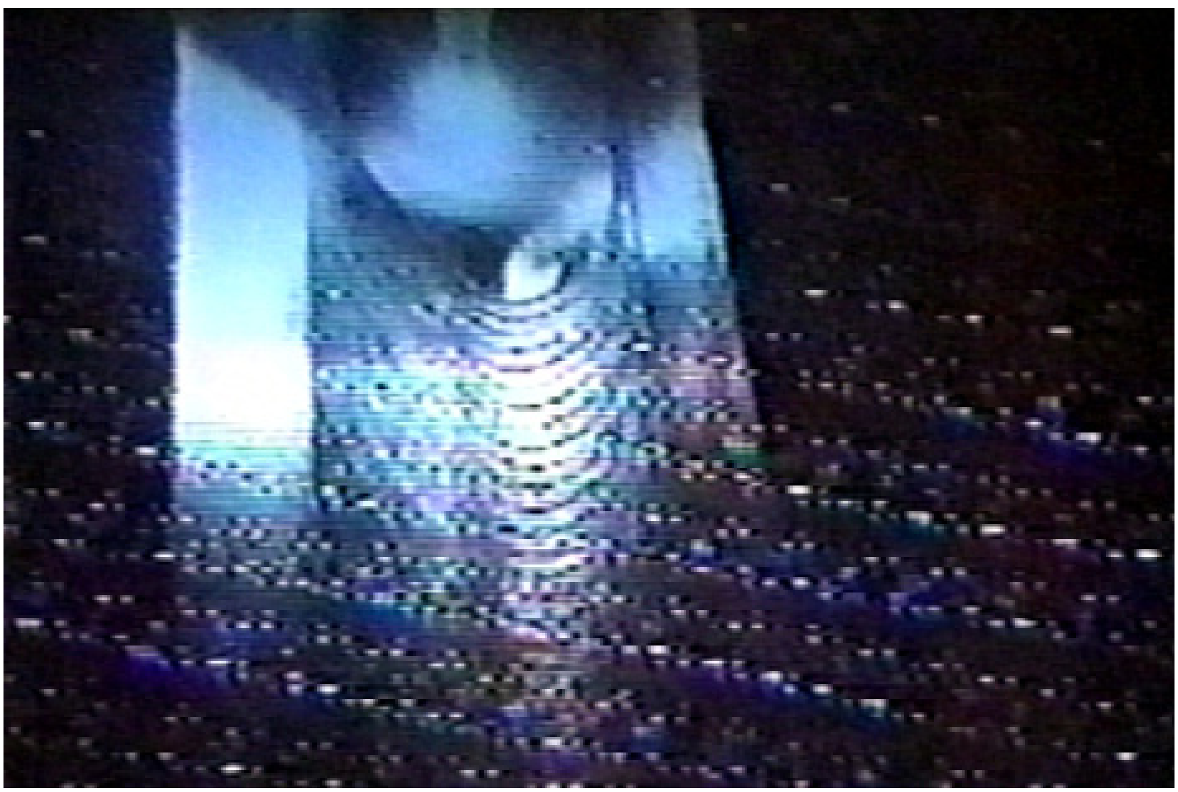


Figure 28. Remotely Monitoring Progress of Final Closure Weld (picture from video provided by Hanford)

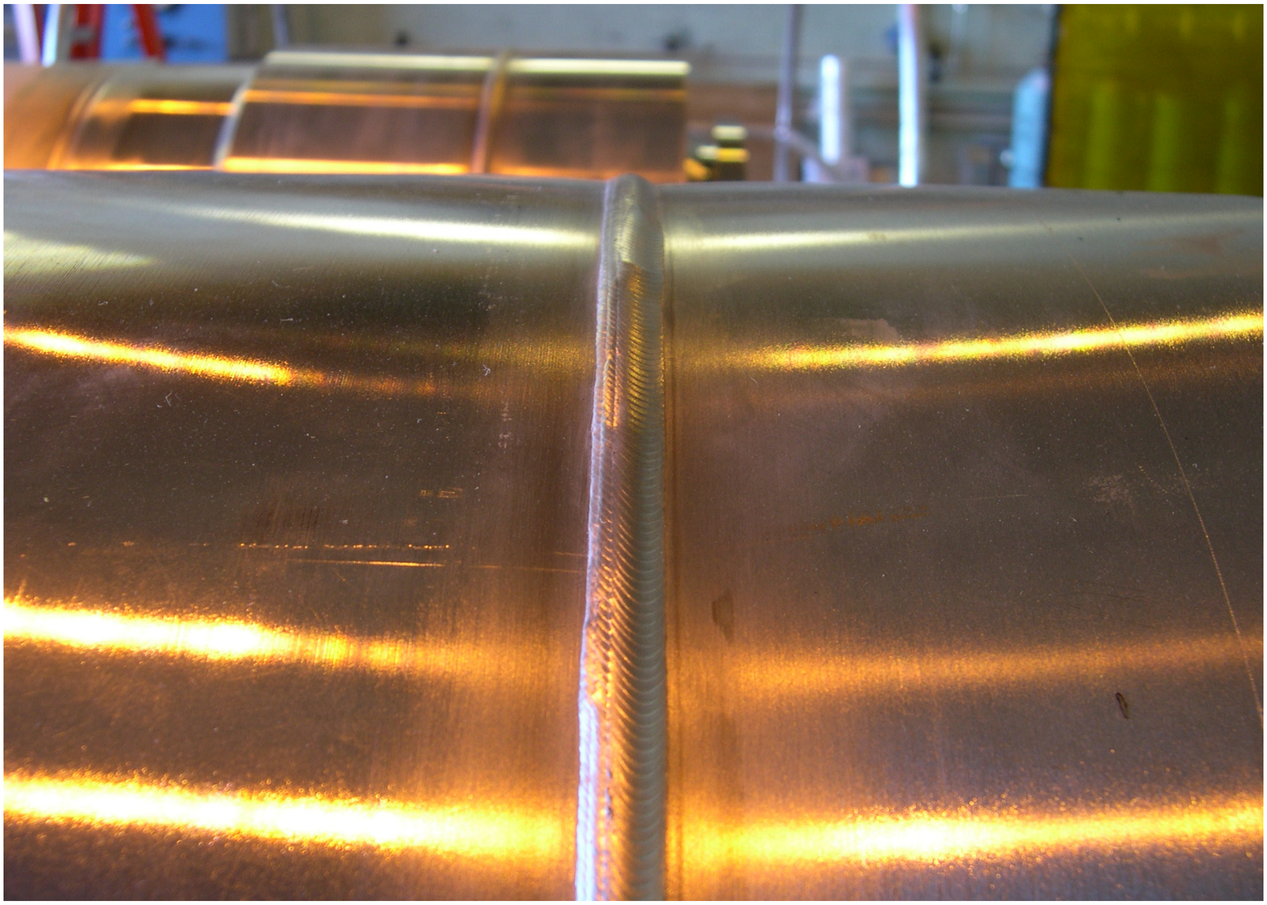


Figure 29. Final Closure Weld on Test MCO

8. PHASE IV – PREPARATIONS FOR DROP TESTING

Upon receiving the loaded test MCOs at the INEEL, proper radiological controls were established so that both the NSNFP test personnel and the INEEL personnel could safely work around the test MCOs. Each test MCO was then positioned horizontally across large concrete blocks onto wooden cradles to prevent rolling. These 2 ft. x 2 ft. x 6 ft. concrete blocks (weighing approximately 3600 lbs. each) also provided a significant personnel safety feature while the loaded test MCOs were being worked on, examined, and measured. Figure 30 shows a typical setup where the test MCOs were positioned onto the concrete blocks.

At this stage, the test MCOs were marked and measured in various locations in preparation for the drop tests. Qualified NSNFP test personnel utilized a variety of markers or tools to perform this task, including etching tools and permanent markers. Marking was based on tape measurement accuracy. The markings, applied using small impact etchers, would permit before and after the drop test measurement comparisons to be made (see Figure 31). These measurements were intended to establish the geometry of each test specimen before the drop tests.

Figure 30. Test MCOs Positioned onto Concrete Blocks

Figure 31. NSNFP Test Personnel Preparing to Mark and Then Take Completed Test MCO Measurements

The accuracy of measurements depended on the measuring device being used. Measurements obtained using a tape measure were required to have a +/-1/8 inch accuracy. (Tape measures were not calibrated.) Micrometer and caliper measurements were required to have a +0.010 / -0.010 inch accuracy. Weight measurements had an accuracy that depended on the load range involved. For lighter loads (less than 500 lbs), the accuracy was +/- 1 lb. For medium loads (less than 5000 lbs.), the accuracy was +/- 6 lbs. For heavier loads (less than or equal to 25,000 lbs.), the accuracy was +/- 30 lbs. Greater accuracy of all measurements was attained where possible. Measurement devices were calibrated at the INEEL and were tagged with unique identifying numbers. Details are contained in Part II with calibration sheets in Part II, Appendix E.

These same measurements were to be repeated after drop testing in order to determine any deformations caused by the drop test. As part of a validation of these measurements, an INEEL QA inspector qualified to take measurements (see Part II, Appendix B) was requested to choose approximately ten measurements and repeat the indicated measurements. With a self-imposed QA hold in effect, additional activities that could alter these measurements were not permitted to proceed until the NSNFP Quality Engineer (QE) reviewed and accepted these validation measurements as being within a 1/16-inch for micrometer measurements and within 1/8-inch for tape measure measurements. These validation measurements were acceptable (within the stated tolerances), demonstrating that the measurements taken by the NSNFP test personnel were valid.

One aspect that was different from the 1999 drop test preparations was the effort to measure test MCO strains. In the 1999 effort, strain gages were applied on the containment boundary material where higher strain values were predicted to occur. These strain values were only in the 5 to 10% magnitude and although the values measured were reasonably predicted by the computer analyses, the insights were not truly significant. More significant insights would have been achieved if it would have been possible to instrument the areas that produced much higher strains (greater than 10%). However, those areas were subject to direct impact damage that would have destroyed the strain gages. Therefore, for this current effort, the decision was made to use strain markings that could provide reasonable indications of high strain magnitudes and would be less susceptible to damage during the drop test. Therefore, a square four point pattern was applied in multiple locations in order to gain insights into the strain responses of the test MCOs. A punch-type device was used to make the marks. Figure 32 shows a close-up view of some of these marks. Since the four marks (forming a square) are placed over an approximate 0.5 square inch area, only average strains can be approximated. These marks were placed at locations expected to experience high strains, even though the test MCOs were not anticipated to have containment boundary strains exceeding 10% at locations where the marks could be placed. Part II contains more details. The application of these strain markings also satisfied Review Panel Recommendation #3, mentioned in the ASME/RSI peer review document (Reference 15).

Attempts were made to helium leak test the test MCOs prior to drop testing. The method planned was to pull a vacuum on the inside of the test MCOs and then with a mass spectrometer, try to detect helium placed on the outside of the test MCO under a plastic wrapping. However, since Hanford had placed helium inside of the test MCOs during their final closure weld leak testing, there was too much residual helium still inside of the test MCOs to complete the planned testing. Therefore, pre-drop helium leak testing was not performed.

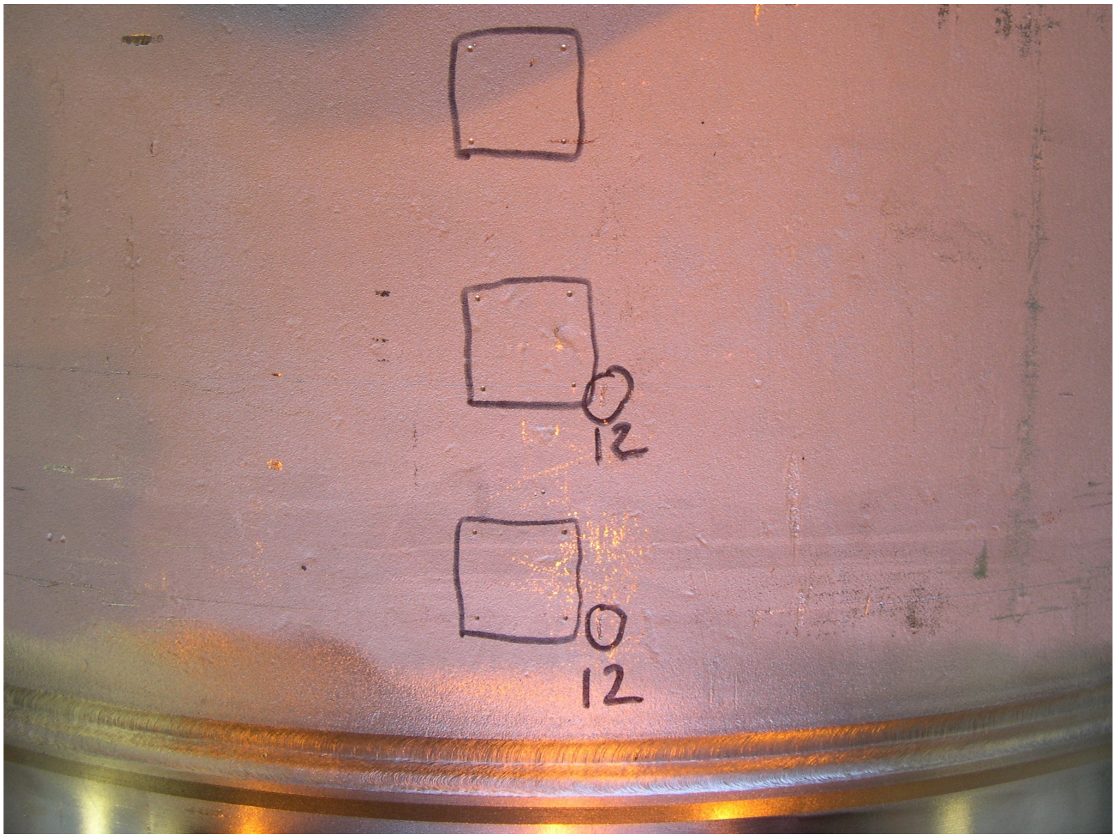


Figure 32. Strain Markings Placed on Test MCO

Final total weight measurements were also taken. Table 4 lists the final total weights for each test MCO. Part II, Appendix B contains all of the pre-drop test data sheets that identify the completed measurements taken.

Table 4. Test MCO Final Weight Information

Test Canister Type	Test MCO Label	Final Weight
MCO	MCO-00-1	17,784 pounds
	MCO-60-2	18,247 pounds

Final labeling of each test MCO was achieved by applying large black and yellow labels on each test MCO. This was done to make canister identification easier and to provide labeling that could be read in the videotapes and still pictures taken. Figure 33 illustrates this labeling. Finally, as a backup to the large applied labeling, each top and bottom was marked (with permanent marker) with the test MCO label. Each test MCO was labeled using a unique sequence of alphanumeric characters with a MCO-AA-B format. MCO is the name of the canister. AA represented the desired impact orientation in degrees, with 00 representing a vertical drop and 90 representing a flat or horizontal drop. B was an additional numerical identifier. For this series of test MCOs, B was simply the numbers 1 through 2.

Figure 33. Example of Test MCO Labeling

The MCO design incorporates a threaded plug into the top head. For the purposes of this drop testing effort, the associated rupture disks and valves in the shield plugs were removed at Hanford. This allowed easier access to the interior of the test MCOs for the pressure and helium leak testing. However, for the drop test, the threaded plugs were installed and then covered with plates that were welded into position (Figure 34) so that no access/egress could occur through the threaded plug openings.

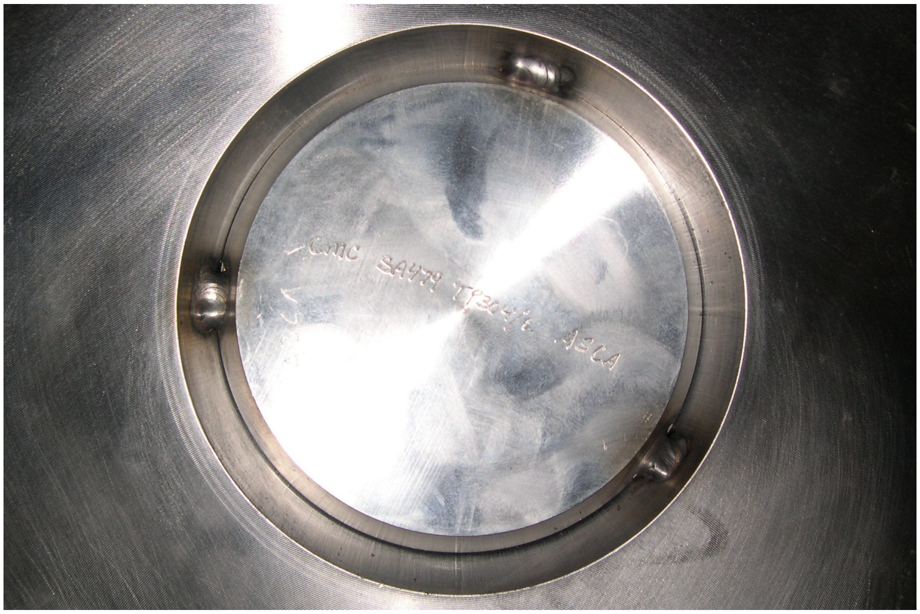


Figure 34. Cover Plate Welded Over Threaded Plug Opening.

The test MCOs were loaded onto a covered flatbed trailer (Figure 35) on July 14, 2004 and trucked to SNL (as a radioactive material shipment), where they arrived on July 15, 2004.

Figure 35. Test MCOs Loaded Onto Truck for Shipment to SNL

9. PHASE V – DROP TESTING AT SNL

SNL, operating under a QA program based on NQA-1 (Reference 16), has an ongoing, qualified drop testing program in place that has been utilized by numerous organizations, including the Department of Defense, the U.S. Nuclear Regulatory Commission, the Department of Energy, and others. An essentially unyielding flat surface, a 2-inch thick steel plate anchor bolted atop a 231 ton block of reinforced concrete, was used for the impact target. A mobile crane was used to lift the test MCOs to the desired drop heights. Figure 36 illustrates the test specimens rigged for drop testing. Note that the test MCOs were treated as radioactive material containers and proper radiological controls were established by SNL. Figure 37 shows the drop test site used at SNL. Their mobile instrumentation data acquisition system (MIDAS) is a self-contained data acquisition facility that can produce fully qualified data documentation. Records of equipment parameters and performance for this drop testing effort were produced, providing a computer-generated audit trail.

Figure 36. Test MCOs Prepared for Drop Testing at SNL With Rigging Attached

Figure 37. Drop Test Site at SNL, With MCO-00-1 Hooked to Crane

SNL was provided a Task Management Agreement (Reference 17) that outlined the NSNFP requirements for this drop testing effort. SNL responded with a test plan (Reference 18) that identified their proposed test procedures and a quality document (Reference 19) that described the quality assurance efforts associated with the testing.

Any test MCO movement activities were to be performed so that excessive or undue harsh treatment of the test MCOs was prevented. The goal was to attribute any damage received by the test MCOs to the drop testing only. SNL spent the rest of July and early August preparing for the drop testing effort. The actual drop testing of both test MCOs was achieved on August 10 and 11, 2004.

SNL was able to fully execute their intended test plan and the results obtained were extremely valuable to the NSNFP. Table 5 lists the test MCOs and whether or not the intended impact orientation was achieved. If not, the magnitude of discrepancy is provided. It can be seen that SNL did an excellent job and the test results obtained were acceptable. Figures 38 and 39 show the test MCOs during their actual drops.

Table 5. Accuracy of Test MCO Impact

Test MCO	Target Impact	Actual Impact	Discrepancy	Acceptable Drop Test
MCO-00-1	0 Degrees	0 Degrees	None	Yes
MCO-60-2	60 Degrees	60.5 Degrees	About ½ Degree	Yes

The MCOs have a specified Design Pressure of 450 psig. Although most of the loaded MCOs are expected to have a much lower internal pressure, this magnitude of Design Pressure was conservatively chosen for safety purposes. Drop testing pressurized canisters adds cost and complicates the drop testing effort from a personnel safety perspective, especially considering the fact that the test MCOs were internally contaminated. In addition, for the MCO canisters, the 450 psig pressure results in low main shell hoop stresses (approximately 11 ksi, below the minimum material yield strength of 25 ksi). Pressure stiffening effects were not expected to adversely affect the drop test results, considering the specific repository-defined drop events. If analysis methods can adequately predict the high strain plastic deformation of the drop test, the analysis method can also incorporate static pressure effects for combined pressure plus drop event evaluations. Therefore, the test MCOs were not pressurized for the drop test.

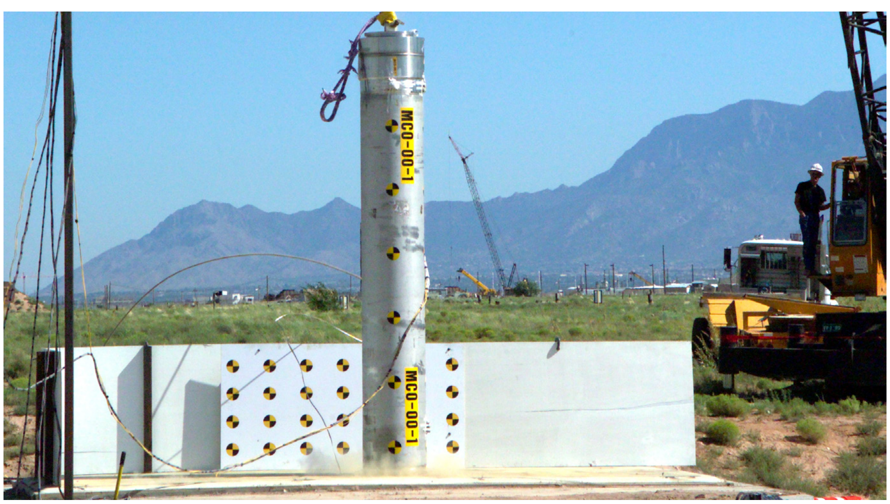


Figure 38. MCO-00-1 During Drop Test

Figure 39. MCO-60-2 During Drop Test

The dropped test MCOs were loaded onto a flat bed trailer and trucked back to the INEEL as a radioactive material shipment. SNL's final drop test data package (Reference 20) was provided to the NSNFP on September 9, 2004.

10. PHASE VI – POST-DROP TEST ACTIVITIES

The test MCOs arrived back at the INEEL for post-drop examination and testing on August 31, 2004. Upon receiving the dropped test MCOs, proper radiological controls were established so that both the NSNFP test personnel and the INEEL personnel could safely work around the test MCOs. The test MCOs were unloaded at the TAN facility. As with the initial loading and unloading activities from the trucks prior to the drop tests, the loading and unloading activities from the trucks after the drop tests were intended to prevent excessive or undue harsh treatment of the test MCOs such that any damage received by the test MCOs could be attributed to the drop tests only.

The post-drop examination, measuring, and testing activities of the deformed test MCOs proceeded at TAN, recording the information onto data record sheets. After deformed measuring efforts were completed, the pneumatic pressure testing to 50 psig minimum and the helium leak testing of both test MCOs was completed, followed by cutting open one test MCO (MCO-00-1) and making brief visual observations of the internals and inside surfaces. MCO-60-2 is currently being stored for potential future use. NSNFP test personnel monitored the activities and completed the visual observations.

For the post-drop evaluation efforts, the test MCOs were placed horizontally across concrete blocks in an effort to duplicate the conditions when the pre-drop test measurements were recorded. Observations by the NSNFP test personnel were made to better understand the structural response of each test MCO during its drop test and how the test MCO geometry changed. As with the pre-drop measurements, these post-drop measurements (Part II, Appendix C) were taken using calibrated measuring devices (except the measuring tape), using the same measuring tolerances. As part of a validation of these measurements and similar to what was done before the drop tests, an INEEL QA inspector qualified to take measurements (see Part II, Appendix C) was requested to chose approximately ten measurements and repeat the indicated measurements (Figure 40). With a self-imposed QA hold in effect, additional activities that could alter these measurements were not permitted to proceed until the NSNFP Quality Engineer (QE) reviewed and accepted these validation measurements as being within a 1/16-inch for micrometer measurements and within 1/8-inch for tape measure measurements. These validation measurements were acceptable (within the stated tolerances), demonstrating that the measurements taken by the NSNFP test personnel were valid.

These observations and measurements were typically canister specific due to the varying canister deformations. However, neither test MCO experience any significant deformation. Visually, little if any dimensional change could be seen after the drop test. The worst diameter change for MCO-00-1 was approximately 1/8-inch and MCO-60-2 experienced a worst diameter change of about 1/10-inch. Part II contains additional information on specific test MCO deformations, including cylindricity insights.

After post-drop measurements were completed, the test MCOs were then subjected to a minimum 50 psig pneumatic pressure test (Figure 41) by qualified INEEL personnel. Using air, each test MCO was slowly brought up to a 50 to 51 psig pressure level and then the air source was valved closed and removed. A digital readout pressure gage was used to measure the test MCO pressure for a one hour interval. After that one hour interval, the pressure gage was read, looking for a noticeable drop. The gage reading remained constant for both test MCOs.

The leak testing effort (Figure 42) utilized INEEL procedure TPR-4976 (Reference 21) and was performed by qualified INEEL personnel (Part II, Appendix D). A full vacuum was pulled inside each test MCO to determine if a helium leak test could proceed. MCO-00-1 was still too “contaminated” with internal helium so a detector probe (sniffer) technique was used. Helium was again placed inside MCO-00-1 and readings with the probe taken on the outside surface. The results determined that MCO-00-1 had a leakage rate not greater than $1x10^{-5}$ std cc/sec (based on the technique used). MCO-60-2 was checked multiple times while pulling a full vacuum on it and was finally able to be helium leak tested using the hood technique. MCO-60-2 was “bagged” in order to permit a helium environment to exist around the outside surface. The results determined that MCO-60-2 had a leakage rate not greater than $1.43x10^{-8}$ std cc/sec or leaktight. The acceptance criteria of leaktight (leakage less than 10^{-7} std cc/sec) are discussed in the ANSI N14.5 standard (Reference 22). Documentation of this helium leak testing can be found in Part II, Appendix D. Although the NSNFP test plan documentation discussed the leak testing acceptance criteria in terms of 1×10^{-7} ref cc/sec [to reflect the latest terminology used in the 1997 version of ANSI N14.5], using either “ref” or “std” yields the same conclusion so this report will continue to use the “std” term since that is what was reported by the INEEL personnel.

Figure 40. Measurements Being Completed By INEEL Level III Inspector

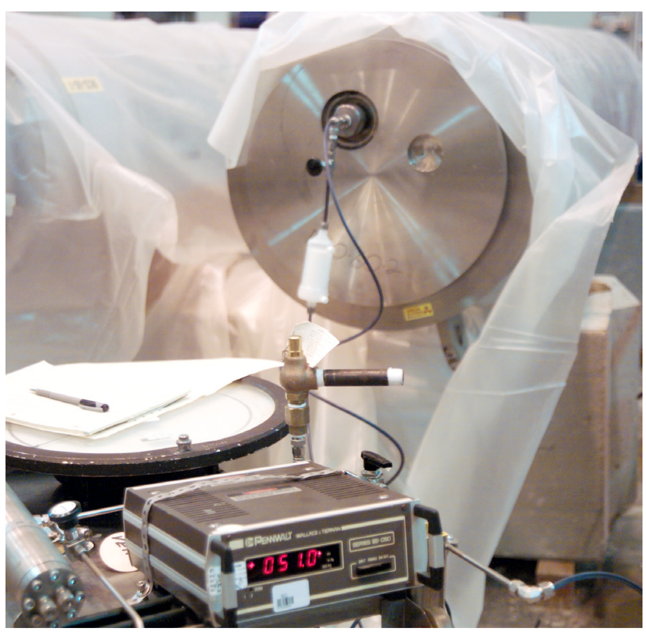


Figure 41. Test MCO Being Pressure Tested

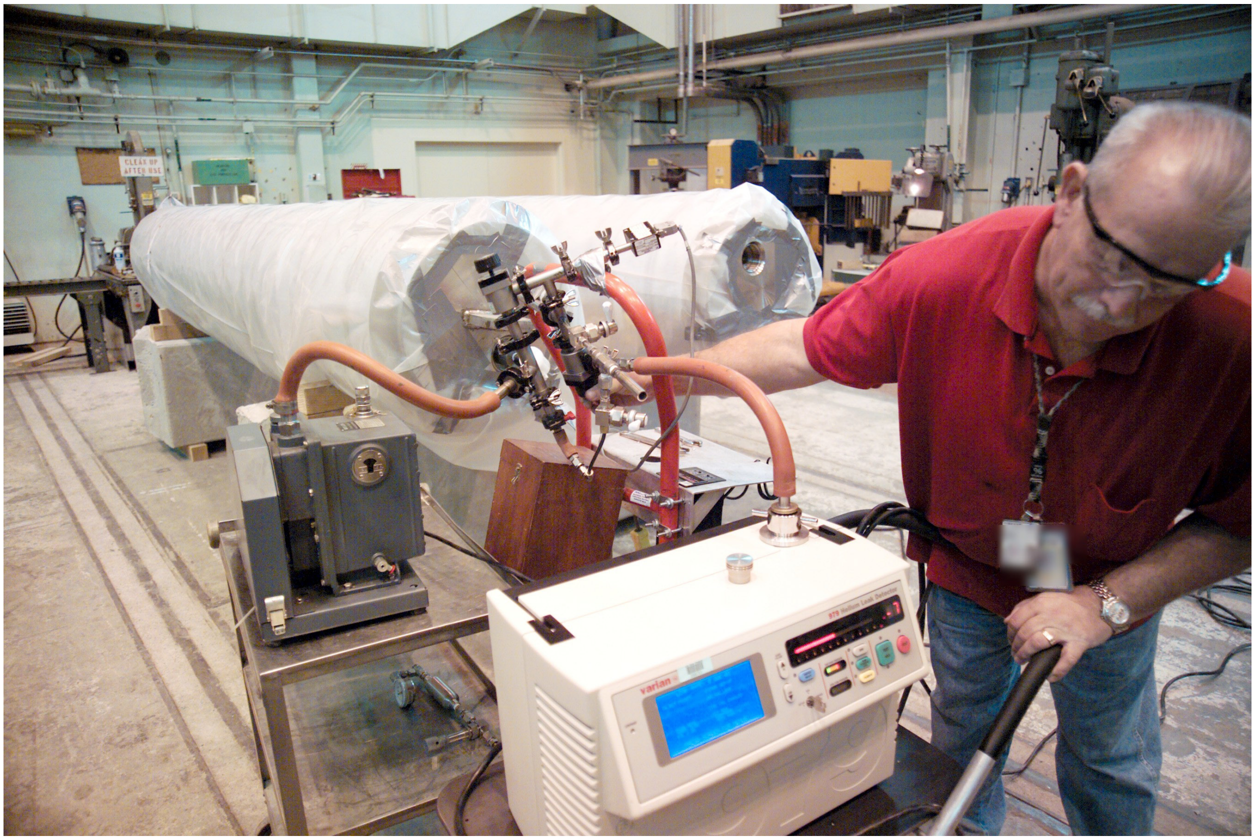


Figure 42. Test MCO Being Helium Leak Tested

After the post-drop measurements, pressure testing, and helium leak testing were completed, one test MCO (MCO-00-1) was cut open (Figure 43) in order to examine the condition of the internal baskets and the interior surfaces of the test MCO. With the exception of the bottom basket, none of the four Mark IV scrap baskets with the large diameter weights appeared to be visibly damaged (Figures 44 and 45) nor was any surface damage observed on the inside shell of the test MCO.

The bottom basket of MCO-00-1 (Figure 46) did experience significant damage as anticipated, due to the baskets above it displacing vertically downward during the drop test. Note from Figure 46 that the foam kept the 2-1/2-inch diameter bars in place while the basket above was able to deform downward, not contacting the 2-1/2-inch diameter bars as anticipated. Figure 46 also indicates that the perimeter bars were not located directly over the basket support bars but approximately half-way between the basket support bars. Figure 47 clearly shows the deformed perimeter bars. Figure 48 shows how the bottom plate of the basket deformed over one of the six basket support bars (1/2-inch wide and 1.25-inch tall) that are welded to the bottom of the test MCO. Figures 49 and 50 show the visible difference between the top of the center post from the bottom basket (Figure 49) and the top of the center post from one of the upper four baskets (Figure 50).

Figure 43. MCO-00-1 Being Cut Open For Internals Inspection

Figure 44. Post-Drop Modified Mark IV Scrap Baskets

Figure 45. Post-Drop Modified Mark IV Scrap Baskets

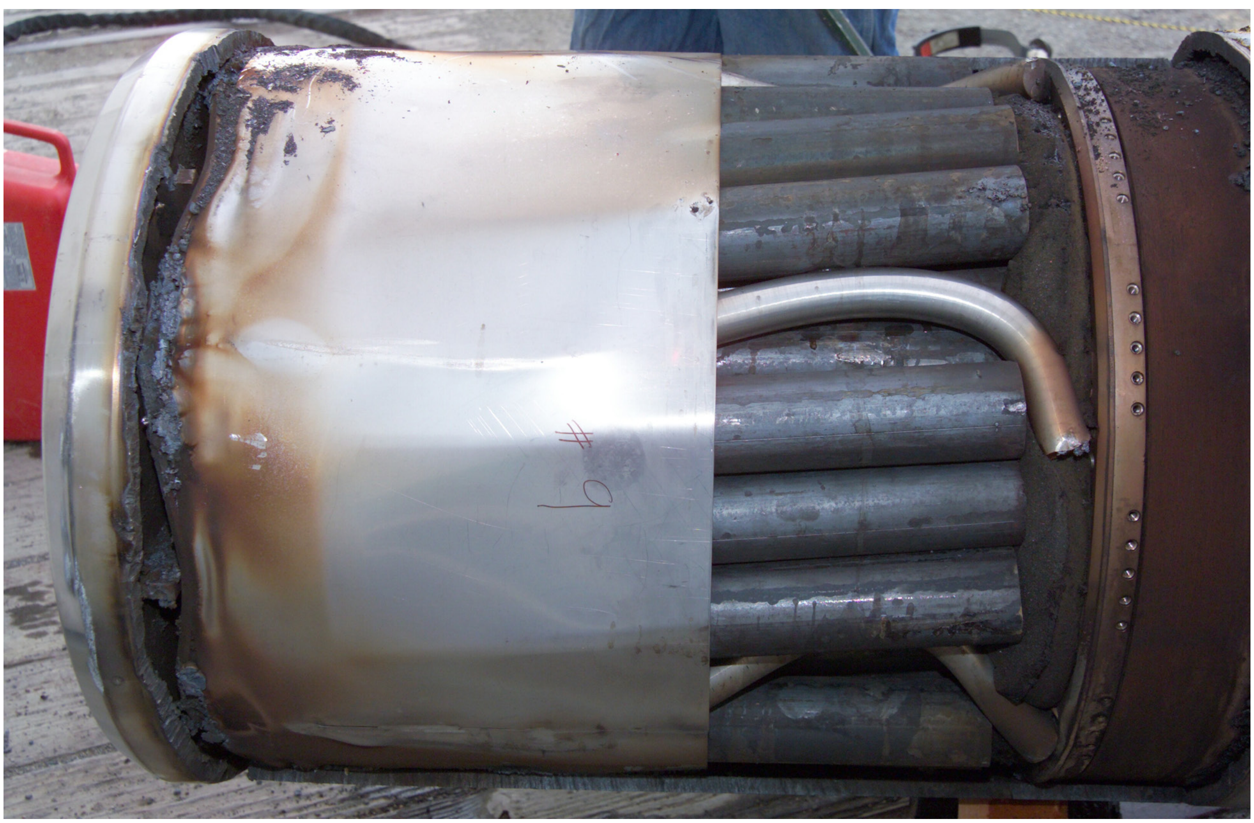


Figure 46. Post-Drop Test Bottom Mark IV Fuel Basket

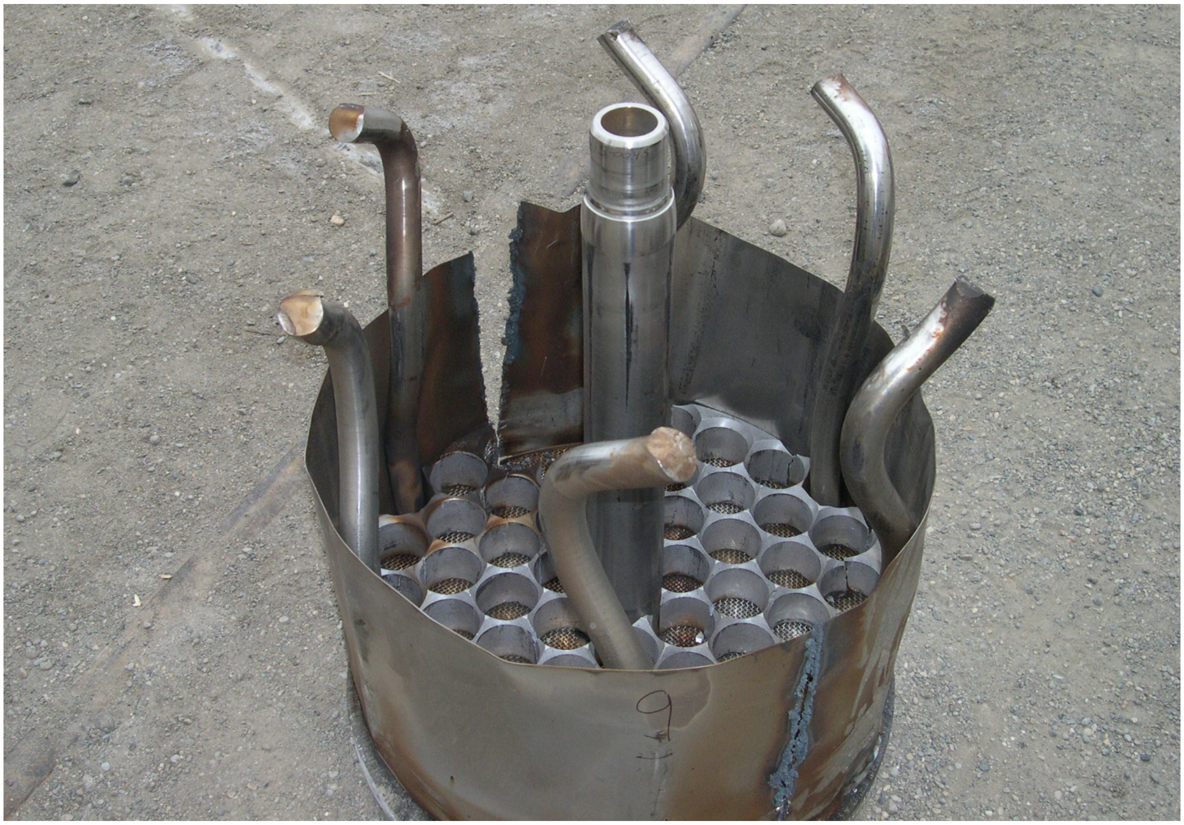


Figure 47. Post-Drop MCO-00-1 Bottom Basket Without Bars Showing Deformed Perimeter Bars (cuts in shroud from plasma cutting of test MCO shell)

Figure 48. Close-up of MCO-00-1 Bottom Basket Plate Deformed Over Basket Support Bar on Test MCO Bottom (slightly rotated during dissaembly)

Figure 49. Top of Center Post of MCO-00-1 Bottom Basket (Post-Drop)

Figure 50. Top of Center Post of Other Upper MCO-00-1 Basket (Post-Drop)

The subsections below provide highlights of the post-drop condition of each test MCO. Additional details can be found in Part II.

10.1. Canister MCO-00-1

This test MCO was dropped from a vertical orientation 23 feet onto the essentially unyielding surface. Figure 51 shows the bottom portion (primary impact location) of the test MCO. No damage is visible, either on the surface of the test MCO bottom or the sides of the test MCO. No bulges formed. A significant point to note is that this test MCO did not fall over but remained standing vertically after being dropped 23 feet. Figure 52 shows the top portion (which did not impact) of this test MCO. Figure 53 shows how the test MCO did not appear to bow over the test MCO length.

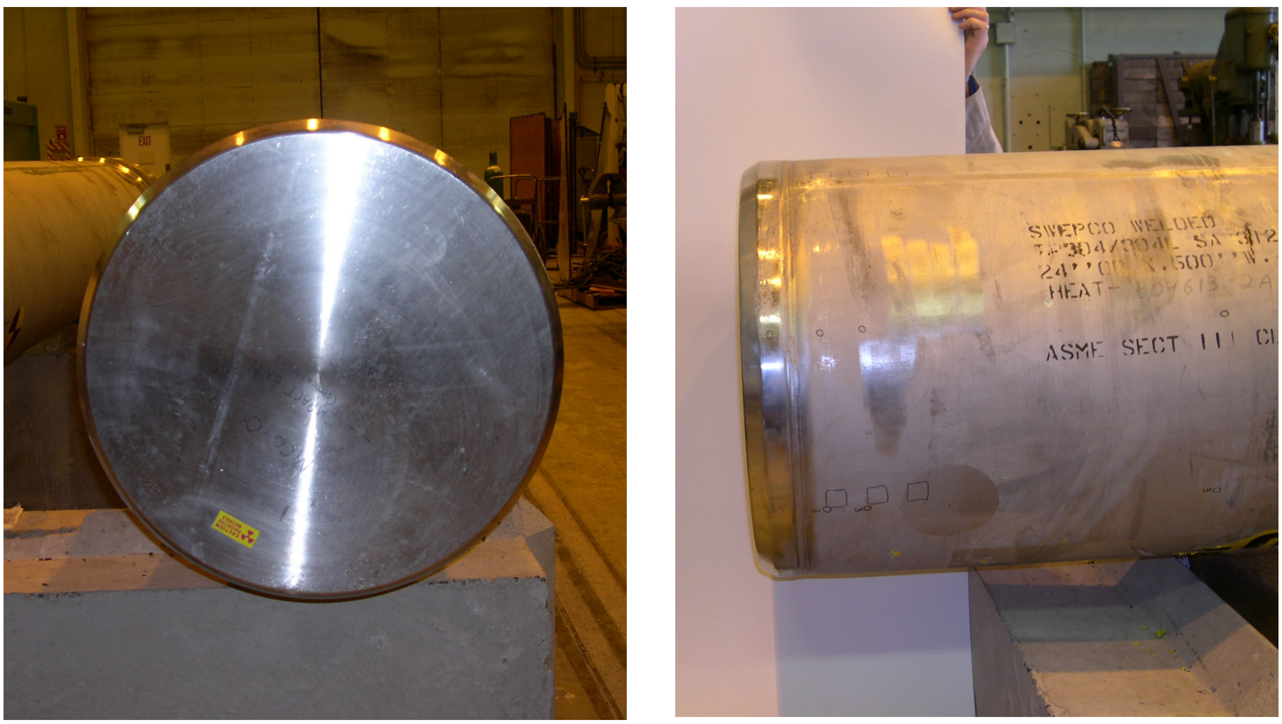
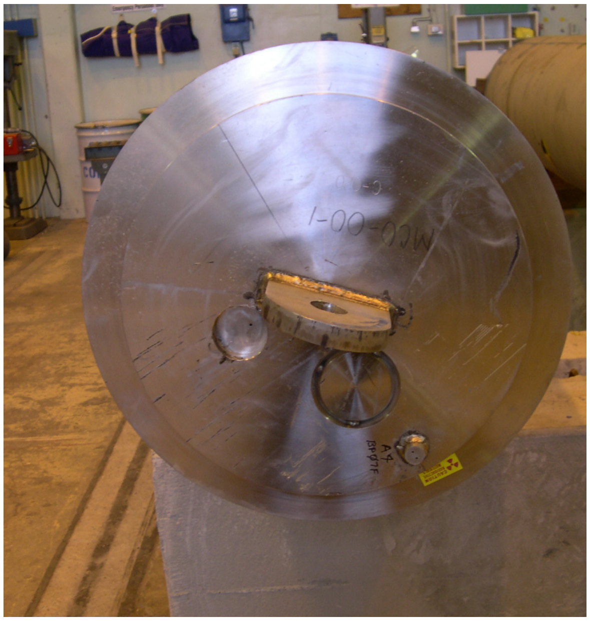


Figure 51. Bottom End and SideView of MCO-00-1



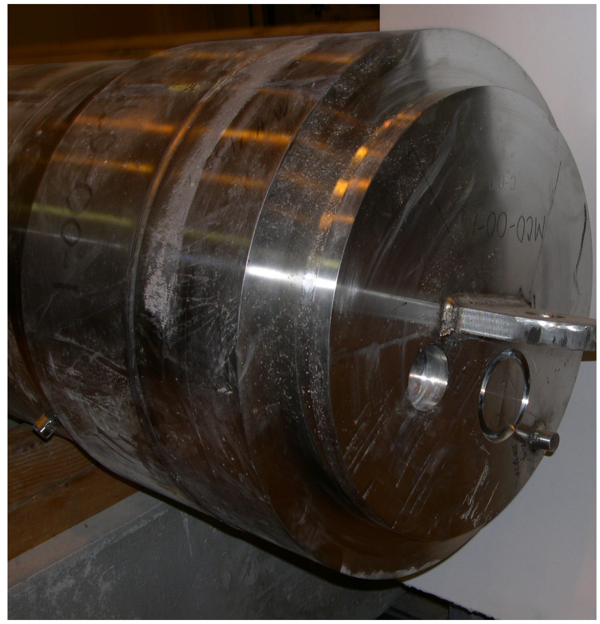


Figure 52. End and AngleView of MCO-00-1 Top (did not impact)

Figure 53. Insignificant Deformation Along Length of MCO-00-1

10.2. Canister MCO-60-2

This test MCO was dropped from a 60-degree (from vertical) orientation 2 feet onto the essentially unyielding surface. This was to simulate a slapdown drop event. Figure 54 shows the bottom portion (primary impact location) of the test MCO while Figure 55 shows the top portion (secondary impact location) of this test MCO. Neither end reveals any visible deformation other than the localized surface scuffing due to impact that is better illustrated in Figure 56. Figure 57 shows that the test MCO did not show any visible bow over its length.

Figure 54. Bottom End and SideView of MCO-60-2

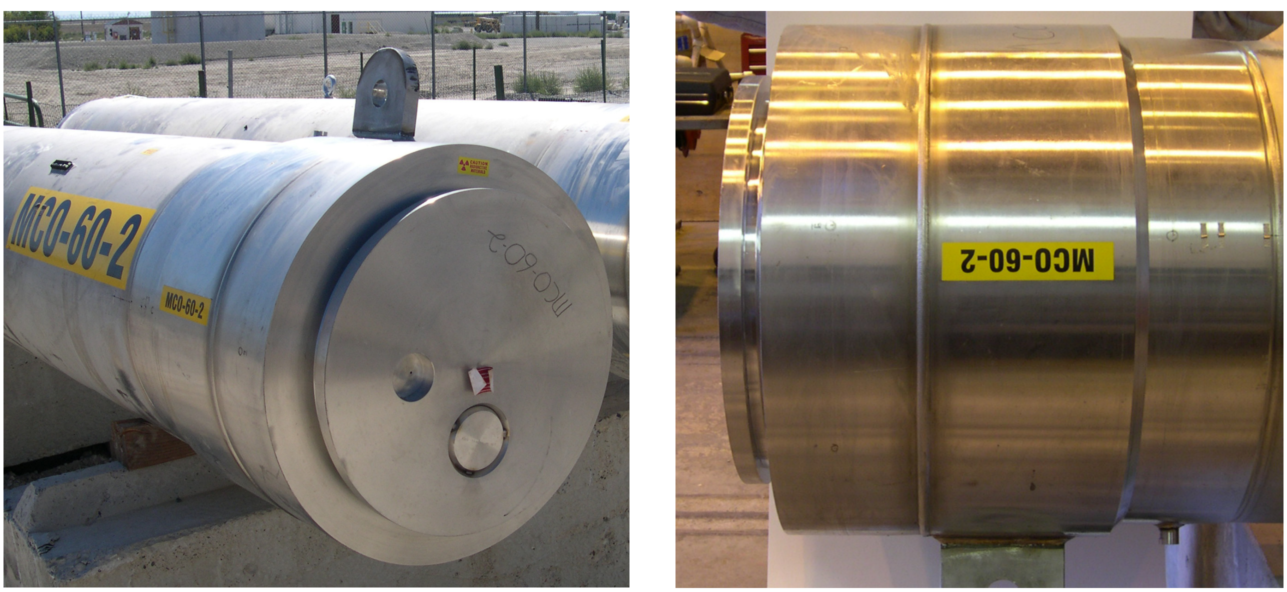


Figure 55. Top End and SideView of MCO-60-2

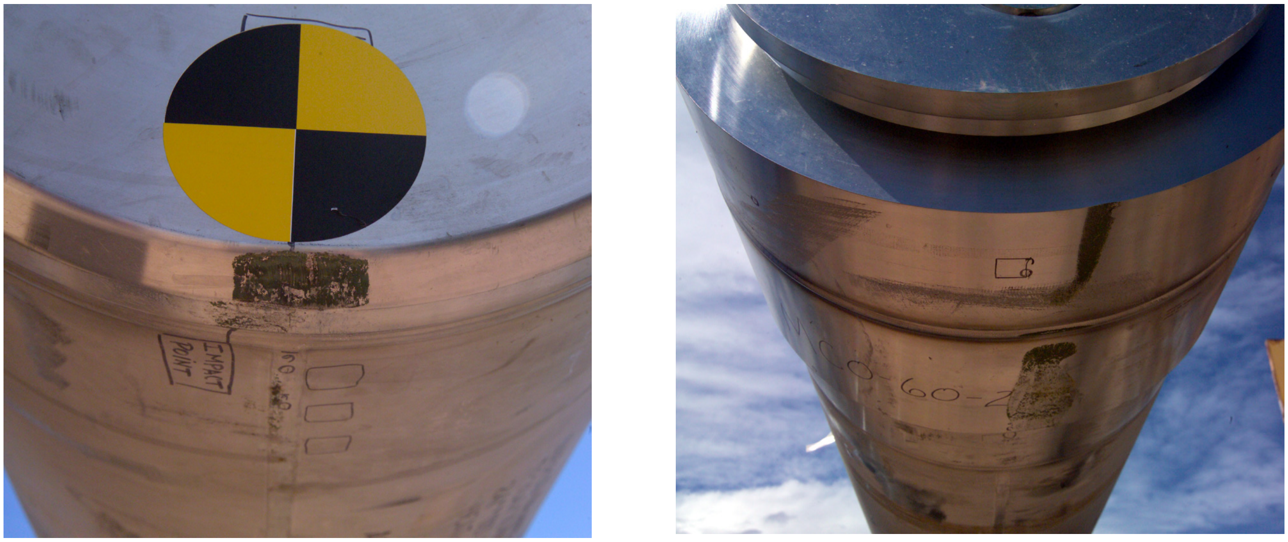


Figure 56. Primary (left) and Secondary (right) Impact Points on MCO-60-2

Figure 57. Insignificant Deformation Along Length of MCO-60-2

11. PHASE VII – FINAL REPORT AND DOCUMENTATION PACKAGES

The last phase of this effort included: (1) the generation of a final report (this report) by NSNFP test personnel that addresses all of the associated activities, including the accuracy of the computer prediction efforts, (2) submitting the Hanford test MCO documentation to the NSNFP, and (3) submitting the documentation generated by SNL, reporting on all of their associated efforts to actually perform the drop tests.

12. CONCLUSIONS

Two test MCOs were fabricated and N-stamped per ASME B&PV Code, Section III, Subsection NB (with Code Case N-595-3) criteria. These test MCOs were drop tested at SNL onto an essentially unyielding flat surface, one test MCO from a height of 23 feet (vertical orientation) and the other test MCO from a height of 2 feet (60-degree from vertical slapdown orientation). After the tests, both test MCOs were able to hold 50 psig of air steady for one hour without a measurable loss of pressure. Then, both test

MCOs were helium leak tested with the vertically dropped test MCO (MCO-00-1) having a demonstrated leakage rate not greater than $1x10^{-5}$ std cc/sec and the slapdown dropped test MCO (MCO-60-2) having a leakage rate of less than $1x10^{-7}$ std cc/sec.

These results demonstrate that the test MCOs were robust and that the pressure boundary remained intact after the defined repository drop events. MCO-60-2 was shown to have a leaktight containment while MCO-00-1 (limited by the type of leak test performed) was shown to have a leakage rate less than the limit of $1x10^{-4}$ std cc/sec specified in ASME B&PV Code Case N-595-3 for closure welds.

13. REFERENCES

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PART II

ANALYSIS AND TEST RESULTS OF THE REPRESENTATIVE MULTI-CANISTER OVERPACK DROP TESTING EFFORT

PART II CONTENTS

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PART II
ANALYSIS AND TEST RESULTS
OF THE REPRESENTATIVE MULTI-CANISTER OVERPACK
DROP TESTING EFFORT

1. INTRODUCTION

The Multi-Canister Overpack (MCO) is a canister designed and fabricated for use at the Department of Energy (DOE) Hanford Site. The MCO is a stainless steel (SST) cylindrical vessel primarily 24 inches in outer diameter and about 166 inches (13.8-feet) long. Spent nuclear fuel (SNF) is placed in one of four types of baskets and then loaded into the MCO. A fully loaded MCO holds five or six baskets (depending on type) and a shield plug fixed in place with a locking ring. A cover cap is welded on the top-end to complete the package. A fully loaded MCO will weigh as much as 10 tons.

The MCO was intended to contain SNF from the Hanford K-Basins during interim storage at Hanford's Canister Storage Building for 40 years or more (References 1 & 2). Analyses have been performed on the MCO to support its use at Hanford (e.g., Reference 2). It is expected that the MCO will be shipped to the national repository for final disposal at some future time. Therefore, analyses were performed on the MCO under accidental drop conditions to envelope those required at the repository (Reference 3), which consisted of a 23-foot vertical drop and a 2-foot worst angle drop onto an unyielding, flat surface. The analytical results indicated that the MCO was expected to maintain containment during the specified drop events. (A drop onto a 6-inch diameter post was also performed on the MCO, Reference 4.)

In order to provide additional evidence of containment of the MCOs under the two repository accidental drop events, the NSNFP decided to perform actual drop tests. This report will discuss the results of a 23-foot vertical and a 2-foot slapdown (60 degrees off-vertical) drop of test MCOs onto an unyielding, flat surface, and the accompanying pressure and leak test and analytical results.

The analytical evaluations discussed herein were performed in accordance with NSNFP Procedure 11.01 (Reference 5), as indicated in the associated Test Plan (Reference 6).

(Fluor Hanford was the M&O contractor at the DOE Hanford Site during this effort. In this report, all work will be referred to as having been performed at or by "Hanford.")

2. SCOPE

It was the NSNFP's desire to assemble and drop test two test MCOs with contents [internals plus representative simulated (non-radioactive) SNF] that would most significantly challenge the test MCOs from a containment perspective. This drop testing effort was not developed to provide specific deformational guidance (i.e., canister or internals deformations) with respect to SNF criticality, shielding, or other related safety issues. However, drop response insights can be realized from this effort when properly evaluated in relationship to the specific safety issue. The main focus of the drop testing was to demonstrate that test MCO containment was maintained for the specified impact orientations. Test MCO deformation was also of interest with respect to the ability of a dropped MCO to fit inside another container, such as the repository waste package or a transportation cask.

The scope of this report (Part II) was limited to discussing the results of the drop testing of two test MCOs. Future acceptance by both the DOE and the United States Nuclear Regulatory Commission (USNRC) of the drop testing and resulting data was desired. This resulted in selecting a supplier with an ASME NQA-1 based quality program for the drop testing, a drop test facility with an essentially unyielding drop surface, and a fully calibrated and quality-controlled data acquisition system. Sandia National Laboratories (SNL) had such a program and facilities and was, therefore, contracted to perform the drop testing. The construction of test canisters was completed at Hanford in the spring/early summer of FY2004. Drop testing of the canisters was performed on August 10 - 11, 2004 at SNL.

This report compares the results of pre-drop and limited post-drop analytical evaluations to the actual test MCO deformations. Additionally, the results of accompanying pressure and helium leak testing will be discussed herein.

Only beginning-of-life material and structural conditions were considered (e.g., un-irradiated canister materials) - no end-of-life (aged) conditions will be addressed in this report.

3. QUALITY ASSURANCE

This document was developed and is controlled in accordance with NSNFP procedures. Unless noted otherwise, information must be evaluated for adequacy relative to its specific use if relied on to support design or decisions important to safety or waste isolation.

The NSNFP procedures applied to this activity implement DOE/RW-0333P, “Quality Assurance Requirements and Description,” and are part of the NSNFP QA Program. The NSNFP QA Program has been assessed and accepted by representatives of the Office of Quality Assurance within the Office of Civilian Radioactive Waste Management for the work scope of the NSNFP. The NSNFP work scope extends to the work presented in this report.

The current, principal NSNFP procedures applied to this activity include the following:

- NSNFP Procedure 6.01, “Review and Approval of NSNFP Internal Documents,”
- NSNFP Procedure 6.03, “Managing Document Control and Distribution,”
- NSNFP Procedure 3.04, “Engineering Documentation.”

4. MCO AND INTERNALS DESIGN

4.1. MCO Design

Details that define the MCO and internal basket configurations are found in Reference 7. The main components of the MCO were as follows:

- A 24-inch nominal outer diameter canister, about 166 inches (13.8 feet) in overall length, with a maximum design weight of 20,080 pounds (with fully loaded Mark IV baskets, dry),
- The main shell was made of 24-inch nominal outer diameter pipe with a 1/2-inch nominal thickness (SA-312 TP304/304L SST),
- The shell bottom was approximately 24 inches in diameter and was about 2 inches thick (SA-182 F304/304L SST),
- The collar (SA-182 F304/304L SST), which was about 15-inches in height with an increased outer diameter of 25.3 inches, was a continuation of the main shell that was threaded to accept the locking ring,
- The locking ring (SA-182 F304N SST), which was about 6-1/2 inches in height, threaded into the collar and held the shield plug in position within the collar (the locking ring also included a ring for lifting the MCO),
- The shield plug was about 16 inches in height, and housed filters, rupture disks, and process valves (SA-182 F304L and SA-240 304L),
  (for the purposes of this evaluation, when the shield plug was referred to, it included the assembly with the guard plate and ring, and the basket stabilizer extension)
- The process tube was made of 1-inch schedule XXS pipe (146-1/2 inches in length), attached to the shield plug, and extended to the shell bottom (SA-312 TP304L SST),
- Six basket support bars were welded to the shell bottom (SA-240 304L SST),
- A guide cone was attached to the basket support bars to hold the bottom-end of the process tube (SA-479 304L SST),
- The closure cover was about 9 inches in height and attached to the collar to seal the container (SA-182 F304L). The cover also included a ring for lifting the sealed MCO.

Figures 1 and 2 show the MCO design, with close-up views of the top and bottom ends.

4.2. MCO Internals

An MCO contains either six Mark 1A baskets or five Mark IV baskets. Two of the baskets within an MCO may be scrap baskets (baskets for SNF pieces) where the remaining baskets must be fuel baskets. Details on the design of the MCO Mark 1A and Mark IV fuel and scrap baskets are discussed in Reference 3. Figures 3 and 4 show the fuel basket designs.

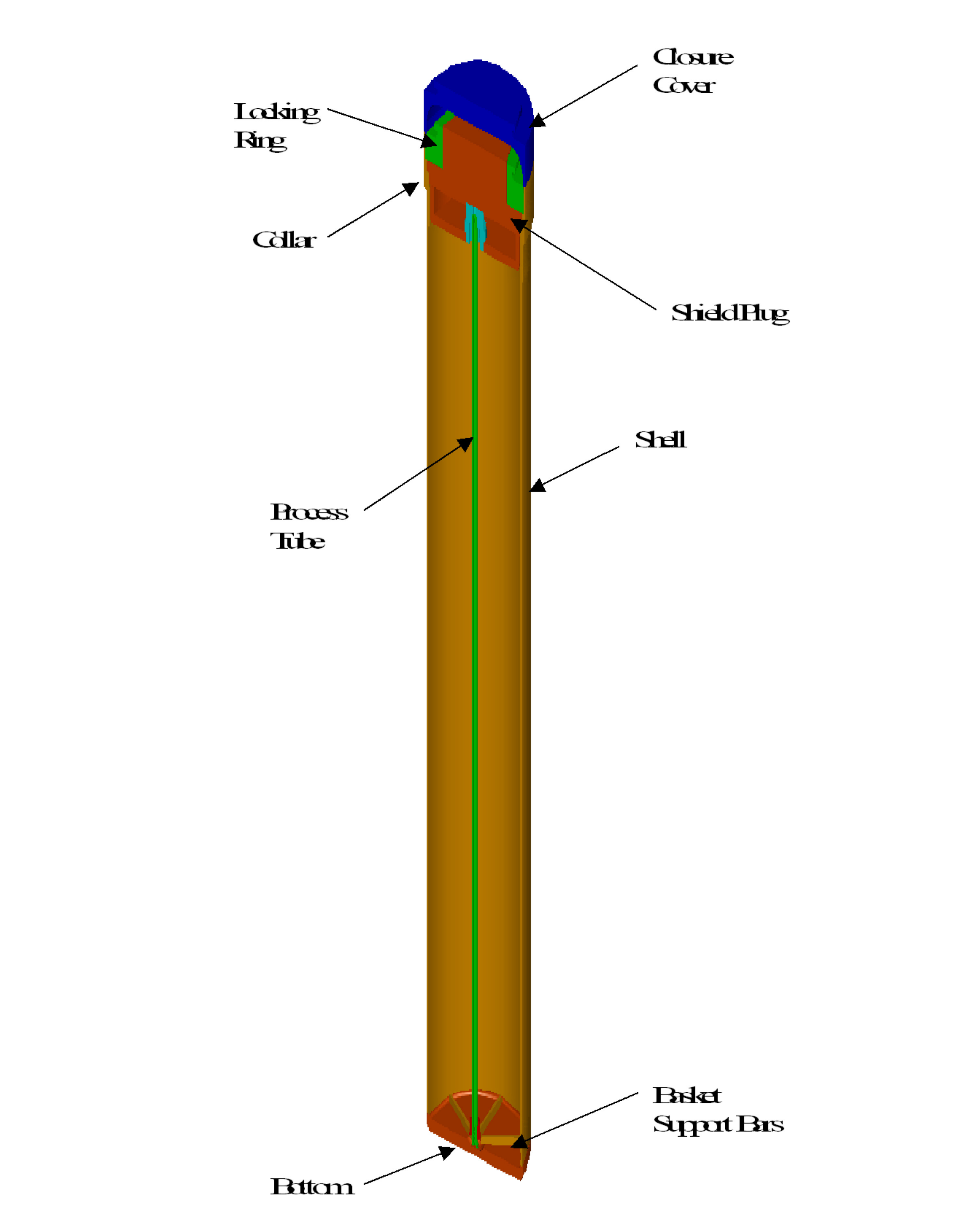
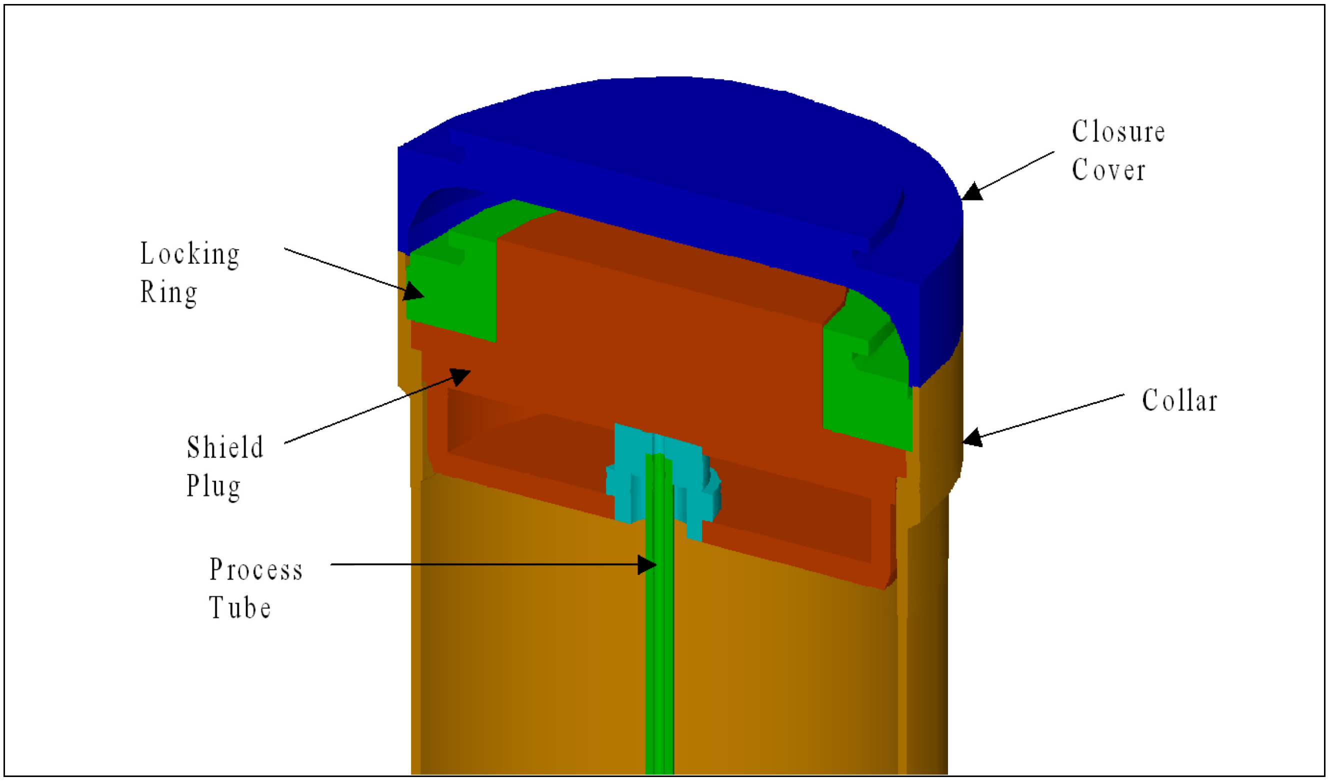
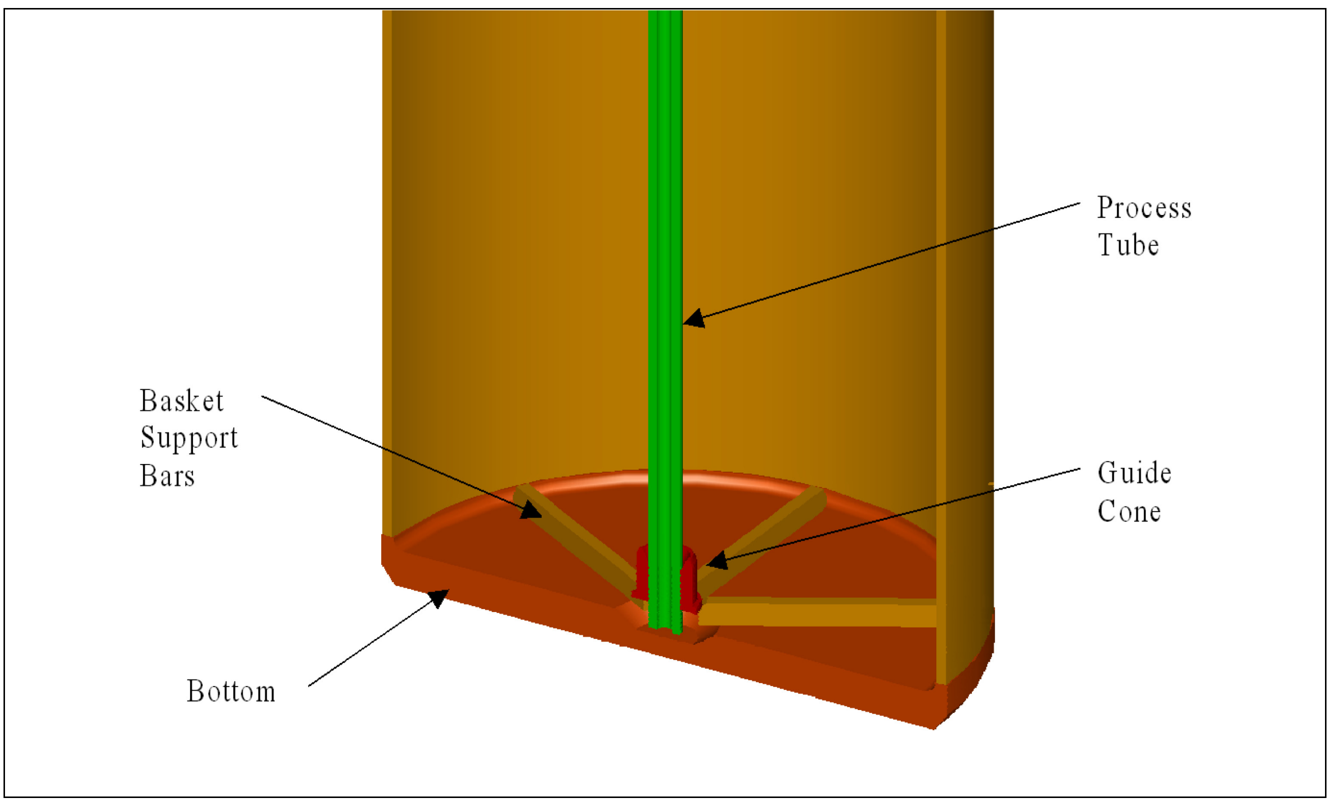


Figure 1. MCO Design (Cross-Section View)



Top-End



Bottom End

Figure 2. Close-up of MCO Ends (Cross-Section View)

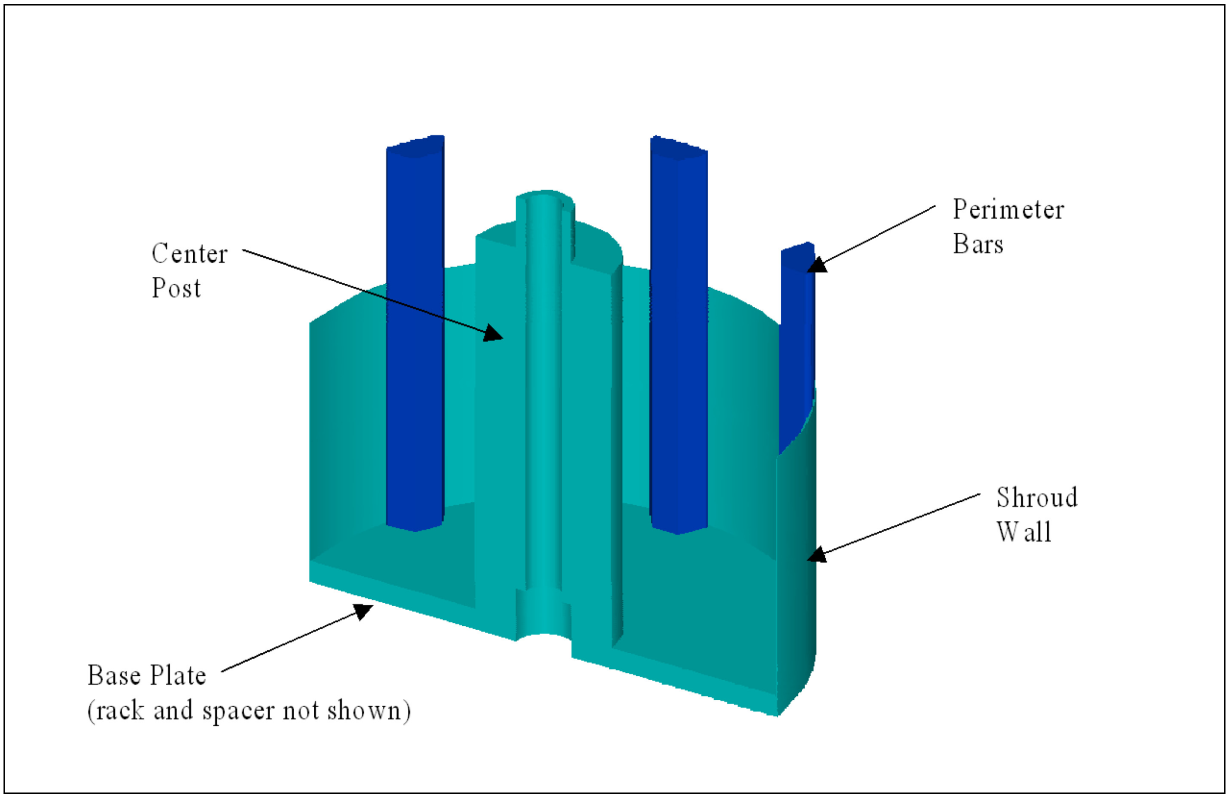


Figure 3. MCO Mark 1A Fuel Basket

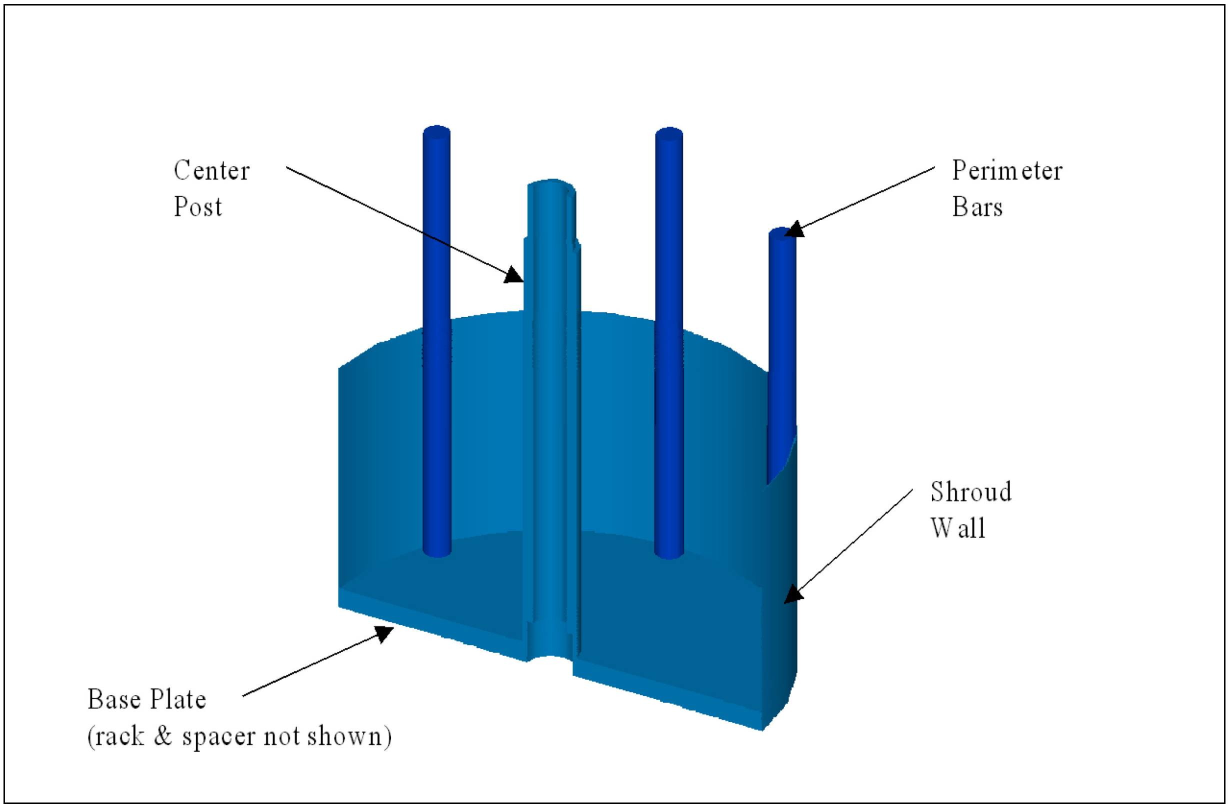


Figure 4. MCO Mark IV Fuel Basket

5. TEST MCO DESIGN AND IDENTIFICATION

The two test MCOs were actual production MCOs fabricated for Hanford. Internal baskets were also actual production baskets, modified to contain the NSNFP-provided simulated SNF. References 8 and 9 discuss the modifications to the baskets, and Appendix A shows the design of the simulated SNF for the two test MCOs.

The test MCOs will be referred to in this report by their labels. The labels consist of three groups of letters/numbers separated by dashes. This may be read as follows: MCO – intended angle at impact – I.D. number. Table 1 below shows the test MCO labels and their meanings.

Table 1. Test MCO Labels

Canister Type	Intended Angle at Impact (from vertical)	Test MCO Label*
Test MCO	0 (vertical)	MCO-00-1
Test MCO	60	MCO-60-2

6. TEST MCO INTERNAL COMPONENTS

The intent of this drop testing effort was not to test every possible combination of baskets within an MCO, but to show that containment was maintained for a worst case loading. The internal components were chosen as discussed in the following subsections. (As a simplification, neither test MCO internal configuration included a process tube - which was considered to have no significant effect on the MCO response during the drop events.)

6.1. Vertical Drop Test MCO-00-1 Internal Components

The previous analysis (Reference 3) showed that during a vertical drop onto a flat, unyielding surface, the drop energy of the internal components (baskets and fuels) was absorbed by those same components – primarily in the bottom basket. Very little internal component drop energy went into the MCO basket support bars or bottom. This was due to the fact that the only transfer mechanism from the internal components to the remaining MCO structure was through the basket support bars and the bottom (primarily in compression). In a similar manner, the drop energy of the MCO structure (everything except for the internal components) was absorbed entirely by that same structure because there was no transfer mechanism from the MCO structure to the internal components. This meant that the choice of Mark 1A or Mark IV baskets for internals in this vertically-dropped MCO was not important as far as the MCO containment boundary was concerned. Therefore, Mark IV baskets were chosen for the vertically-dropped test MCO. (Mark 1A baskets will not be discussed further in this report subsection.)

The previous analysis showed that the bottom Mark IV basket in an MCO deformed significantly during a vertical drop event while the upper four baskets experienced comparatively negligible deformations. Since the bottom Mark IV fuel basket was the only one of real interest, the upper fuel baskets were modified so as to maximize the weight that could be held by them. The basket modifications consisted of removing all components except for the base plate and the center post (Hanford elected to modify Mark IV scrap baskets for these four baskets). This allowed for a nominal 22-inch diameter solid steel bar, 26.7 inches long, with a center hole for the center post to be placed on the four top baskets. (The length of 26.7 inches matched the length of the basket perimeter bars which supported the base plate of the basket above.) Appendix A shows these internal basket weights.

The bottom representative Mark IV fuel basket (made by Hanford by modifying a Mark IV scrap basket) held fifty-four 2-1/2-inch diameter steel bars that were 21 inches long. These bars simulated the fuel elements held by a Mark IV fuel basket. The actual fuel elements were at most 26.1 inches long. Making these simulated fuel elements 21 inches long allowed for deformation of the basket perimeter bars and center post before the simulated fuel elements were contacted. Appendix A shows these simulated fuel elements.

Figure 5 shows the loading configuration for the vertical drop MCO-00-1.

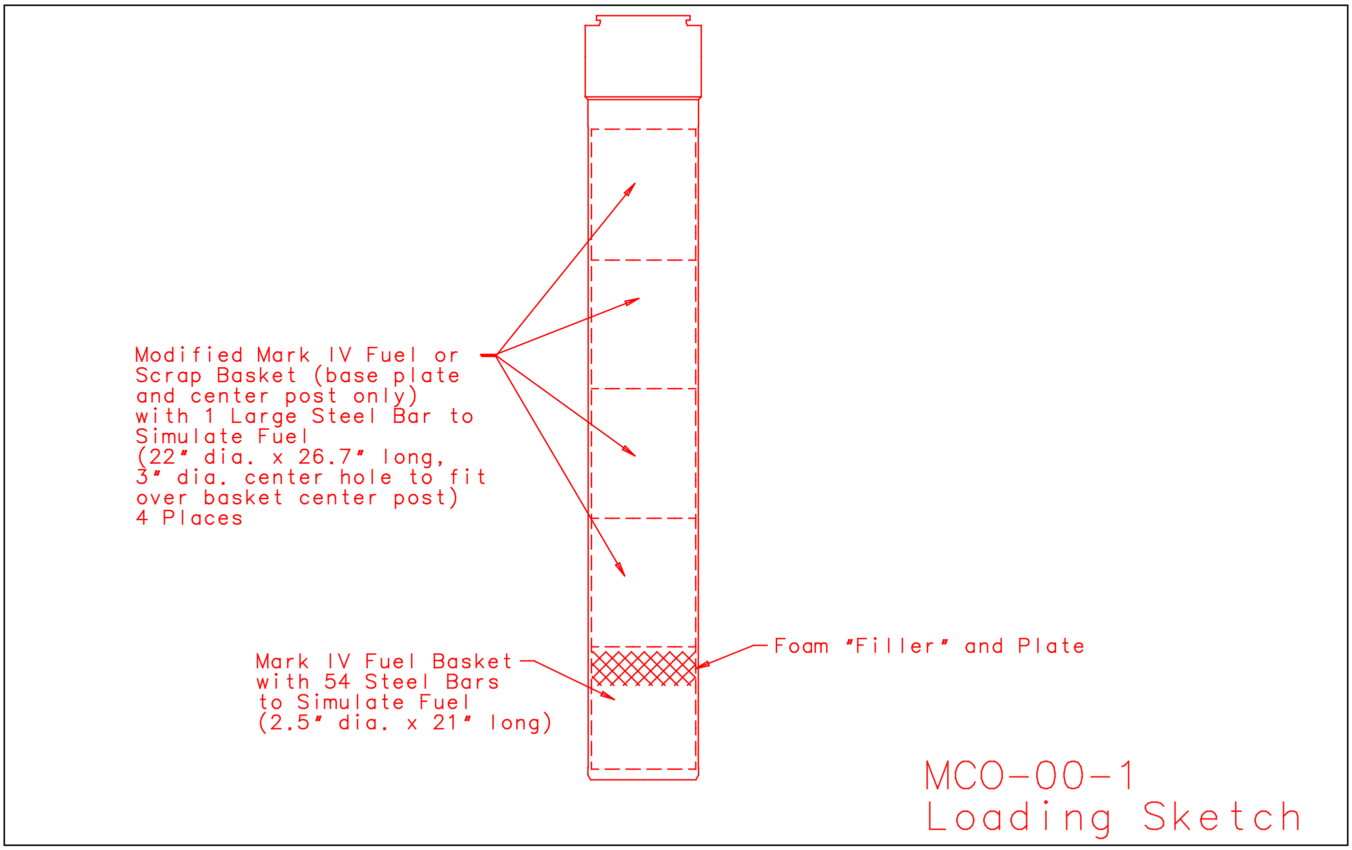


Figure 5. Loading Sketch for MCO-00-1

In order to keep the simulated fuel elements in place during transportation, a foam filler and a thin steel plate were placed above them during assembly. The sketches in Appendix A also show these components.

6.2. 60-Degree Off-Vertical Drop Test MCO-60-2 Internal Components

Unlike the vertical drop event, the 60-degree off-vertical test MCO internal components bore directly on the MCO bottom, main shell, and shield plug during a 60-degree off-vertical drop event. The goal, therefore, was to maximize the weight of the internal components while providing some internal space for MCO deformation. An internal component configuration similar to that used for test MCO-00-1 was selected for test MCO-60-2. In this test MCO, the bottom four baskets consisted of modified Mark IV baskets (base plate and center post only remaining) each with the nominal 22-inch diameter steel bar with center hole discussed previously. The top basket was a Mark IV fuel basket (made by Hanford by modifying a Mark IV scrap basket) with fifty-four 2-1/2-inch diameter steel bars that were 26 inches long to simulate the actual fuel elements. By using the 2-1/2-inch bars in the top basket, the MCO main shell and collar regions would not be artificially stiffened during the top end impact (which would have been the case if the 22-inch diameter bar had been used in that location). The MCO main shell was not considered artificially stiffened at the bottom due to the 22-inch bar in the bottom basket due to the stiffness already provided by the MCO bottom (2 inches thick) and the bottom basket base plate.

Figure 6 shows the loading configuration for the 60-degree off-vertical drop MCO-60-2.

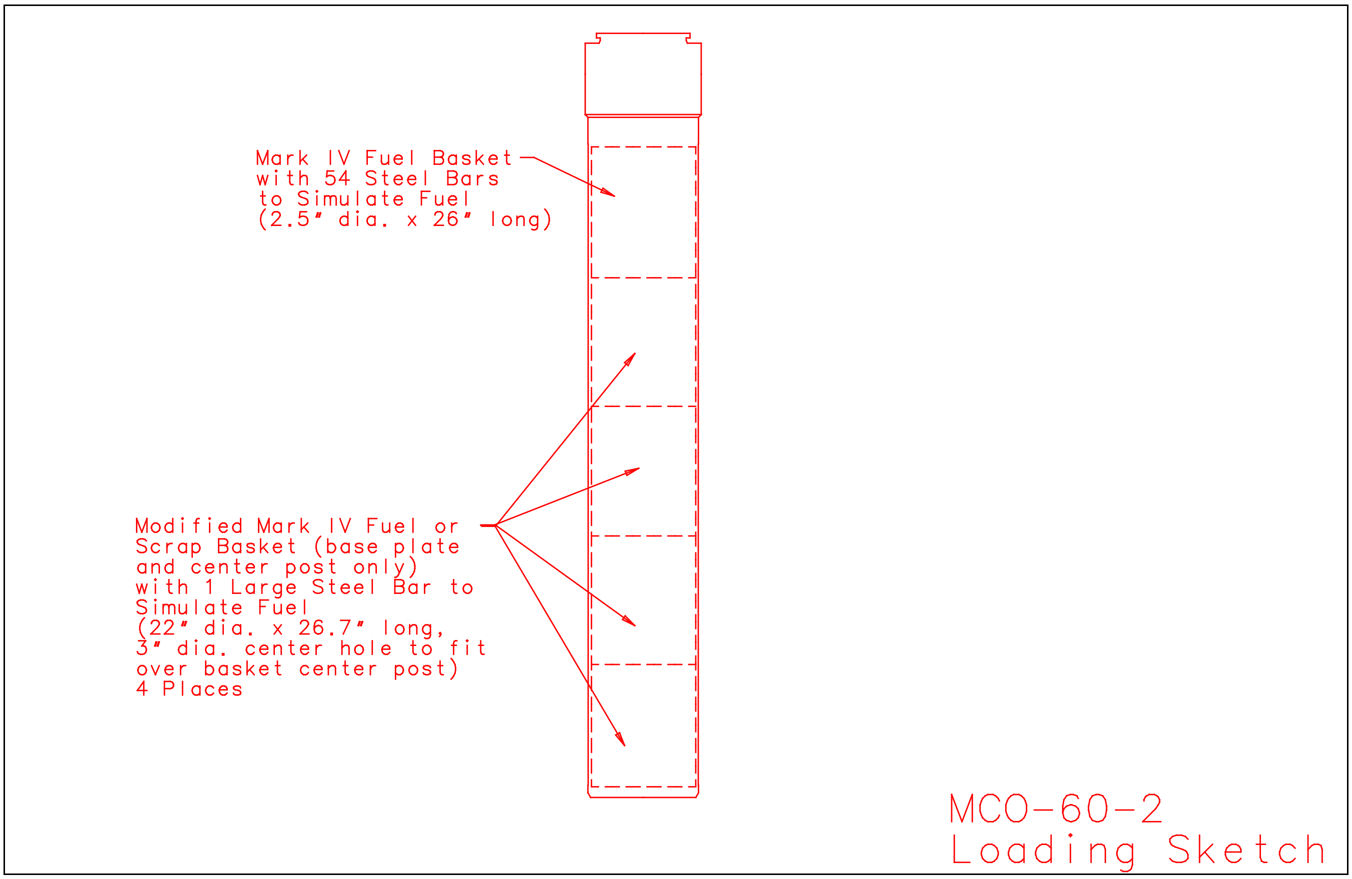


Figure 6. Loading Sketch for MCO-60-2

7. DROP TEST CONDITIONS

Table 2 shows the test MCO drop test conditions. Also included are the test MCO length and total loaded weights.

Table 2. Test MCO Drop Conditions

Test MCO Label	Length (ft.)	Desired Impact Angle[1] (deg.)	Total Weight (lbs)[2]	Drop Height (ft.)
MCO-00-1	13.83	0 (vertical)	17,784	23
MCO-60-2	13.83	60	18,247	2

1. The impact angle was with respect to vertical (i.e., 0 is vertical and 90 is horizontal).
2. The total test MCO loaded weight was listed in the pre-drop data sheets in Appendix B.

The impact surface at SNL was a 2-inch thick steel armor plate grouted and anchor bolted to a heavily reinforced concrete block that weighed about 462,000 pounds (Reference 10). This was 25 times heavier than the test canisters and was considered essentially unyielding.

8. TEST MCO AND INTERNALS MATERIALS

8.1. Test MCO Material Properties

The test MCOs used 304/304L stainless steel for all bottoms, main shells, collars, covers, and shield plugs (304H for locking rings). Table 3 shows the material properties from the manufacturer-provided certified material test reports (CMTRs, see Reference 9).

Table 3. Test MCO Certified Material Properties (at 70 Degrees F.)

Component Specification (Material)	Heat No.	Engineering Yield Strength (psi)	Engineering Ultimate Strength (psi)	Elongation (%)	Area Reduction (R)
Main Shell SA-312 (TP304/TP304L	804613[1] 804632[2]	41416 45372	85671 94526	45 54	75.6 69.6
Collar SA-182 (F304/F304L)	H7972	37395	78933	61.5	76.9
Bottom SA-182 (F304/F304L)	31769	40100	82900	57	73
Cover SA-182 (F304/F304L)	M273	40500	80000	67	80
Locking Ring SA-182 (F304H)	H8037	54910	102180	51.4	76.2
Shield Plug SA-182 (F304/F304L)	M273	40500	80000	67	80

1. MCO-00-1 data only. 2. MCO-60-2 data only.
The material properties for the guide cone and basket support bars used that listed for the bottom.

The Table 3 material yield and ultimate strength properties were based on the original cross-sectional area – making them engineering properties. The analytical software (to be discussed later) required a material true stress-strain curve for each component. With the Table 3 data and one assumption (discussed next), a bi-linear true stress-strain curve was created for each Table 3 component as follows.

The yield strength from Table 3 was defined at 0.2% offset, which was a nominal plastic strain of 0.002. This meant that the actual true stress at the engineering yield strength was a factor of 1.002 higher than the engineering yield strength. The difference between the two was considered negligible. Therefore, the engineering yield strength was used as the true stress at a plastic strain of 0. The strain at fracture was calculated as follows:

- True Fracture Strain ($\varepsilon_{f\ true}$)= ln [1 / (1-R/100)]

The matching true fracture stress must be determined or calculated next. In order to calculate the true fracture stress, the nominal stress (or force) at fracture must be known. For materials where the engineering stress-strain curve is always increasing (positive slope) to fracture (or at least not decreasing), the ultimate strength is also the fracture strength. However, with 304 and 304L stainless steels, the engineering stress-strain curve reaches an ultimate strength (highest strength on the curve) and then the curve decreases (negative slope) – meaning that the load decreases to fracture. In this case, using the engineering ultimate strength as the fracture strength would give a higher than actual true fracture strength (300,000 – 400,000 psi range). Because the actual fracture load was not available for the Table 3 materials, recourse to another source was therefore required. Reference 11 (page 67) shows a typical true stress-strain curve for 304 stainless steel with a true fracture stress of about 240,000 psi. This value was used for the true fracture stress in this evaluation of the test MCO materials shown in Table 3. (This was consistent with the methodology used in References 3 and 4.)

The material stress-strain data discussed thus far was based on a quasi-static strain rate. During an MCO drop event, the material strain rate will not be quasi-static – but comparatively quite high. Many materials, including stainless steels, are sensitive to strain rate and experience a significant dynamic strengthening due to high strain rates. Reference 12 documented the actual drop testing of nine representative standardized DOE SNF canisters and the accompanying analytical analyses. A dynamic increase in strength of 20% was included in those analyses in order to match analytical to actual results. Reference 12 discusses in some detail the documentation and justification for the 20% strength increase. These test MCO evaluations also included a 20% increase in strength to account for the dynamic strengthening of the 304 and 304/304L stainless steels during the specified drop events. Table 4 shows the actual dynamically strengthened true material properties employed in the test MCO analyses.

Table 4. True Stress-Strain Curves Employed for MCO Containment Components

Component		Dynamic True Stress / Matching Strain Points for Bi-Linear Curve	
		Yield Point[1] (psi, in./in.)	Fracture Point[2] (psi, in./in.)
Main Shell	MCO-00-1	49699, 0.0	288000, 1.411
	MCO-60-2	54446, 0.0	288000, 1.191
Collar		44874, 0.0	288000, 1.463
Bottom		48120, 0.0	288000, 1.309
Cover		48600, 0.0	288000, 1.609
Lock Ring		65892, 0.0	288000, 1.435
Shield Plug		48600, 0.0	288000, 1.609

1. This point was the Table 3 yield strength multiplied by 1.20.
2. This fracture point was the selected true fracture stress (240,000 psi) multiplied by 1.20. The matching true fracture strain was calculated using the equation: True Fracture Strain = ln [1 / (1-R/100)] where R is the area reduction.

The welds that were a part of the containment boundary were full-penetration circumferential welds that attached the bottom to the main shell, the main shell to the collar, and the collar to the cover. These welds were assumed to have the same properties as the base material (e.g., half of weld thickness had bottom material properties; half of weld thickness had main shell properties).

8.2. Test MCO Internal Component Properties

The test MCOs used one Mark IV fuel basket and four modified Mark IV baskets (consisting of a base plate and a center post only) to hold the simulated SNF. The baskets were made of 304L stainless steels. The material properties employed in the analytical models of the test MCOs used the average basket component properties listed in the Reference 3 report (because specific material information for these baskets was not provided by Hanford). Consistent with the bi-linear true stress-strain curves developed for the MCO containment components, the material properties for the baskets were increased by 20% to account for dynamic strengthening. Table 5 shows the Mark IV basket material properties.

Table 5. True Stress-Strain Curves Employed for Mark IV Baskets

Component	Dynamic True Stress / Matching Strain Points for Bi-Linear Curve	
	Yield Point (psi, in./in.)	Fracture Point (psi, in./in.)
Base Plates[1]	41400, 0.0	288000, 1.41
Perimeter Bars[1]	55200, 0.0	288000, 1.37
Center Posts, Shroud Walls[1]	47400, 0.0	288000, 1.40
Perimeter Bar Bolts	60000, 0.0	288000, 0.799

1. Table data from Table 3 of Reference 3.

The bolts that connected the perimeter bars to the base plate were explicitly modeled in this current analysis. These bolts were specified as SA-193, B8S or B8SA Class 1C (18-8), stainless steel bolts. The basic minimum properties (Reference 13) for these bolts were: yield strength of 50 ksi, ultimate strength of 95 ksi, elongation of 35%, and area reduction of 55%. Using the method of developing a dynamic true stress-strain curve described for the MCO containment components, a bi-linear true stress-strain curve was developed for these bolts (listed in Table 5 also).

The simulated SNF consisted of carbon steel bar stock (either 2-1/2-inch diameter or 22-inch diameter). This simulated SNF was not expected to absorb much energy in deformation during the drop events. Therefore, the material true stress-strain curves used in the analytical models were only required to approximately represent the actual material curves. Therefore, all simulated SNF used a simplified bi-linear dynamic true stress-strain curve defined by a yield strength of 36,000 psi and an ultimate strength of 100,000 psi (occurring at a strain of 1.0) within the analytical models.

8.3. Other Material Properties

Other relevant material properties (at 70 degrees F.) employed in the analytical evaluations included:

- Modulus of Elasticity (E) = 28.3×10^6 psi for the 304/304L stainless steel components,
  30.0×10^6 psi for the carbon steel components
- Poisson's Ratio (μ) = 0.29 (used for both stainless and carbon steel components).

9. COMPUTER PROGRAM VERIFICATION AND CONFIGURATION MANAGEMENT

9.1. Modeling Software

The I-DEAS 10 NX Series computer program manufactured by Unigraphics Solutions, Inc. (Reference 14) was used to create finite element models of the test MCOs. A solid model of a test MCO was created and then used to generate the finite element model. Because the I-DEAS software was used for modeling purposes only, no onsite validation and verification of this software was required. The accuracy of the models generated in I-DEAS was checked in the calculation software discussed in the next subsection.

9.2. Calculation Software

The computer program ABAQUS/Explicit Version 6.3-3, a nonlinear finite element (FE) analysis software package (Reference 15) that is widely used in many industries, was employed to calculate the response of the test MCOs to the specified drop events. Extensive onsite validation and verification (Reference 16) has been performed by the NSNFP on this software, approving it for drop evaluations. This rigorous checking process eliminated the need to control or validate I-DEAS, the solid modeling software. All models were run in double precision. Models were run on INEEL compute servers “Mira1” and “Merope” as approved by the Reference 16 validation report.

10. PRE-DROP TEST ANALYTICAL MODELING OF TEST MCOS

10.1. Test MCO Model Mesh Details

The MCO was modeled using solid linear brick elements (ABAQUS element type C3D8R) and wedge elements (ABAQUS element type C3D6) as follows:

- Bottom: The bottom used 2,944 solid (brick and wedge) elements, with four elements through the thickness of the base and four in the connection to the wall. This was done to ensure adequate modeling of bending responses.

- Main Shell: The cylindrical shell employed 14,720 solid (brick only) elements, with four elements through the thickness. The connection between the shell and the bottom consisted of a full-penetration groove weld. This connection was modeled using nodes common to the shell and bottom elements.

- Collar: The collar was modeled with 4,992 solid (brick only) elements, with a minimum of four elements through the thickness. The connection between the collar and the main shell, consisting of a full-penetration groove weld, was modeled using nodes common to the collar and main shell elements.

- Cover: The cover used 2,144 solid (brick only) elements, with four elements through the thickness in the cylindrical portion and three elements through the flat top. The groove weld connection between the cover and the collar was also represented with common nodes.

- Shield Plug: The shield plug utilized a total of 762 solid (brick only) elements. The mesh size in this component was quite coarse in order to simplify the model. The coarse mesh size was considered acceptable since the plug consisted of very thick members that were unlikely to deform significantly during either drop event – a coarse mesh would adequately simulate such a response. Valves, ports, filters, and etc. that were part of the shield plug were not explicitly modeled because their influence on the adjacent components was considered negligible.

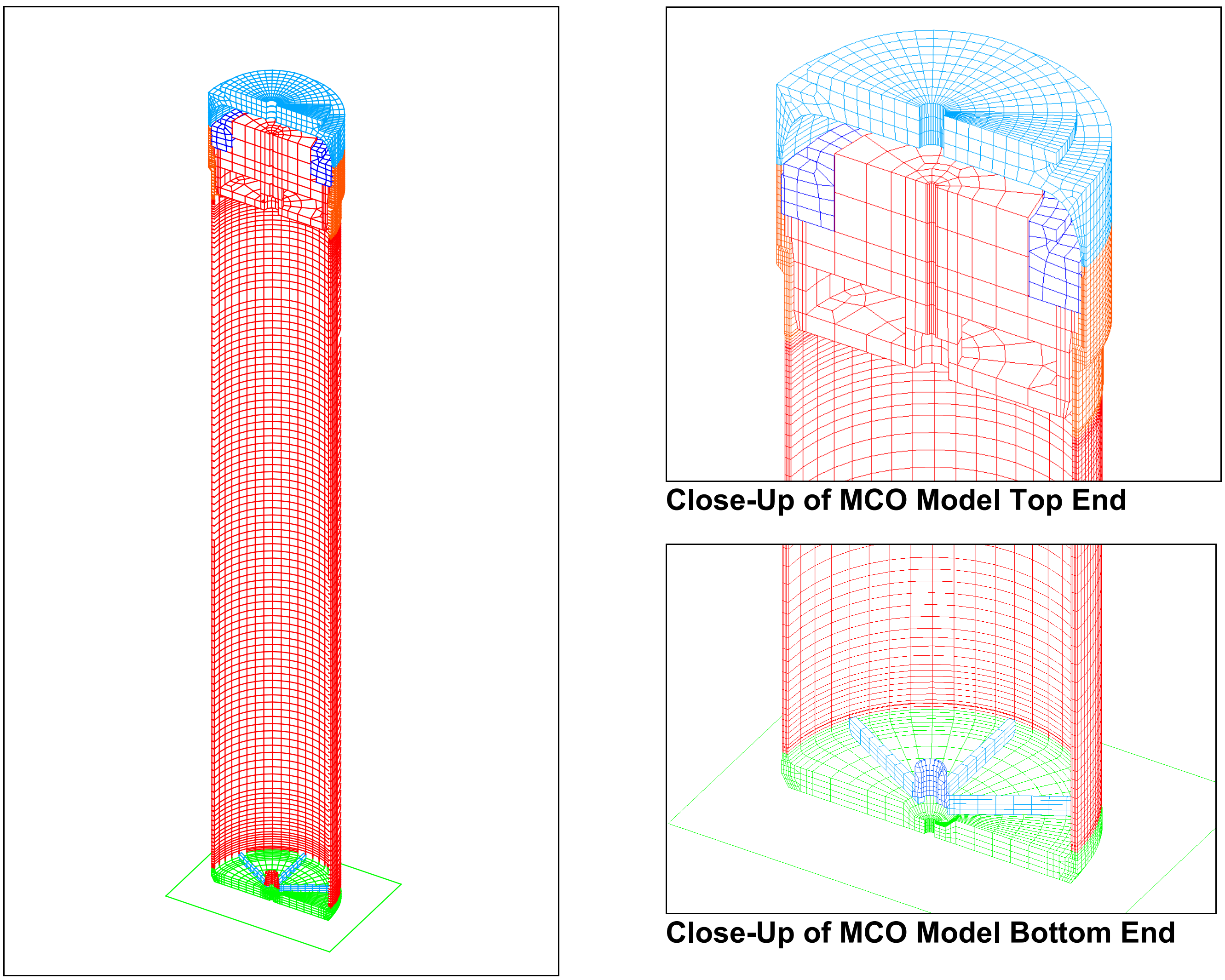
- Locking Ring: The lock ring employed 432 solid (brick only) elements. This mesh was also coarse for the same reasons given for the shield plug. The threaded connection between the locking ring and the collar was represented by fixing the lock ring nodes (in the threaded portion) to the inside wall of the collar (*TIED option). This assumed that the threaded connection between the ring and collar would not fail during any drop event and that the drop events would not load this region in a way that would deform the collar away from the locking ring. (This assumption was considered valid because of the more than 3 inches of thread engagement length was far in excess of that required to resist the worst-case loading during any drop event without failure, and only the slapdown event would load this region – but in compression only.) The setscrews on the locking ring were ignored in this evaluation since they had no significant effect on the MCO response during any drop event. Their purpose was to ensure a seal between the shield plug and the collar – which was not needed after the cover was welded onto the collar.

- Basket Support Bars: The six basket support bars were each represented using 29 solid (brick only) elements. The fillet weld that attached each bar to the MCO bottom was represented by fixing the bar edge nodes to the top surface of the bottom (*Tied option). This was considered adequate since the exact condition of these welds was not of interest, only their affect on adjacent components during any drop event. This assumed that these welds would not fail during any drop event.

- Guide Cone: The guide cone was modeled using 108 solid (brick only) elements. The welded connection between the guide cone and the six basket support bars was conservatively modeled using common nodes (as described previously).

- Process Tube: The process tube was not included in the test MCOs and was not part of the analytical models.

Figure 7 shows the FE model of the test MCOs.



Close-Up of MCO Model Top End

Close-Up of MCO Model Bottom End

Figure 7. FE Model of MCO

Half of an MCO structure was explicitly modeled. (Unless otherwise noted, the number of elements listed above for the MCO components reflected a half-model only.) This assumed one plane of symmetry existed, through the MCO centerline and main shell longitudinal seam weld, with respect to modeled geometry, loading, and response during the drop events. That symmetry in modeled geometry existed for all test MCO components - with two possible exceptions: the representative Mark IV fuel basket and the basket support bars. The assembly of these test MCOs assured that the one representative Mark IV fuel basket (with simulated 2-1/2-inch diameter fuel rods) per MCO was oriented such that the main shell longitudinal seam weld was halfway between two of the six basket perimeter bars (References 8 and 9). This provided the desired symmetry. However, the six basket support bars, which were welded to the MCO bottom during fabrication, were not necessarily located with the main shell seam weld halfway between two support bars (not a positioning expected to be of interest and thus not controlled by the fabricator).

The possible (and likely) non-symmetrical positioning of these basket support bars with respect to the main shell seam weld was not expected to alter the response of MCO-60-2 because these bars directly supported a basket base plate with center post and a substantial 22-inch diameter steel bar. In contrast, the basket support bars in test MCO-00-1 directly supported the representative Mark IV fuel basket. Deformations of the Mark IV basket base plate (and possibly the basket perimeter bars) would be directly affected by the location of the basket support bars. However, the response of the MCO-00-1 containment components (bottom, main shell, collar, and cover) was expected to be negligibly affected. (During the post-drop tasks, MCO-00-1 was cut open and the location of these basket support bars was noted. See Section 12 for details.) Therefore, for the purposes of the pre-drop analytical evaluations, the basket support bars were assumed oriented on the MCO bottom with the main shell longitudinal weld seam halfway between two of those support bars.

Because the test MCO models were oriented so that the loading (gravity) was in the symmetry plane, symmetry in loading was achieved. Therefore, symmetry in modeled geometry, loading, and response was assured using symmetry boundary conditions.

10.2. Test MCO Internal Components Mesh Details

Each test MCO contained four modified Mark IV scrap baskets (consisting of a base plate and a center post only) holding a 22-inch diameter weight, and one representative Mark IV fuel basket holding fifty-four 2-1/2-inch bars, as discussed earlier. The basket base, center post, perimeter bars, 22-inch diameter bar, and 2-1/2-inch bars were modeled using solid linear brick elements (ABAQUS element type C3D8R). Linear quadrilateral shell elements (ABAQUS element type S4R) were used to model the fuel basket shroud. Meshing was as follows:

- Basket Base: The basket base was represented with 324 solid (brick only) elements, with three elements through the thickness. (The multiple holes through the base were ignored in the model.)

- Center Post: The center post was modeled using 1032 solid (brick only) elements, with three elements through the wall. The threaded connection between the center post and the basket base employed nodes common to both components. This assumed that the post would remain firmly attached to the base during all drop events. The design of this connection prevents the post from separating from the base during either of the specified drop events, though the vertical drop does cause significant bending in the post just above this connection. Therefore, the modeling of this connection was considered valid.

- Perimeter Bars: The round perimeter bars were each represented using 312 solid (brick only) elements. Each perimeter bar was connected to the basket base with a bolt.

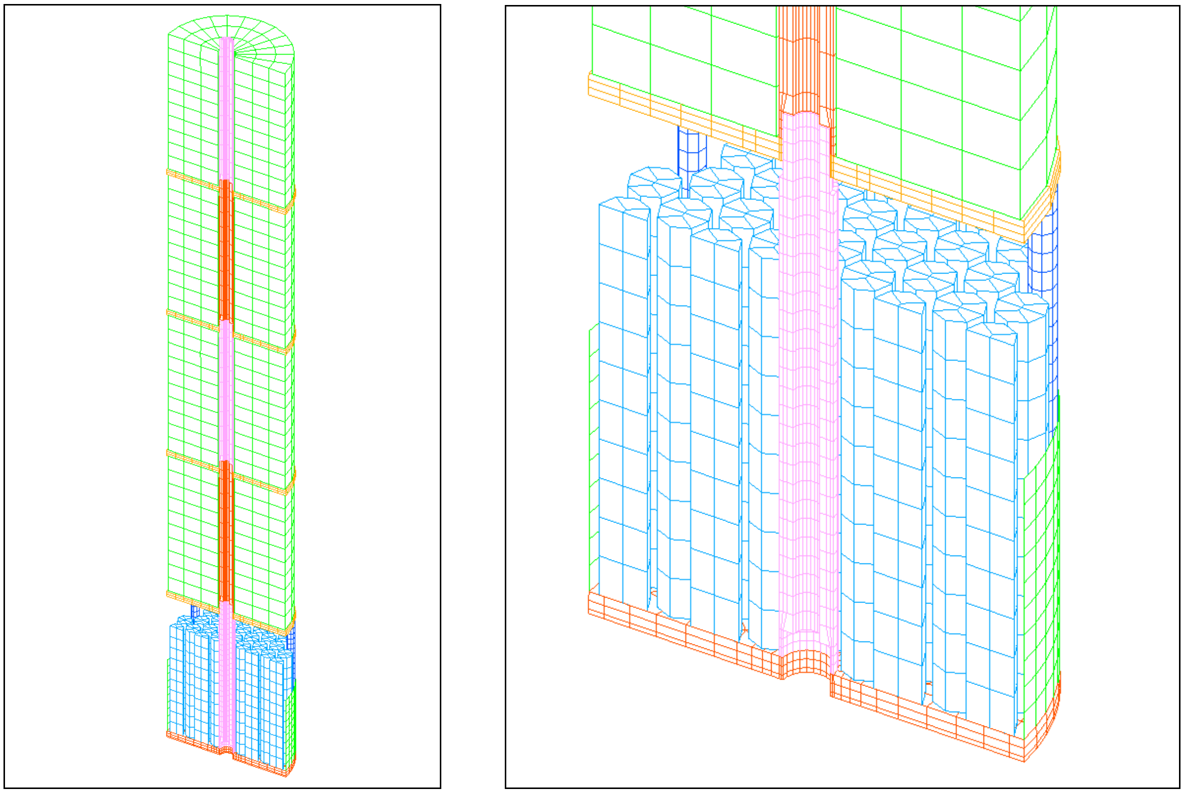
- Perimeter Bar Bolts: The perimeter bar bolts were each represented using 12 solid (brick only) elements. The first ¼-inch of bolt elements used nodes common to the basket base to simulate the bolt head bearing against the cone-shaped hole. The modeled bolt length was 1.19 inches. The element top nodes were common to the perimeter bar base to simulate the threaded connection. This allowed for plastic deformation in the bolt during the drop event with the assumption that the bolt heads did not pull through the base and that the threaded connection did not fail (both considered reasonable assumptions).

- Basket Shroud: The fuel basket shrouds were simulated with 300 shell elements. The shrouds were connected to the basket base using common nodes to represent the attachment weld.

- Simulated Fuels: The nominal 22-inch diameter bars with the 3-inch center hole were modeled with 360 solid (brick only) elements each. The fifty-four 2-12-inch bars were modeled using 60 solid elements per bar. The bar bases were connected using 64 stiff spring elements to simulate the rack in the bottom of the fuel basket.

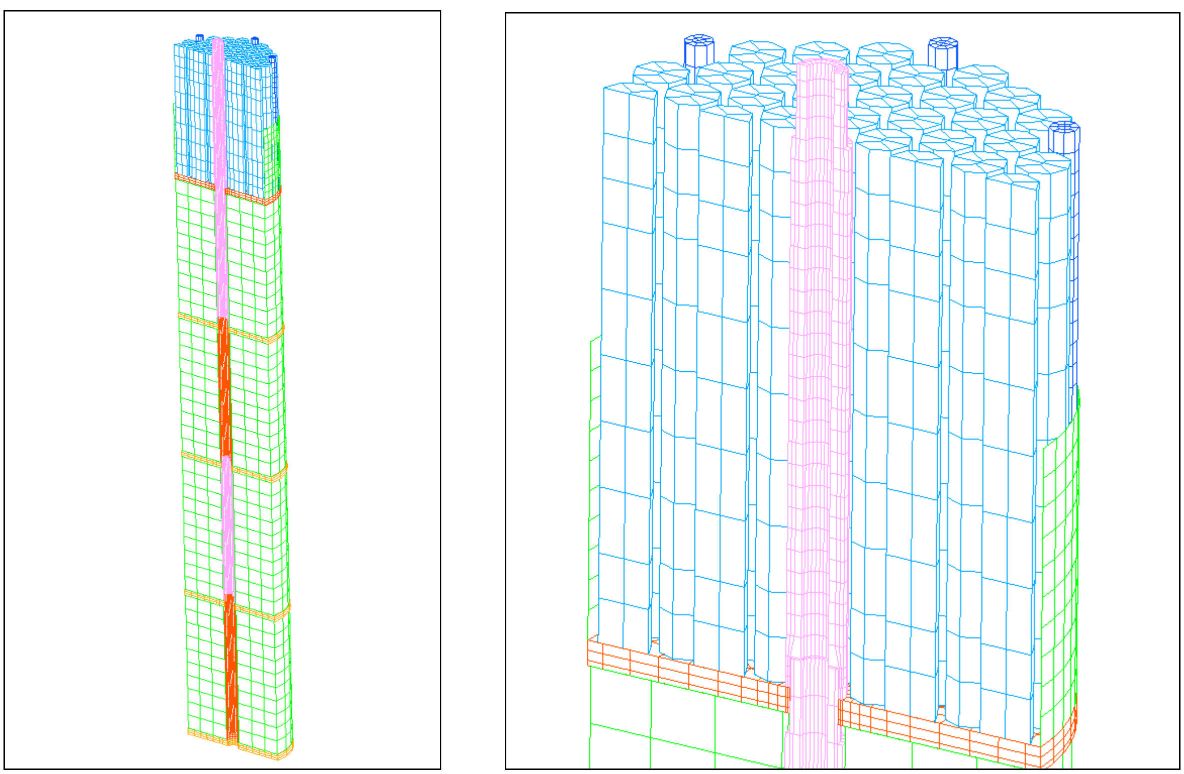
As with the MCO structure, only half of a basket and simulated fuel were explicitly modeled due to the symmetry in modeled geometry, loading, and response during the drop events. (Therefore, unless otherwise noted, the number of elements listed above for the basket and simulated fuel components reflected a half-model only.) Plane symmetry boundary conditions were applied.

Figures 8 and 9 show the internal baskets and weights for MCO-00-1 and MCO-60-2.



(Whole Model) (Close-Up on Bottom Basket)

Figure 8. FE Model of the MCO-00-1 Internal Components



(Whole Model) (Close-Up on Top Basket)

Figure 9. FE Model of the MCO-60-2 Internal Components

10.3. Finite Element Mesh Size

The element sizes for the test MCO models were chosen based on the type of event being simulated and the expected response. Because large plastic deformations were expected, the element sizes could not be too small or they would distort excessively (causing the calculation to terminate) before the event was completed. Small element size would also require many elements, resulting in excessive solution times. At the other extreme, elements that were too large would not respond properly (e.g., a bulge in a component would be shown as a sharp edge instead of a smooth curve) and the results would be in question. This was particularly important in areas where significant deformations would occur. Additionally, large elements in areas of high deformation required excessive artificial energy (model energy required to maintain solution stability). Some iteration in preliminary modeling was performed to arrive at elements sufficiently small to provide acceptable results.

10.4. Component Thickness

All test MCO components were modeled using nominal dimensions except for the 22-inch diameter internal weights which used measured dimensions (e.g., actual diameter was 22-1/4 inches).

10.5. Material Density

The basic density of the carbon steel and the 304/304L stainless steel used in these test MCOs was 0.283 pounds per cubic inch. However, densities were adjusted in the analytical models to achieve the correct weights for the various components. Appendix B contains the pre-drop test data sheets which include measured weights for components and assemblies (including those taken by Hanford – see Reference 9).

10.6. Contact Modeling

Contact between components was simulated using the ABAQUS General Contact option supplemented by the Contact Pairs option in areas of interest (impact locations). This was one of the approved methods detailed in the ABAQUS Software Report (Reference 16). These contact options employed penalty contact stiffness. Preliminary evaluations increased the default stiffness calculated within ABAQUS/Explicit Version 6.3-3 by a factor of 10. The results were not significantly different from those obtained using the default stiffness values. This indicated that the default penalty stiffness calculated within ABAQUS was adequately stiff to simulate a “hard impact” (essentially non-penetrating impact) for these MCO evaluations.

10.7. Flat, Rigid Impact Surface

The flat, rigid impact surface was modeled using one large rigid quadrilateral element (element type R3D4) that was fixed in space.

10.8. Friction

The coefficient of friction (COF) between two steel surfaces during an impact event can vary widely. An ASME paper (Reference 17) showed that the COF could vary significantly and still predict similar deformations (and thus material strains) for a stainless steel canister drop that was oriented vertically (or near vertical) or from about 60 degrees off-vertical to horizontal, impacting a flat, rigid surface. The range of drops evaluated herein fall into that category. Therefore, a COF of 0.3 was used in all of the test MCO analyses.

10.9. Initial Conditions

The FE models began the drop event by locating the test MCO model just above the rigid surface and applying a gravitational acceleration and an initial velocity. This allowed the elimination of calculations while the test MCO was freely falling through air. The initial velocity was calculated by equating the potential energy of the test MCO at the beginning of the drop (mass * gravity * drop height) to the kinetic energy just before impact (1/2 * mass * velocity^2). For example, at a drop height of 23 feet (276 inches) the velocity at impact of the test MCO would be 462 inches per second.

10.10. Model Solution Termination

The model solution for test MCO-00-1 was terminated when the test MCO had progressed through the first impact in this vertical drop and had rebounded off the surface. The model solution for test MCO-60-2 ran through the bottom end impact and the subsequent top end impact (slapdown) and was terminated when the top end had rebounded off the rigid surface. No significant MCO deformation was expected after that point in the solution, even though the MCO was still moving and had a small amount of drop energy remaining.

10.11. Plastic Strain Hardening

ABAQUS/Explicit Version 6.3-3 gave two options for defining the hardening law for plasticity: isotropic hardening, and Johnson-Cook hardening. Because specific data on these test canister materials were not available to justify using the Johnson-Cook hardening law, isotropic hardening was used in the analyses reported herein. This was consistent with the previous analyses (References 3, 4, and 12).

11. TEST RESULTS VS. PRE-DROP ANALYTICAL PREDICTIONS

11.1. Actual Test Conditions

Drop testing of the two test MCOs was performed on August 10 - 11, 2004 at SNL. SNL provided (to the NSNFP) documentation packages containing data pertinent to the testing (References 10 and 19). Both drop tests were performed with the ambient air temperature between 75 and 92 degrees F. Table 6 shows the target impact angles, the angle at which a test MCO was hanging prior to dropping, and the actual test MCO angle on impact with the rigid surface. The actual impact angle was determined from still photos taken from SNL high speed video of the events.

Table 6. Test MCO Orientation Angles

MCO	Target Impact Angle (degrees)*	Hang Angle (degrees)*	Actual Impact Angle (degrees)*
MCO-00-1	0 (vertical)	0.2	0
MCO-60-2	60	60.2	60.5

*Measured from vertical.

The above table shows that the actual angle at impact of test MCO-00-1 was right on vertical, where that of test MCO-60-2 was only one-half degree off the target angle. ***All pre-drop evaluations used the target impact angles.***

11.2. Pre-Drop Test Analytical Model Energy Histories

Several types of model energy were tracked within the ABAQUS/Explicit software. Figures 10 and 11 show plots of the energy history for each pre-drop test MCO model. The plots show model artificial energy history (ALLAE), frictional dissipation history (ALLFD), kinetic energy history (ALLKE), plastic dissipation history (ALLPD), and elastic energy history (ALLSE).

11.2.1. Test MCO-00-1 Model Energies

Test MCO-00-1 began the drop event with a high kinetic energy and all other model energies at zero. In the first four milliseconds, essentially all of the kinetic energy of the test MCO structure was transformed into plastic deformation in the main shell. This energy transformation occurred quickly because the MCO canister was very stiff and no components buckled. However, the transformation of kinetic energy of the internal components, primarily into plastic deformation, required another fourteen milliseconds while the bottom basket perimeter bars and center post deformed. About 7% of the total kinetic energy was consumed in frictional dissipation as well.

Artificial energy, the amount of drop energy used (taken away from the total model energy) to prevent finite element numerical instabilities was also shown in Figure 10. An artificial energy total of 3% - 6% for a drop evaluation is typical – results are considered valid. The pre-drop test MCO-00-1 model had a maximum artificial energy of about 7% at the end of the model solution. Most of that artificial energy was taken up in the basket support bars because of the large compressive loads experienced by them. A finer mesh would likely lower the artificial energy used in the model. However, an artificial energy of 7% was considered acceptable for this evaluation – results were considered valid.

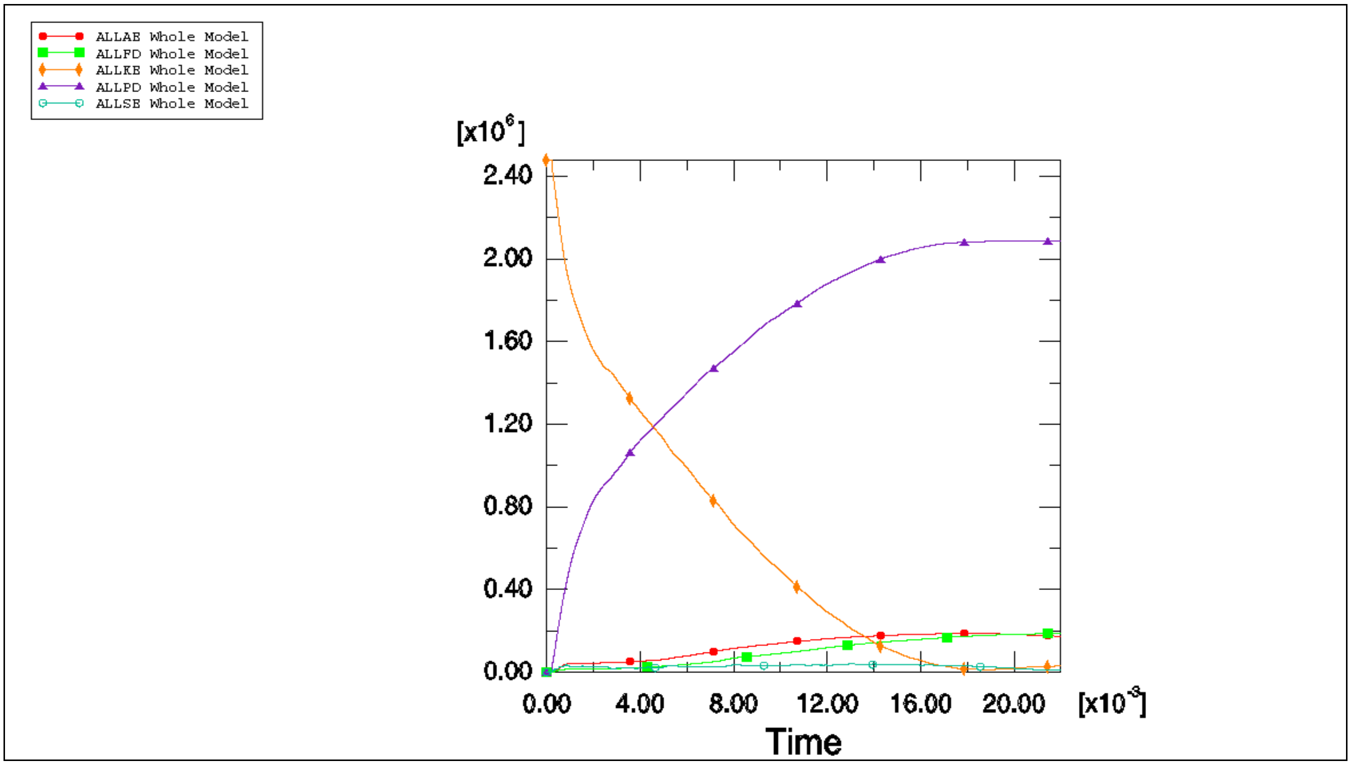


Figure 10. Pre-Drop Test MCO-00-1 Model Energies

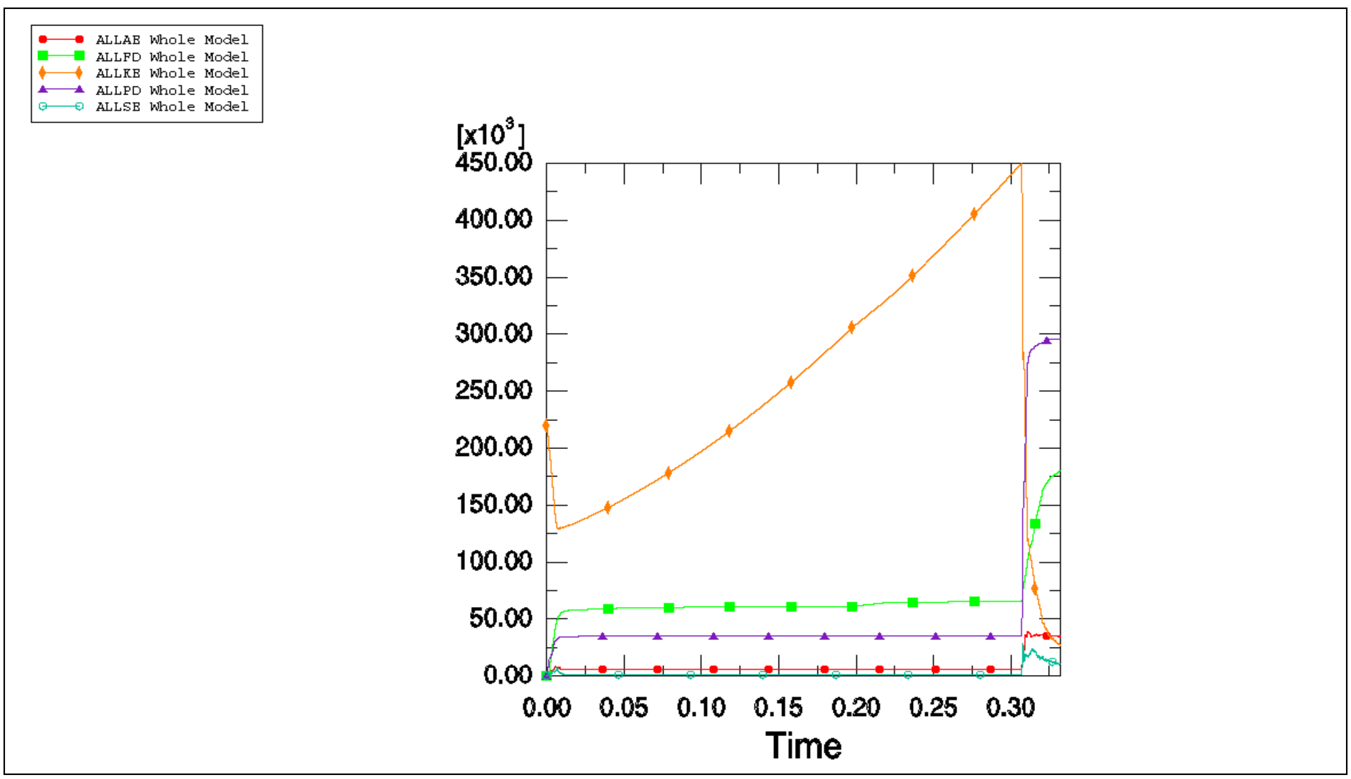


Figure 11. Pre-Drop Test MCO-60-2 Model Energies

11.2.2. Test MCO-60-2 Model Energies

Test MCO-60-2 began the drop event with kinetic energy and all other model energies at zero. In the first 15 milliseconds the test MCO bottom impacted the rigid surface and expended energy in frictional dissipation and plastic deformation as it slid. In approximately the next 300 milliseconds, the test MCO rotated to impact the top end on the rigid surface. At that point the kinetic energy was mostly absorbed in plastic deformation, with some consumed in frictional dissipation as well. This top end impact and energy transformation occurred over a very short period of time, as evidenced by the nearly vertical kinetic, plastic, and frictional dissipation lines on Figure 11 at about 310 milliseconds.

Artificial energy, the amount of drop energy used (taken away from the total model energy) to prevent finite element numerical instabilities was also shown in Figure 11. An artificial energy total of 3% - 6% for a drop evaluation is typical – results are considered valid. The pre-drop test model for test MCO-60-2 had a maximum artificial energy of about 7% at the end of the model solution. Most of that artificial energy was taken up in the shield plug at the impact of the top end on the rigid surface. A finer mesh would likely lower the artificial energy used in the model. However, an artificial energy of 7% was considered acceptable for this evaluation – results were considered valid.

11.3. Pre-Drop Test Analytical Predictions vs. Actual Deformations

Appendix C contains the post-drop data sheets on these test MCOs. Included in the data sheets were sketches and measurements of the deformed shapes of the test canisters.

11.3.1. Test MCO-00-1 Predicted vs. Actual Deformations

MCO-00-1 Containment Component Deformations: Test MCO-00-1 was dropped from 23 feet onto the impact surface, impacting in a vertical orientation. In the actual drop test, test MCO-00-1 impacted the surface and then remained in an upright position. Therefore, no damage was experienced in this test MCO due to a secondary impact (i.e., tip-over). After the drop test, the test MCO-00-1 was examined for damage and none was apparent.

Figure 12 shows the analytical model after the drop event was terminated. Figure 13 shows a photo of the post-drop test MCO-00-1 bottom end in a side view and Figure 14 shows the same for the analytical model. Figure 15 shows a photo of post-drop test MCO-00-1 in a bottom end view and Figure 16 shows the same for the analytical model. No deformation is apparent from the photos or the analytical model views.

Table 7 gives a comparison of several dimensions measured on the test MCO-00-1 to the predicted values from the analytical model (pre-drop test FE model). The actual test MCO dimensions were from the pre- and post-drop data sheets (Appendices B and C).

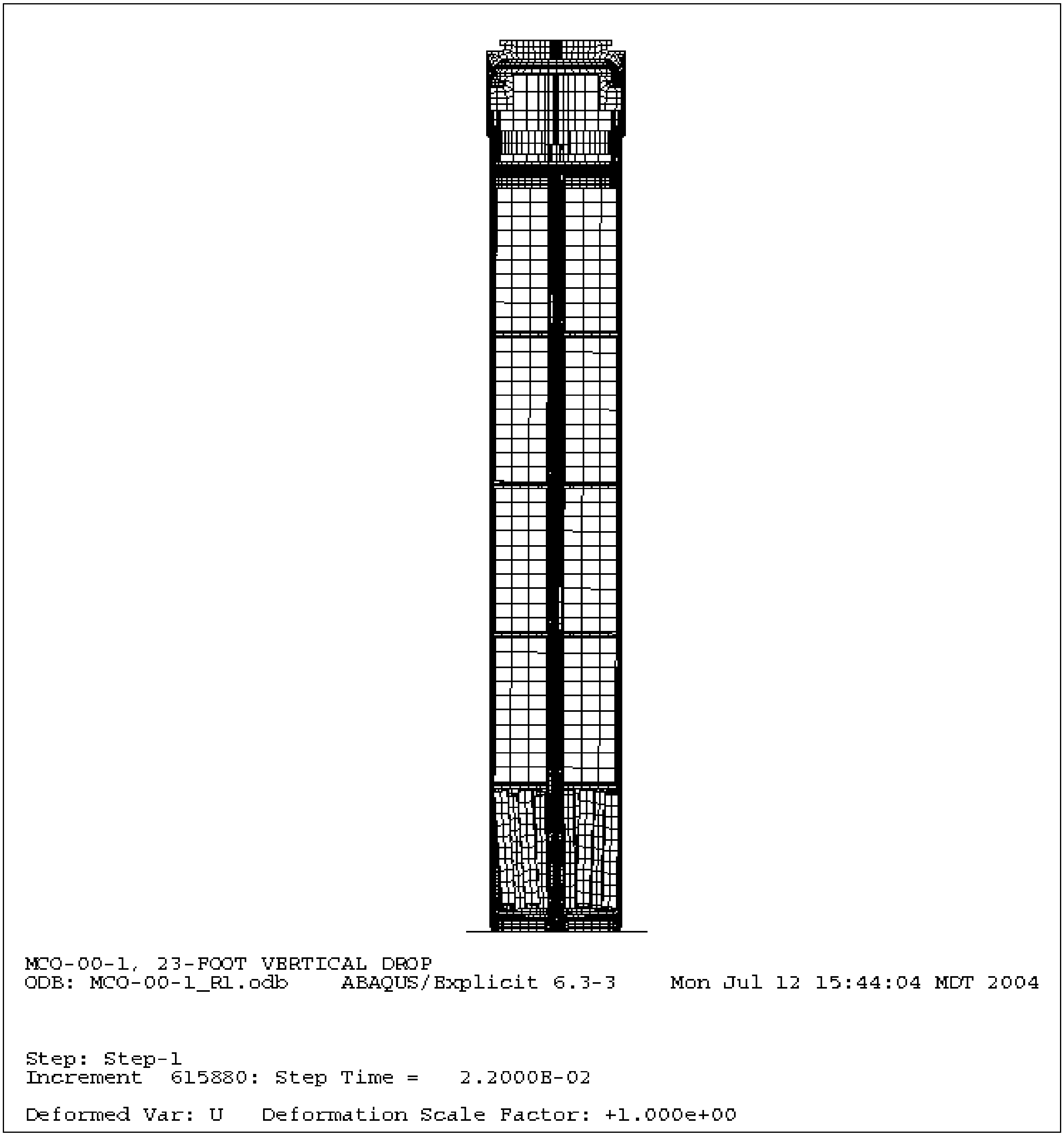


Figure 12. Pre-Drop Predicted Deformed Shape of Test MCO-00-1

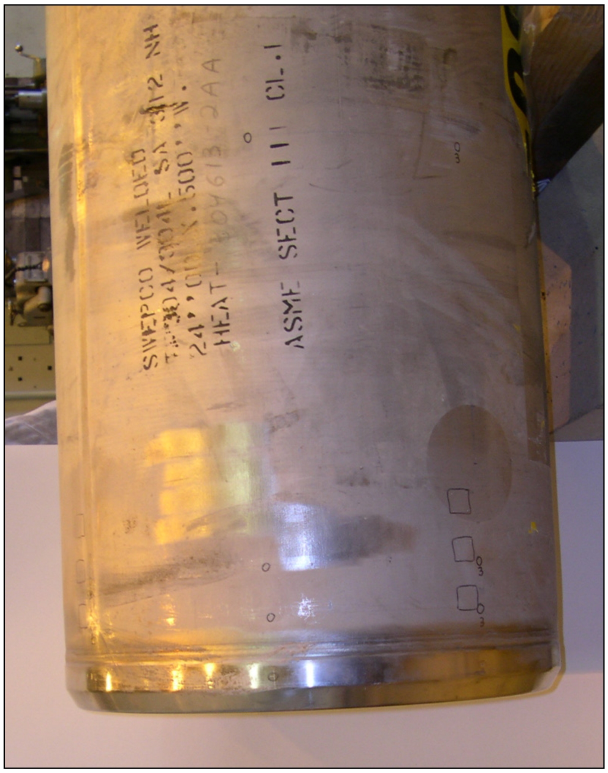


Figure 13. Photo of Test MCO-00-1 Bottom End Deformed Shape, Side View

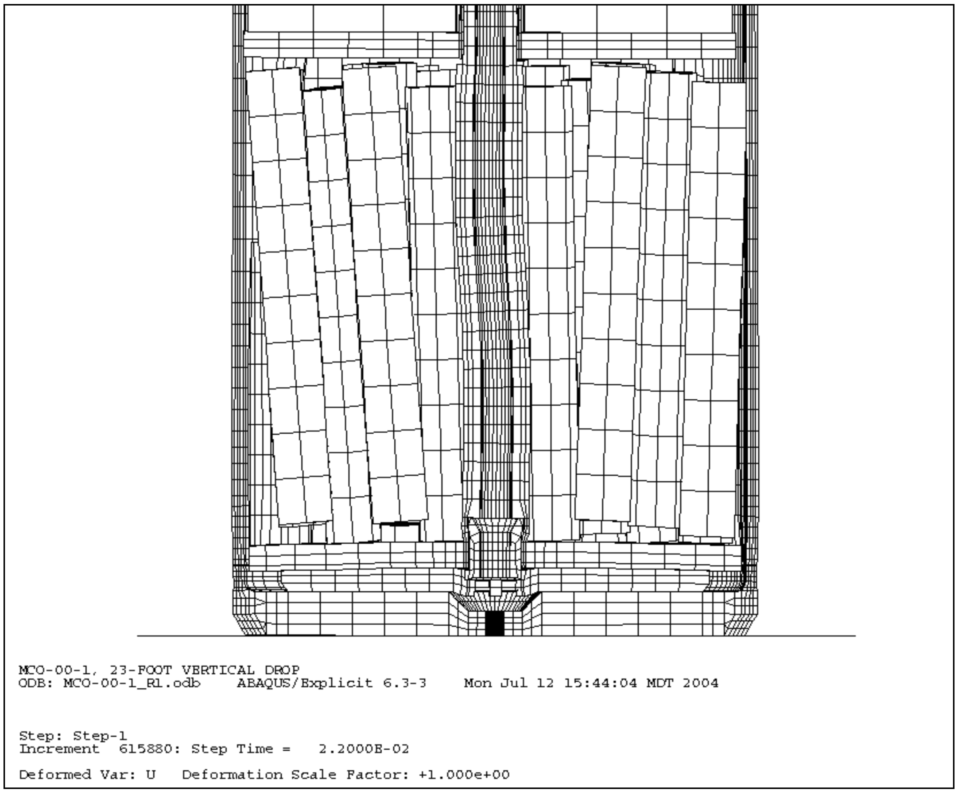


Figure 14. Pre-Drop Test MCO-00-1 Model Bottom End Deformed Shape, Side View

(Cross-section view of test MCO half-model.)

Figure 15. Photo of Test MCO-00-1 Bottom End Deformed Shape, End View

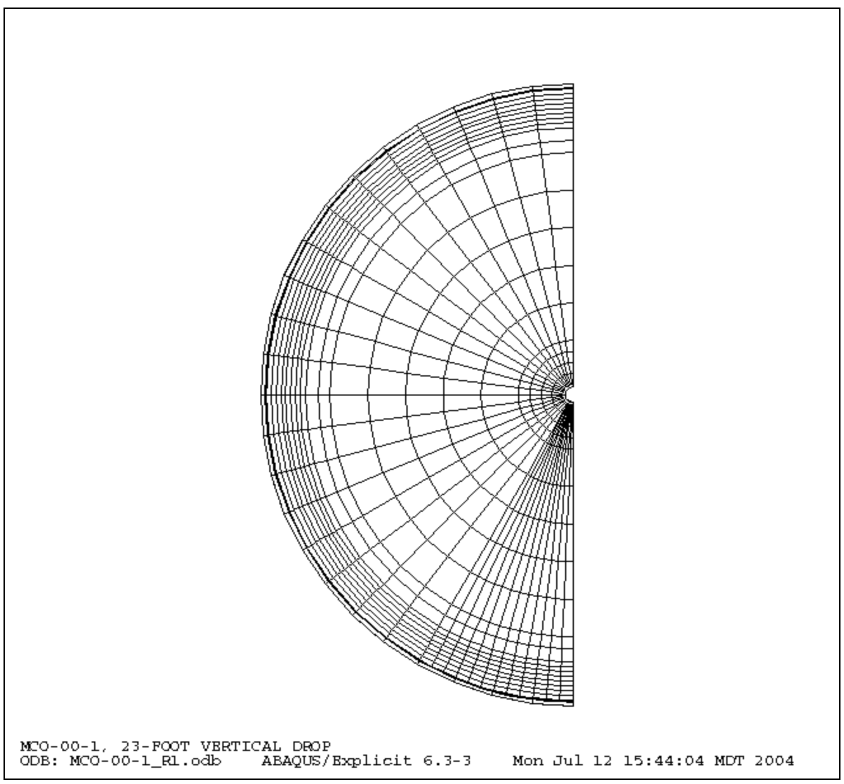


Figure 16. Pre-Drop Test MCO-00-1 Model Bottom End Deformed Shape, End View

(End view of test MCO half model.)

Table 7. Comparison of Actual to Pre-Drop Predicted Deformations, Test MCO-00-1

Location	Position (O'Clock)	Actual Test MCO (in.)		Pre-Drop Analytical Model	
		Undeformed (Deformed)	Diameter Change	Modeled (Deformed)	Diameter Change
Lower Shell, 4-inches from bottom edge	12-6	24.022 (24.074)	0.052	23.985 (24.112)[1]	0.127
	1:30-7:30	23.917 (23.9513)	0.034	23.985 (24.107)[2]	0.122
	3-9	23.962 (24.014)	0.052	23.985 (24.110)[3]	0.125
	4:30-10:30	24.002 (24.054)	0.052	23.985 (24.110)[4]	0.125
Lower Shell, 6-inches from bottom edge	12-6	24.014 (24.101)	0.087	23.985 (24.186)[5]	0.201
	1:30-7:30	23.934 (23.987)	0.053	23.985 (24.170)[6]	0.185
	3-9	23.978 (24.037)	0.059	23.985 (24.177)[7]	0.192
	4:30-10:30	24.007 (24.093)	0.086	23.985 (24.178)[8]	0.193
Lower Shell, 24-inches from bottom edge	12-6	23.939 (23.920)	-0.019	23.985 (24.110)[9]	0.125
	1:30-7:30	23.970 (23.957)	-0.013	23.985 (24.096)[10]	0.111
	3-9	24.015 (24.092)	0.077	23.985 (24.092)[11]	0.107
	4:30-10:30	24.015 (24.140)	**0.125**	23.985 (24.094)[12]	0.109

1. Distance between model nodes 1364 and 34441. 2. Two times the square root of [(X from center)^2 + Z^2] at node 6787.
3. Two times the Z dimension at model node 13961. 4. Two times the square root of [(X from center)^2 + Z^2] at node 22426.
5. Distance between model nodes 1368 and 34445. 6. Two times the square root of [(X from center)^2 + Z^2] at node 6791.
7. Two times the Z dimension at model node 13981. 8. Two times the square root of [(X from center)^2 + Z^2] at node 22430.
9. Distance between model nodes 1385 and 34462. 10. Two times the square root of [(X from center)^2 + Z^2] at node 6808.
11. Two times the Z dimension at model node 14066. 12. Two times the square root of [(X from center)^2 + Z^2] at node 22447.

Table 7 shows that the analytical model slightly overpredicted the change in diameter (1/16 to 1/8-inch) when compared to the actual MCO change. However, the actual MCO changes in diameter (≤1/8-inch) and those of the analytical model (<1/4-inch) were very small for this drop event. *In terms of a comparison between actual and predicted deformed diameters, the worst case would be [lower shell, 24-inch line, 12-6 position, 1 – (23.920 / 24.110) = 0.007 or < 1%]* ***less than 1% difference***. Predicted material straining (to be discussed in the next subsection) may be slightly conservative because of the difference between actual and predicted deformations. This was considered acceptable.

Note that at 24 inches from the bottom of MCO-00-1 at the 4:30-10:30 diameter, the test MCO experienced its greatest change in diameter (1/8-inch). This was likely due to a lower basket perimeter bar impacting the main shell as it buckled (see Figure 19 discussed in the next subsection). However, this showed that impact on the main shell from the buckling of a lower basket perimeter bar was negligibly small.

MCO-00-1 Bottom Basket Deformations: As discussed in the pre-drop analytical modeling Section 10.1 (also to be discussed in post-drop Section 12.4), the post-drop destructive evaluation of test MCO-00-1 showed that the basket support bars on the MCO bottom were not actually located as was assumed in the pre-drop modeling. (Pre-drop modeling located the main shell seam weld so as to be half-way between two basket support bars. This placed a basket support bar immediately below each bottom basket perimeter bar.) The actual placement of the basket support bars located one bar on the main shell longitudinal seam weld, which put each basket support bar half-way between two bottom basket perimeter bars. Therefore, the actual bottom basket base plate deformed significantly where the pre-drop model base plate was not expected to deform much. The deformations of this base plate would affect the deformations of the basket perimeter bars as well. Therefore, some of the pre-drop predicted deformations of the bottom basket were not expected to exactly match those of the actual test MCO-00-1.

Figures 17 and 18 show that the actual and pre-drop modeled bottom basket deformations with the simulated fuel rods (2-1/2-inch bars) removed. The actual and pre-drop predicted perimeter bars were deformed into a similar “S” shape, though tipped towards horizontal at the top in the actual case but still near vertical in the predicted case. Figure 19 shows the actual MCO-00-1 lower end with a portion of the main shell removed and Figure 20 shows the pre-drop model with the main shell removed. It can be clearly seen that the actual basket base plate deformed over the basket support bars, where the pre-drop model base plate experienced negligible deformations. Table 8 gives a comparison of several bottom basket deformations.

Table 8. Pre-Drop Model vs. Actual MCO-00-1 Bottom Basket Dimensions

Dimension Location	Pre-Drop Model Dimension (in., at 70 °F.)	Actual Dimension (in., at 20 °F.)
Center Post – length* from top of basket base to top of post	25.218	25-1/8
Center Post – diameters** near base plate near transition at top at reduced top	 3.057 3.052 2.473	 3.008 – 3.025 3.027 – 3.444 2.444 – 2.446
Perimeter Bars – distance from top of center post to top of perimeter bars	2.850	2.5 – 2.9375

*Original length was 29.278 inches, **Original diameter was 2.835 – 2.849 inches based on the Reference 7 drawings, but modeled as 2.840 inches. Difference in model and actual temperatures would cause negligible changes in the measured values.

What Table 8 shows is that even though the actual MCO-00-1 basket support bars were positioned differently from the pre-drop model, specific deformations of the center post and perimeter bars matched well whereas the basket base plates did not match well.

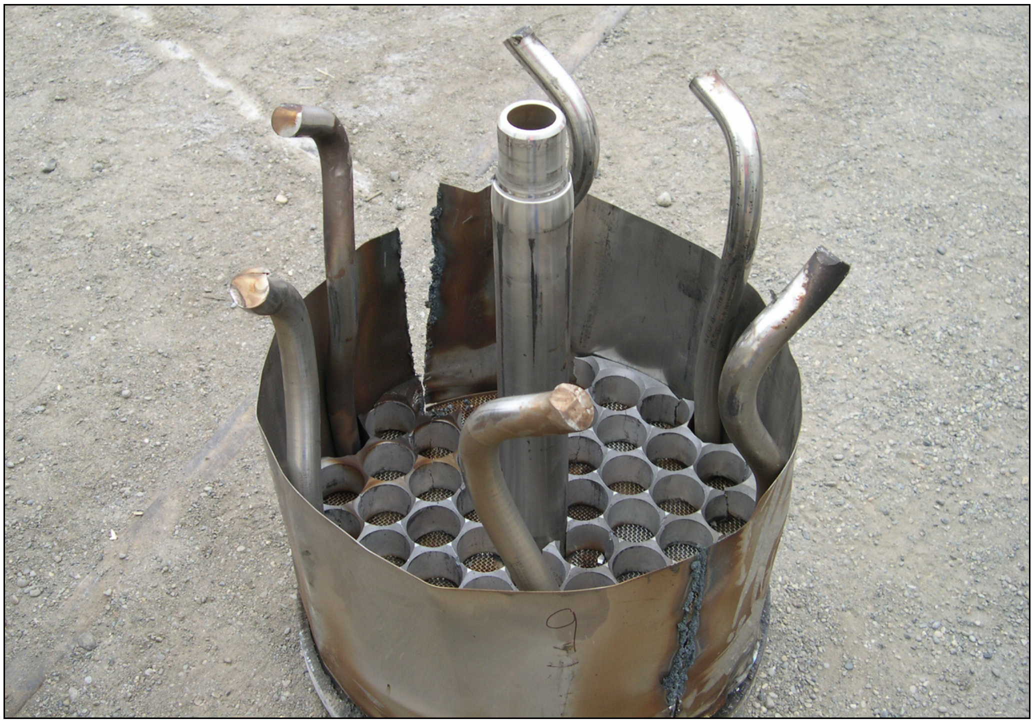


Figure 17. Test MCO-00-1 Bottom Basket Deformations

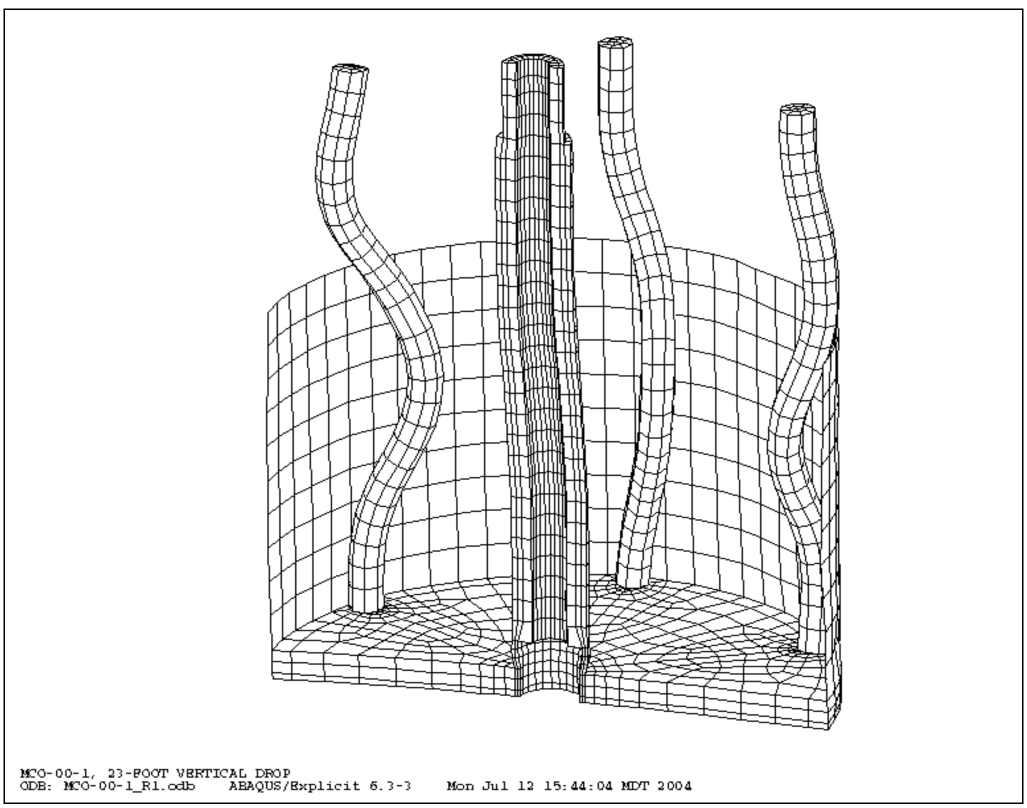


Figure 18. Pre-Drop Model of Test MCO-00-1 Bottom Basket Deformations

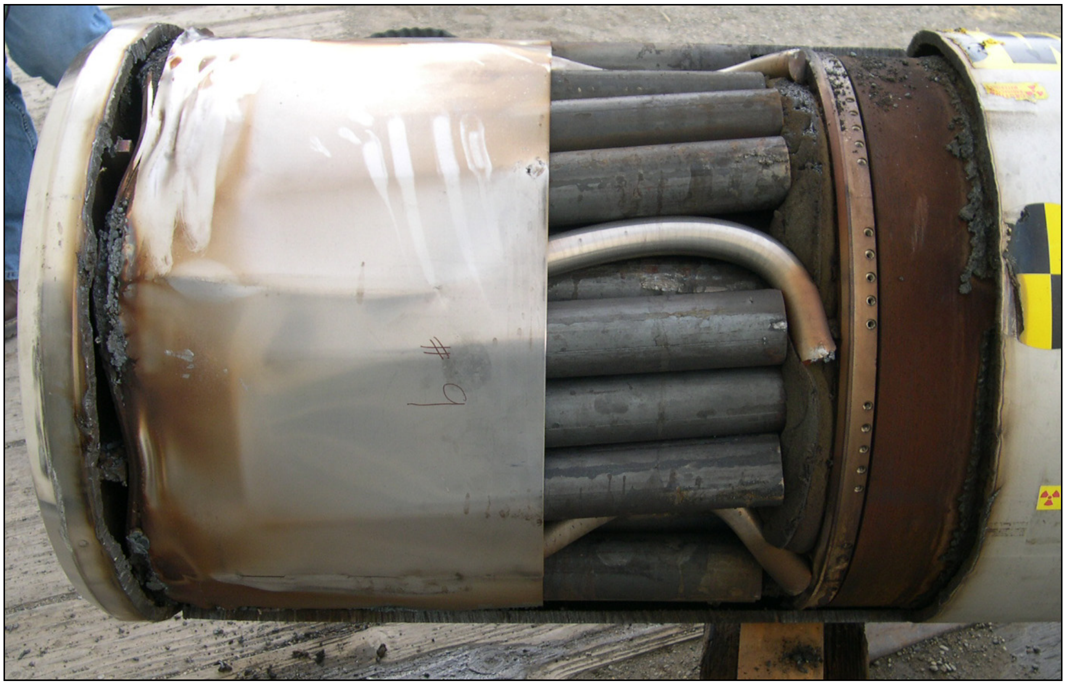


Figure 19. Test MCO-00-1 Bottom Basket Deformations (Side)

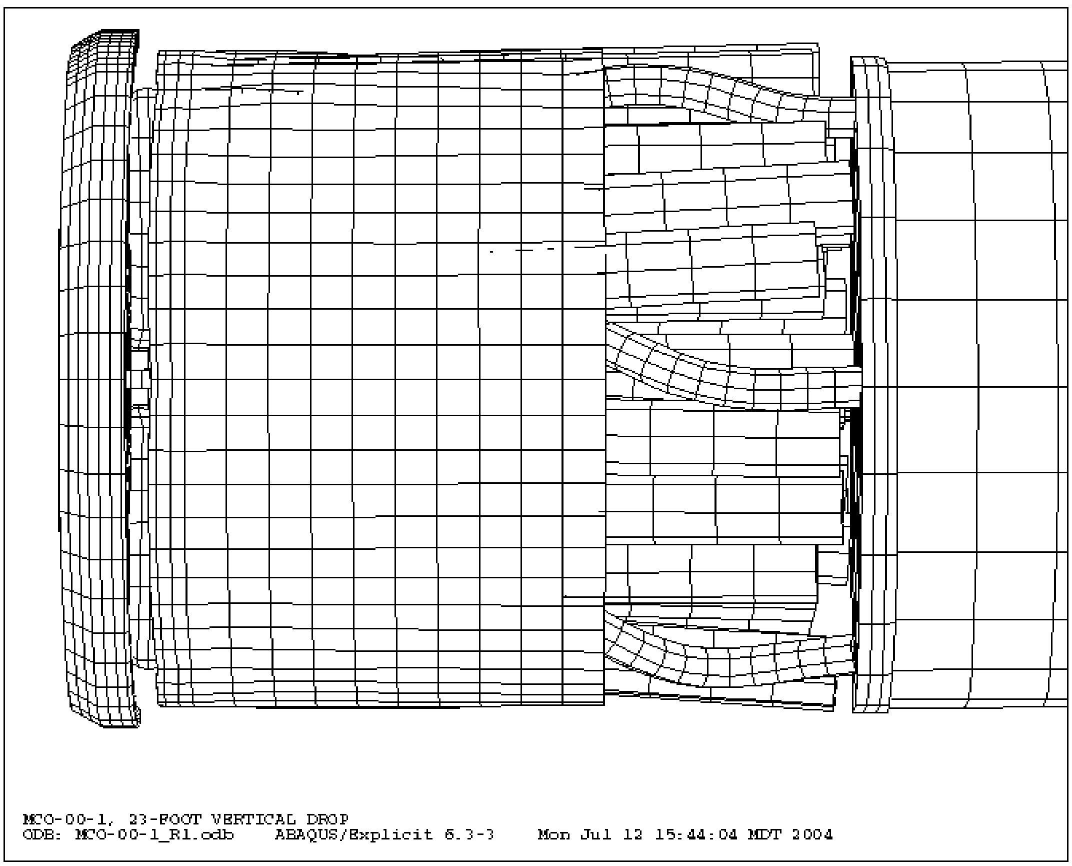


Figure 20. Pre-Drop Model of Test MCO-00-1 Bottom Basket Deformations (Side)

11.3.2. Test MCO-60-2 Predicted vs. Actual Deformations

Test MCO-60-2 was dropped from 2 feet onto the impact surface, impacting at an angle of 60-1/2 degrees off-vertical. Because of the low drop height (2 feet), test MCO-60-2 deformations were expected to be small.

The bottom of test MCO-60-2 first contacted the flat impact surface, sliding on the surface for a few milliseconds before lifting off due to test MCO rotation. Next, the top end hit the impact surface, resulting in a minor flattening of the collar in the impact area. Figure 21 shows the deformed test MCO-60-2 model.

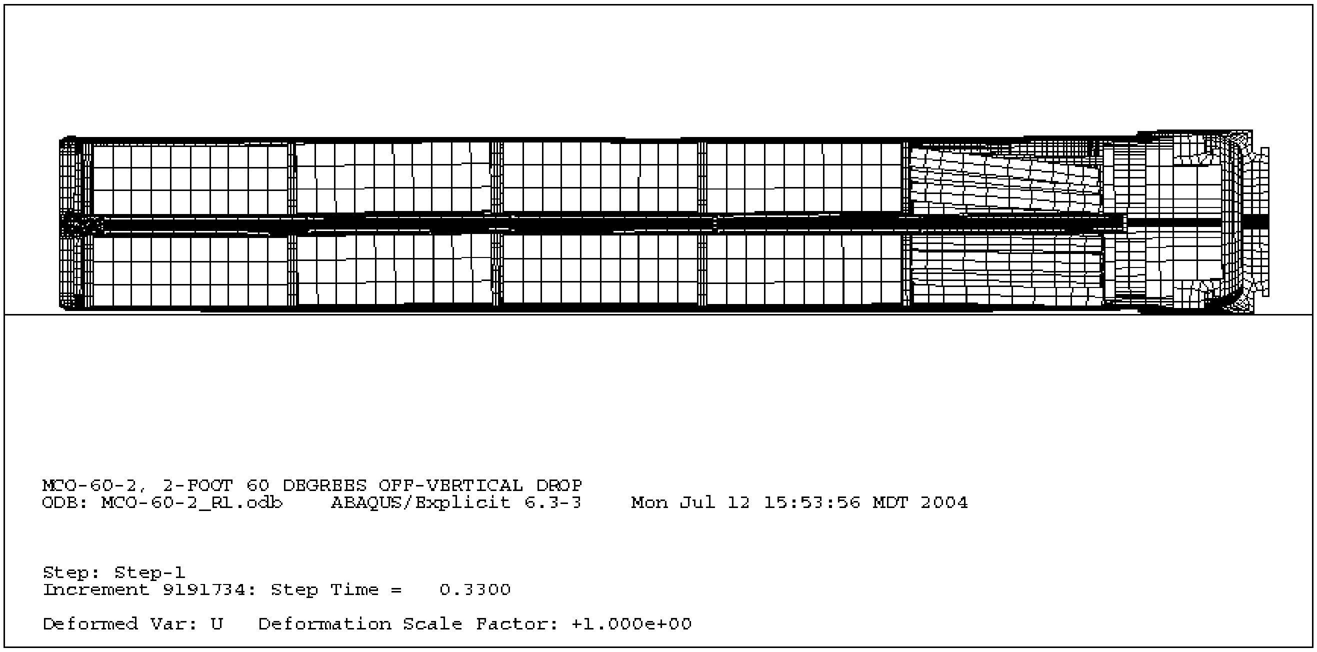


Figure 21. Pre-Drop Predicted Deformed Shape of Test MCO-60-2

Figure 22 shows a photo of the bottom of test MCO-60-2 at the initial impact location. The photo shows a small area where the bottom edge rubbed against the impact surface, leaving a trace of green paint. The deformations predicted in the analytical model of test MCO-60-2 do not show clearly because they were so small. However, Figure 23 shows the bottom of the test MCO-60-2 model with equivalent plastic strains contoured on the surface. This showed that the deformations to the analytical model, represented by plastic strains, were in the same location as on the actual test MCO.

Figure 24 shows a photo of the test MCO-60-2 upper end (main shell, collar, and cover region) at the second impact location. As with the bottom, a scuffed/flattened area was visible in the photo where the collar hit the impact surface. Because the deformations predicted in the analytical model did not show well in a plot, Figure 25 shows that area of the analytical model with equivalent plastic strains contoured on the surface. This again showed that the deformations predicted by the analytical model, represented by plastic strains, were in the same location as on the actual test MCO. (Note that the test MCO had a raised cover-to-collar weld that was not included in the analytical model. Deformation markings were therefore only similar in that area.)

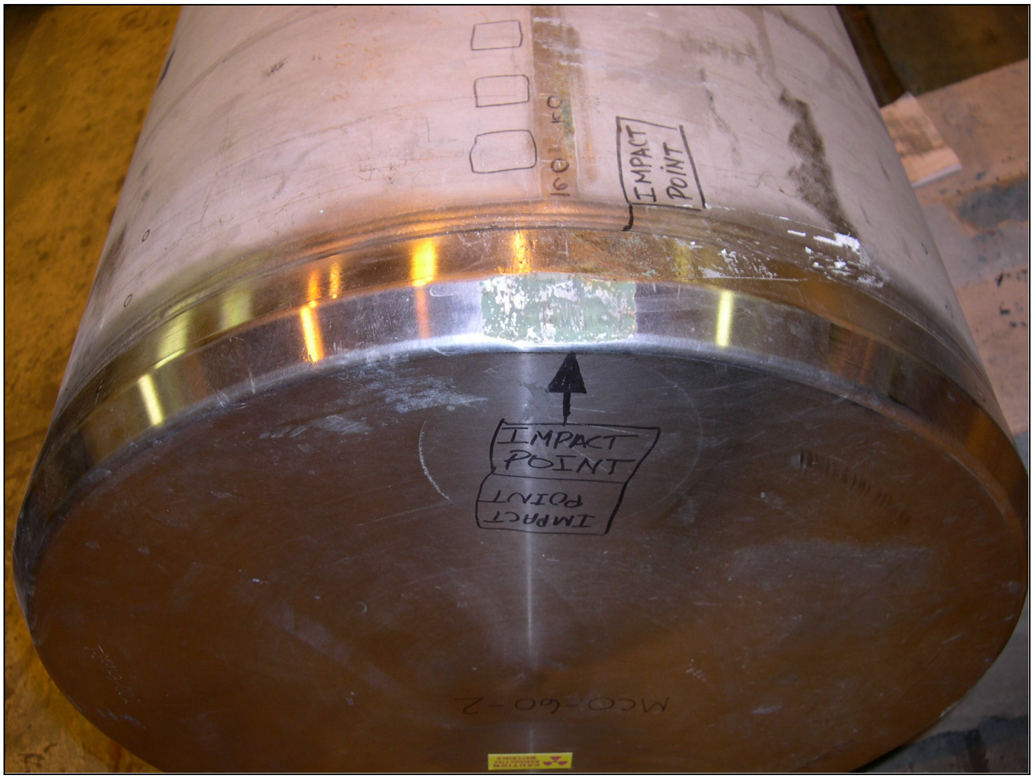


Figure 22. Photo of Test MCO-60-2 Bottom End at First Impact Location

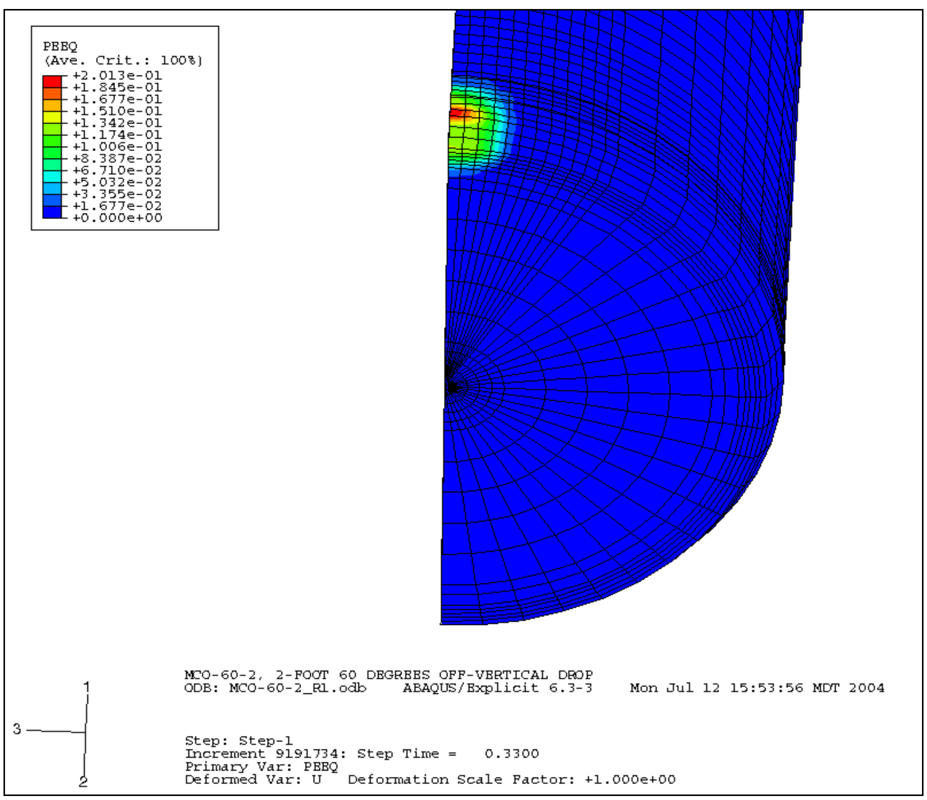


Figure 23. Pre-Drop Test MCO-60-2 Model Bottom End at First Impact Location, Strains

Figure 24. Photo of Test MCO-60-2 Top End at Second Impact Location

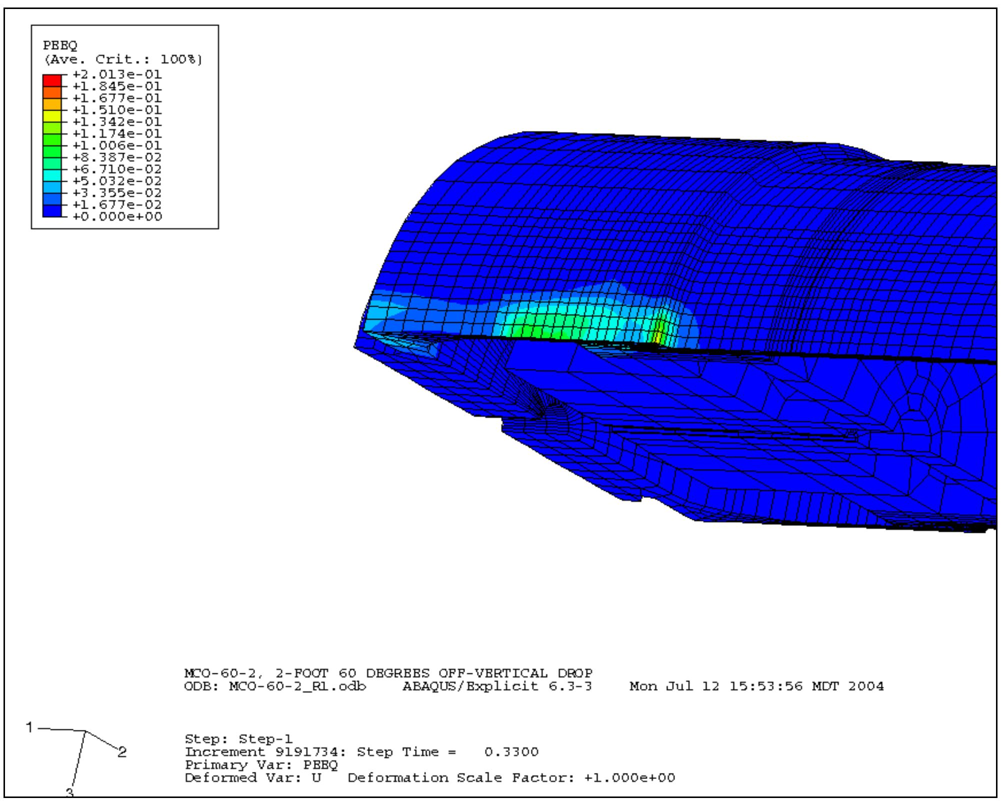


Figure 25. Pre-Drop Test MCO-60-2 Model Top End at Second Impact Location, Strains`

Table 9 gives a comparison of several dimensions measured on the test MCO-60-2 to the predicted values from the analytical model (pre-drop test FE model). The actual test MCO dimensions were from the pre- and post-drop data sheets (Appendices B and C).

Table 9. Comparison of Actual to Pre-Drop Predicted Deformations, Test MCO-60-2

Location	Position (O'Clock)	Actual Test MCO (in.)		Pre-Drop Analytical Model	
		Undeformed (Deformed)	Diameter Change	Modeled (Deformed)	Diameter Change
Bottom, 1-1/2-inches from bottom edge	12-6	24.071 (24.067)	0.004	24.080[1] (24.022)	0.058
	3-9	24.069 (24.072)	0.003	24.080[2] (24.080)	0.0
Collar, 17-inches below actual top	12-6	25.304 (25.203)	0.101	25.310[3] (25.174)	0.136
	3-9	25.289 (25.276)	0.013	25.310[4] (25.319)	0.009

1. Distance between model nodes 1311 and 34639.
2. Two times the deformed Z dimension at model node 13891.
3. Distance between model nodes 1004 and 35424.
4. Two times the deformed Z dimension at model node 14632.

At the bottom near the first impact area, the analytical model predicted a reduction in the diameter of about 1/16-inch where the actual canister experienced essentially zero reduction in diameter. Ninety degrees from the first impact area both the analytical model and the actual test MCO showed essentially no change in diameter. On the collar in the area of the second impact, both the analytical model and the actual test MCO predicted about 1/8-inch of diameter reduction, and essentially zero diameter reduction ninety degrees away.

The lack of significant deformation in MCO-60-2 was expected for two reasons. First, the drop height was only 2 feet, which created a relatively small amount of drop energy. Second, the primary impact was on a 2-inch thick bottom, while the secondary impact was on the collar which was supported by the locking ring and the shield plug – both substantially thick steel components.

The analytical model of MCO-60-2 was considered to simulate the actual drop event well.

11.4. Pre-Drop Test Analytical Predictions of Material Strains

During these test MCO drop events, the majority of the kinetic energy at impact was transformed into plastic work in the material. The best measure of that plastic work was the equivalent plastic strain, which was a cumulative strain measure that takes into account the entire deformation history. The equivalent plastic strain was defined as:

$$\varepsilon^{pl} = \int_0^t \left(\frac{2}{3} \dot{\varepsilon}^{pl} : \dot{\varepsilon}^{pl} \right)^{1/2} dt$$

The equivalent plastic strain was, therefore, never decreasing and always positive (straining occurred, whether caused by tension, compression, or shear).

11.4.1. Test MCO-00-1 Component Strains

Table 10 shows the peak equivalent plastic strains (PEEQ) in the MCO containment components, namely the bottom, main shell, collar, and cover. The strain was reported at three positions through the thickness of a component: at the outside surface, middle, and inside surface. Also shown were the peak strains the basket support bars and several bottom basket components. (Strains discussed in this report, unless specifically referred to as another type of strain, were always equivalent plastic strains.) Straining in all other components, including the internal weights and baskets, was negligible or not of interest.

Table 10. Test MCO-00-1 Pre-Drop Predicted Component PEEQ Strains

MCO Containment Component	Peak Equivalent Plastic Strains (PEEQ, %)		
	Outside Surface	Middle	Inside Surface
Bottom	3.5	2.7	2.2
Main Shell	3.1	2.9	2.7
Collar	0.2	0.2	0.1
Cover	0	0	0
Basket Support Bars	21		
Bottom Basket Component	**Max. PEEQ (%)**		
Basket Base	8		
Basket Center Post	34		
Basket Perimeter Bars	24		
Basket Perimeter Bar Bolts	14		

(Peak strains did not necessarily occur at the same location through the thickness.)

Figures 26 through 34 showed these PEEQ strains on several of these MCO-00-1 components.

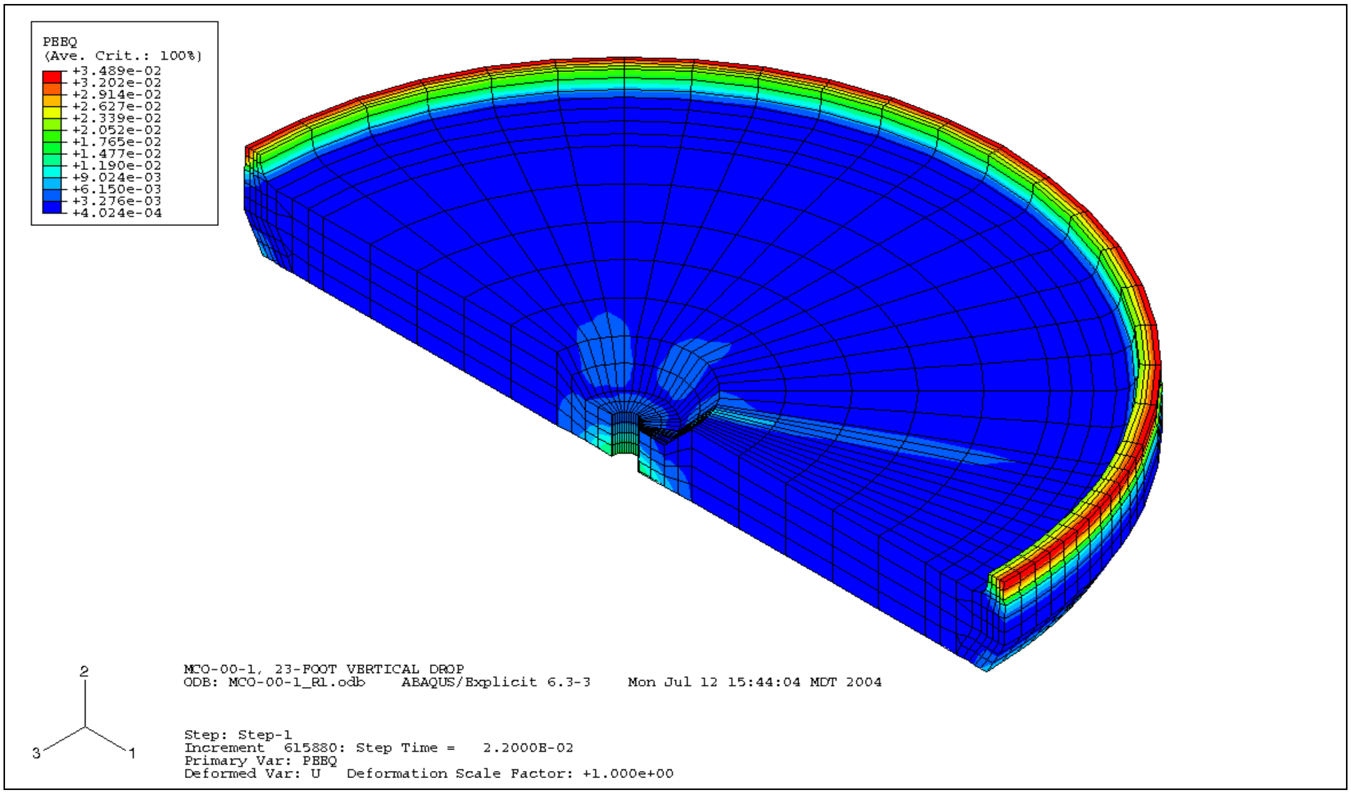


Figure 26. Test MCO-00-1 Bottom PEEQ Strains

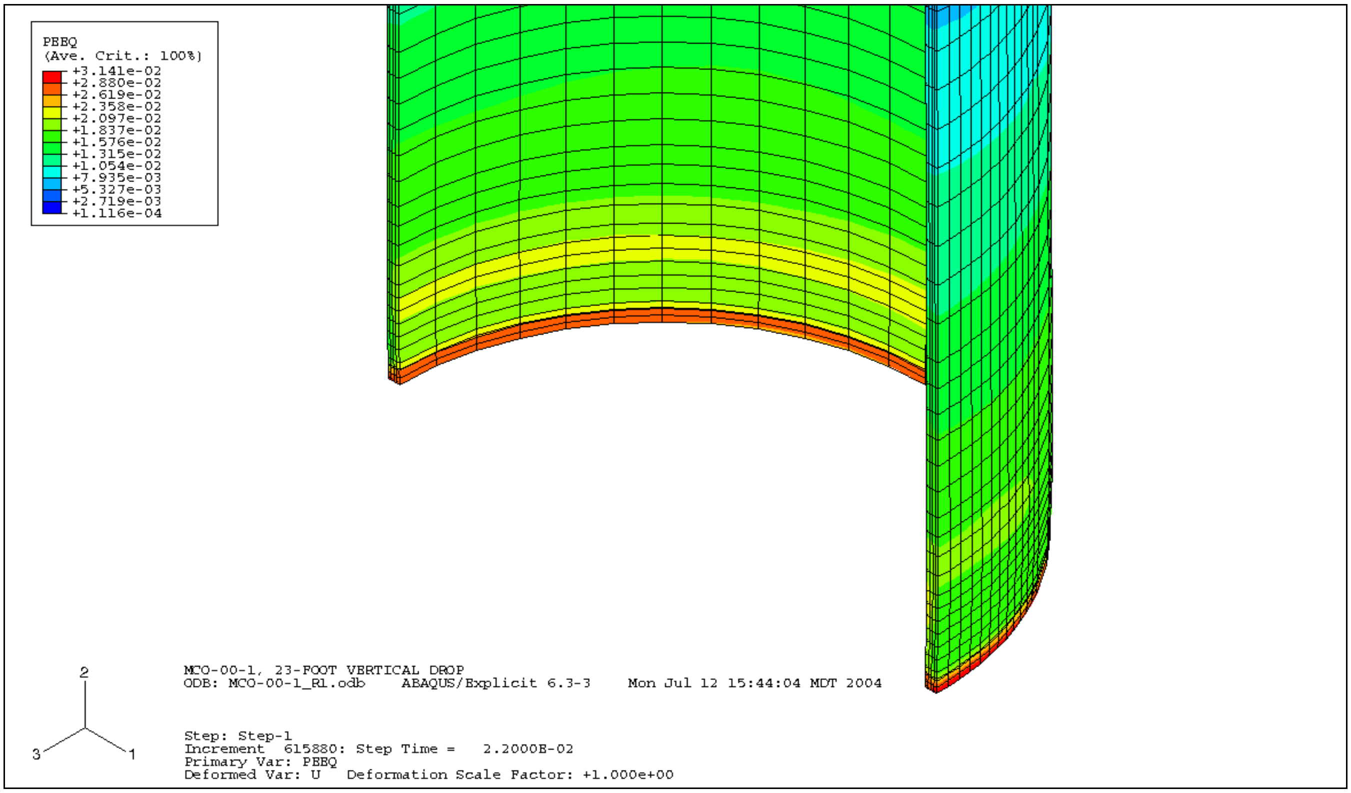


Figure 27. Test MCO-00-1 Main Shell PEEQ Strains

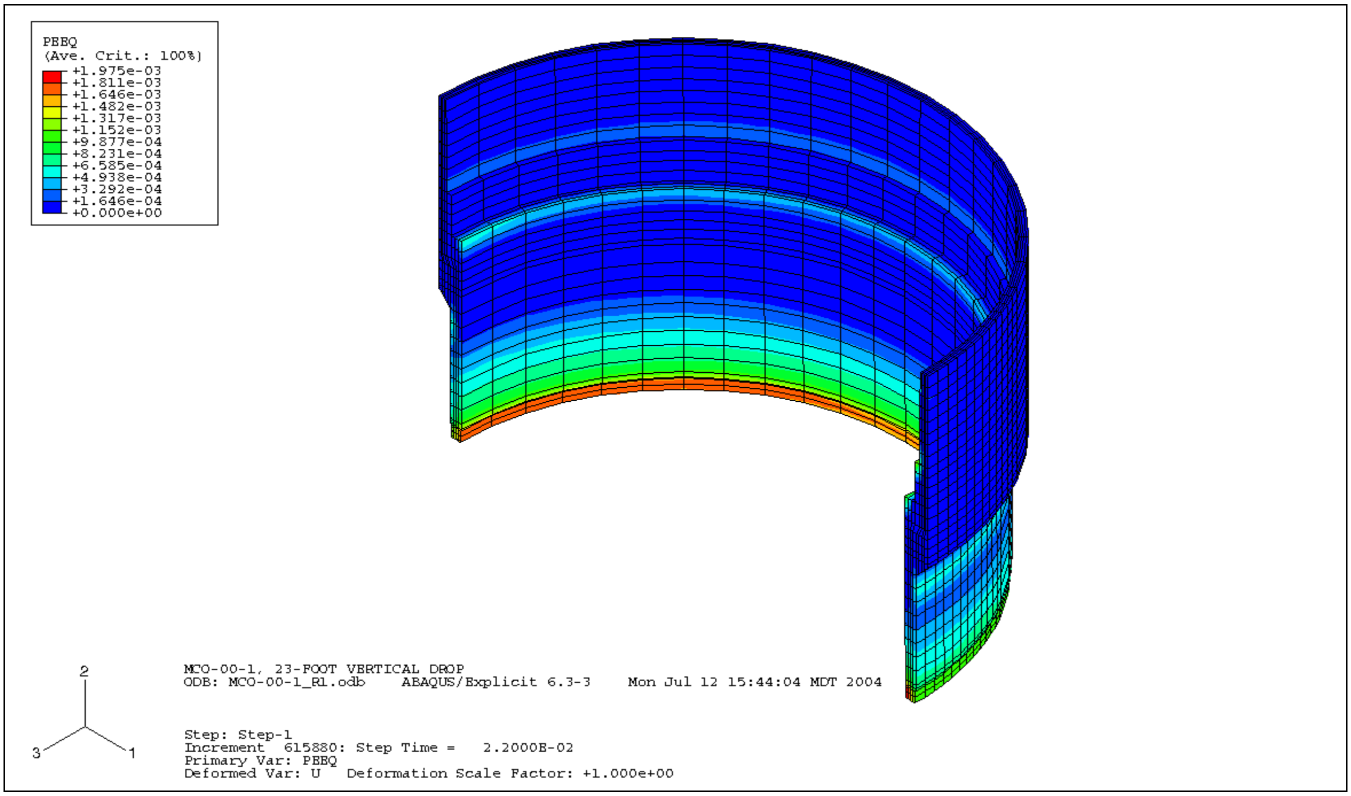


Figure 28. Test MCO-00-1 Collar PEEQ Strains

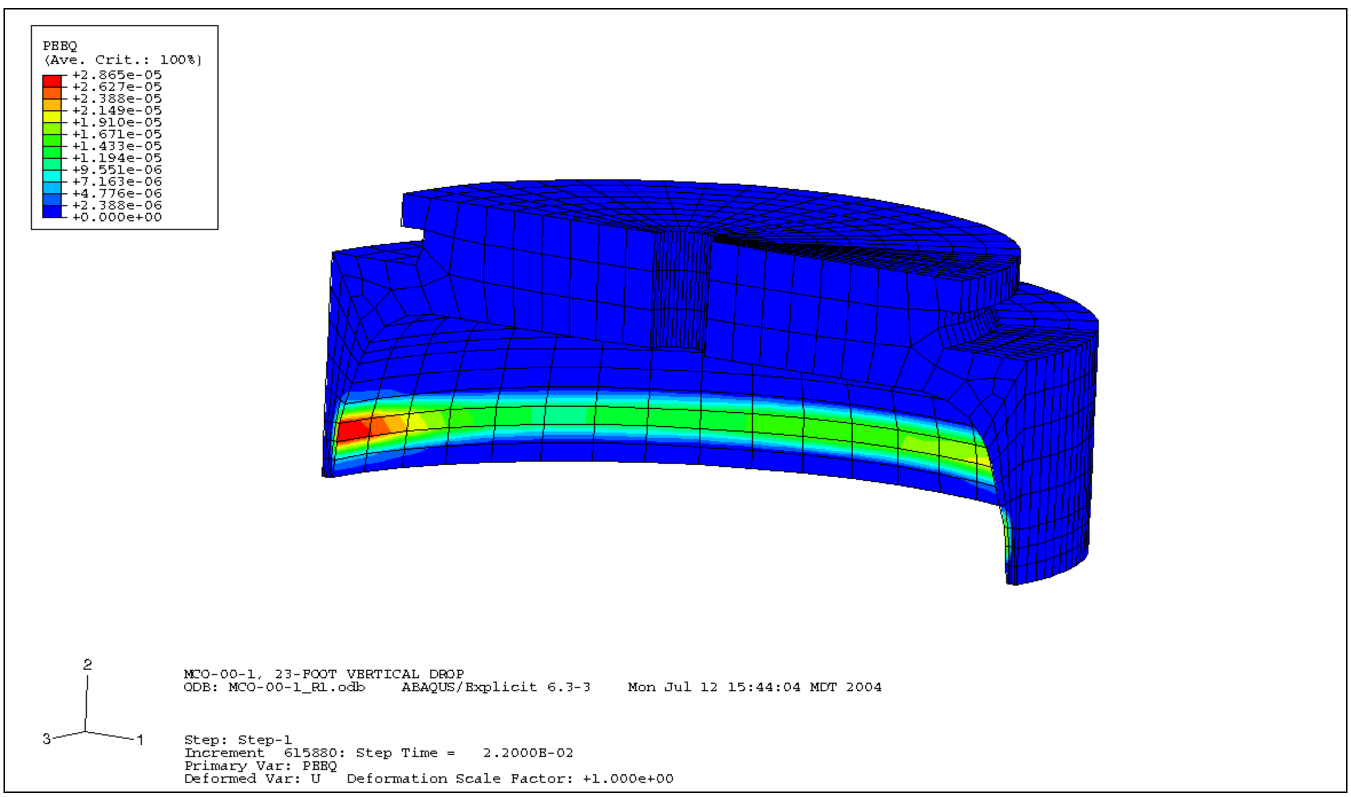


Figure 29. Test MCO-00-1 Cover PEEQ Strains

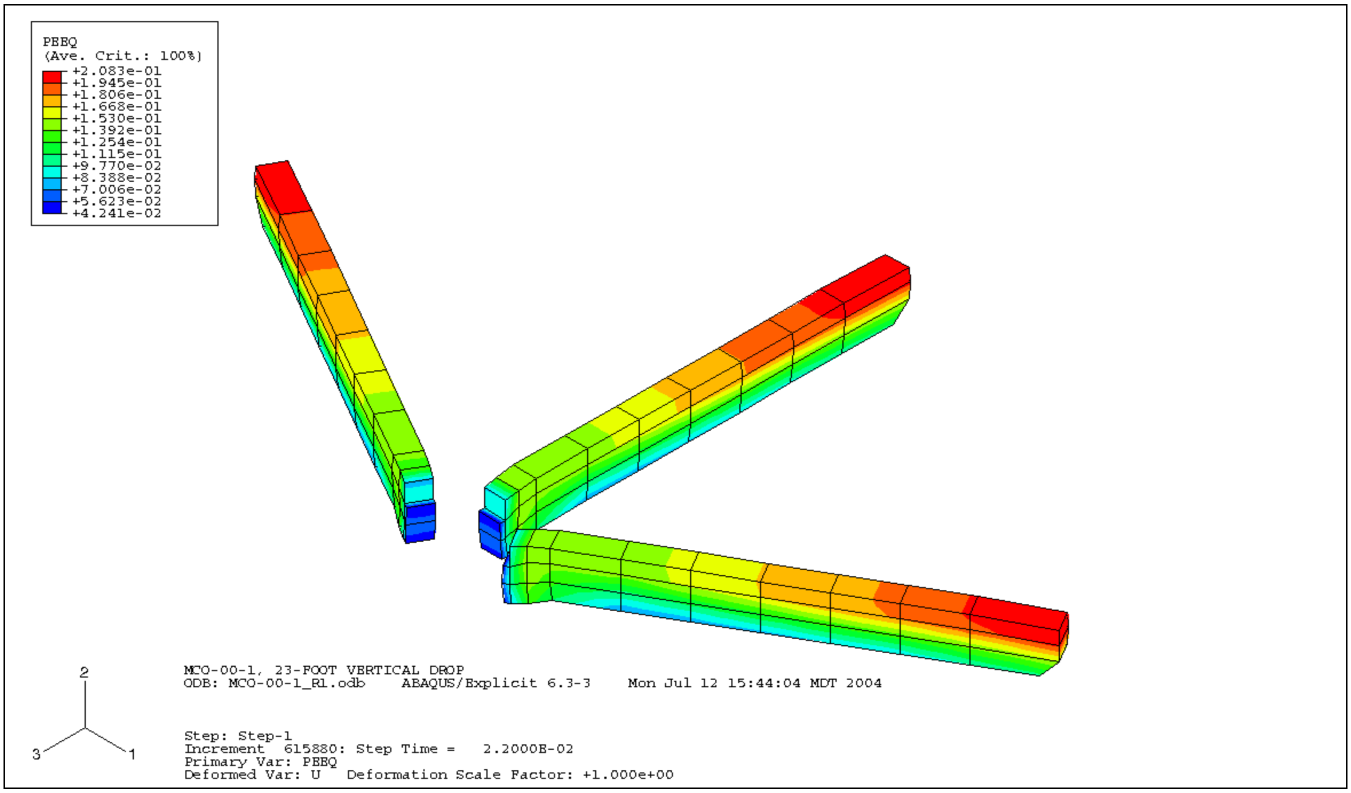


Figure 30. Test MCO-00-1 Basket Support Bars PEEQ Strains

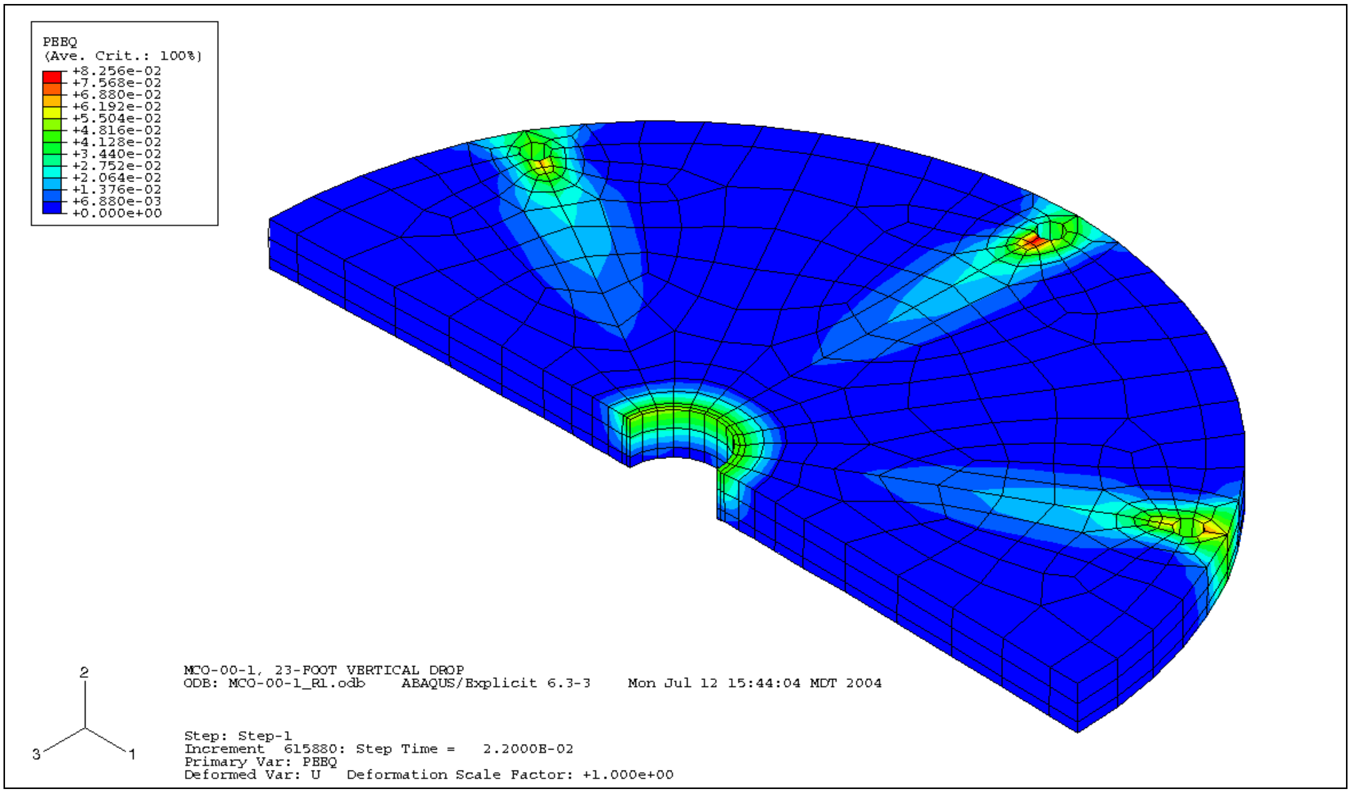


Figure 31. Test MCO-00-1 Bottom Basket Base Plate PEEQ Strains

Figure 32. Test MCO-00-1 Bottom Basket Center Post PEEQ Strains

Figure 33. Test MCO-00-1 Bottom Basket Perimeter Bars PEEQ Strains

Figure 34. Test MCO-00-1 Bottom Basket Perimeter Bar Bolts PEEQ Strains

The question at this point was whether the strains shown in Table 10 in the test MCO-00-1 containment components were high enough that rupture was predicted to occur. Table 3 showed a minimum elongation of 45% for the materials used in the test MCO-00-1 containment components, while Table 4 showed a minimum rupture strain of 131%. These strain values reflected that the test MCO-00-1 materials could uniformly (uniaxially) strain in tension in approaching the 45% value. Continued material straining would then focus to a smaller volume (e.g., necking in a tensile test coupon) and rapidly proceed to the minimum fracture strain of 131%. Bi-axial tension in the material could reduce the uniform strain limit and minimum fracture strain level (insufficient data available to quantify the reduction) where tension in one axis and compression in the other could increase these values (insufficient data, again, to quantify these). Because of the lack of more detailed material data with respect to bi-axial strain states in a high strain rate scenario, this evaluation used the 45% elongation value as the conservative through-wall strain limit for evaluating (preventing) potential MCO containment leakage. This was consistent with the analyses of References 3 and 4.

All containment boundary components of the analytical model for test MCO-00-1 had peak strains that were 35% or below. Therefore, rupture of test MCO-00-1 was not predicted for the specified 23-foot vertical drop event.

No evidence of material failure was noted in the actual test MCO-00-1 after drop testing. Post-drop helium leak testing was discussed later in this report.

11.4.2. Test MCO-60-2 Component Strains

Table 11 shows the peak equivalent plastic strains (PEEQ) in the MCO containment components, namely the bottom, main shell, collar, and cover. The strain was reported at three positions through the thickness of a component: at the outside surface, middle, and inside surface. Also shown were the peak strains the basket support bars and several basket components. (Strains discussed in this report, unless specifically referred to as another type of strain, were always equivalent plastic strains.) Straining in all other components, including the internal weights, was negligible.

Table 11. Test MCO-60-2 Pre-Drop Predicted Component PEEQ Strains

MCO Containment Component	Peak Equivalent Plastic Strains (PEEQ, %)		
	Outside Surface	Middle	Inside Surface
Bottom	20	7	8
Main Shell	4	5	6
Collar	16	8	9
Cover	5	4	4
Basket Support Bars	10		
Bottom Four Basket Bases & Center Posts	13		
Top Basket	7		

(Peak strains did not necessarily occur at the same location through the thickness.)

The straining in the bottom shell occurred at the location of the first impact. Therefore, that maximum strain of 20% is due to compression. The straining in the main shell was due primarily to the impact along its length. The collar straining was due to the second impact, with the maximum strain of 16% due to compression at impact. Cover strains due to the second impact were low.

The straining in the bottom four baskets was a maximum of 13%, occurring in the bottom of the center posts and the base plate at the connection between the center post and the base plate. The top basket experienced a maximum strain of 7%, also occurring at the bottom of the center post. Figures 35 through 41 showed these PEEQ strains on several of these MCO-60-2 components.

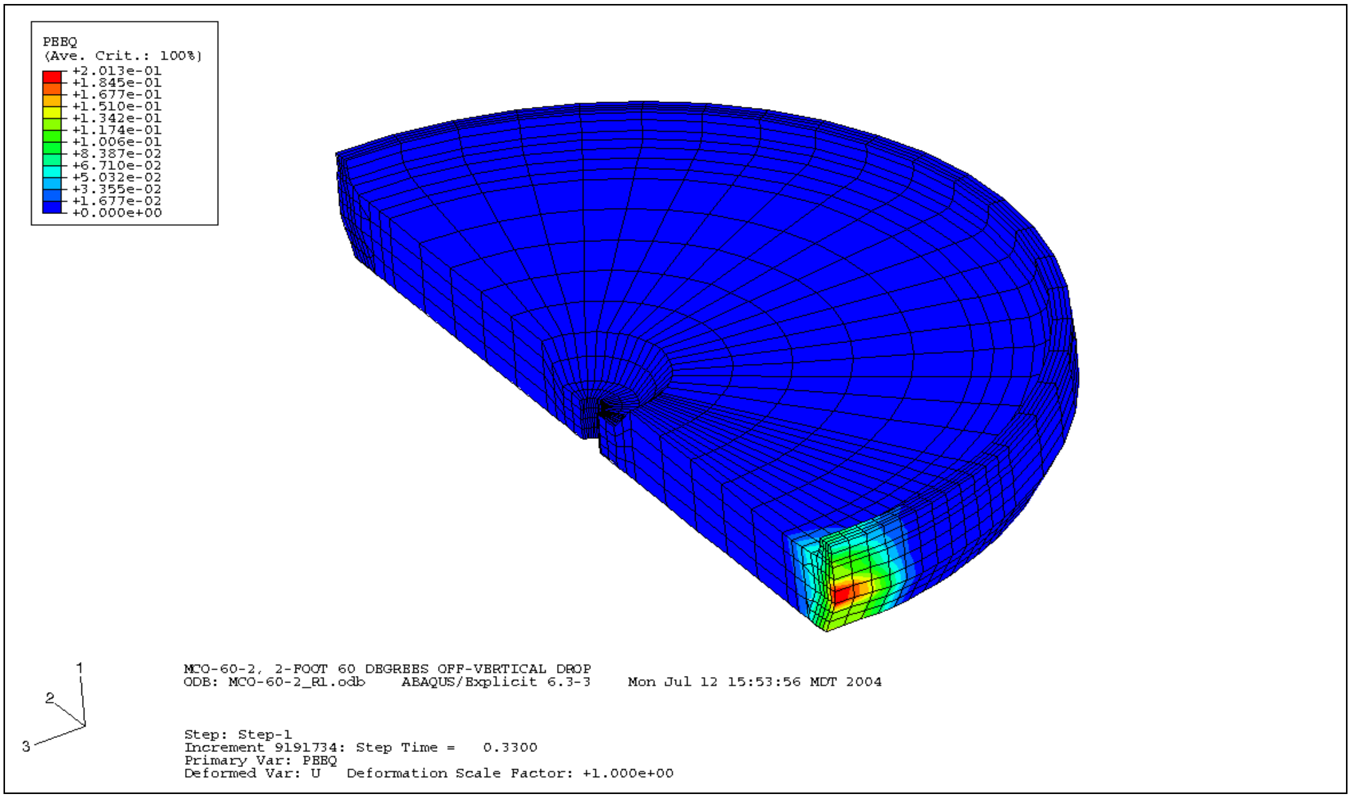


Figure 35. Test MCO-60-2 Bottom PEEQ Strains

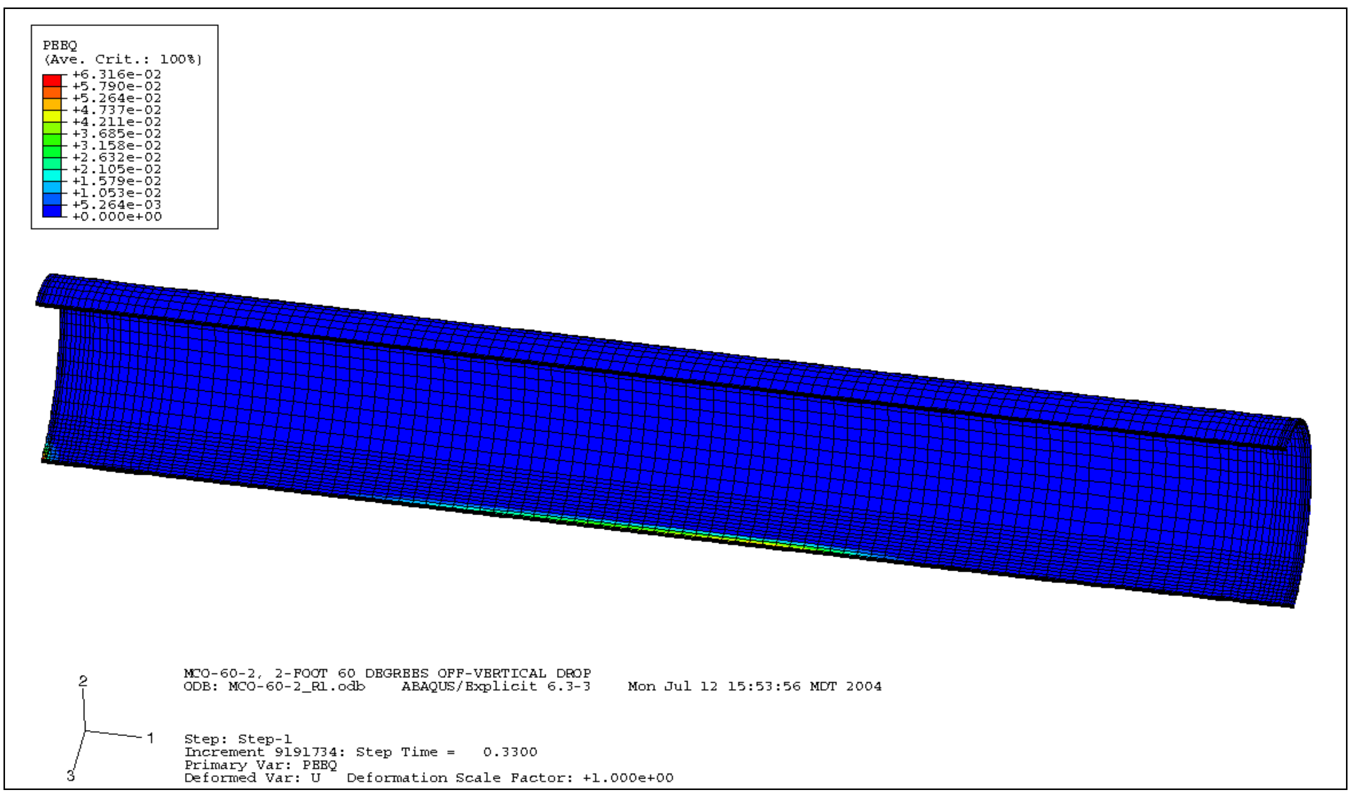


Figure 36. Test MCO-60-2 Main Shell PEEQ Strains

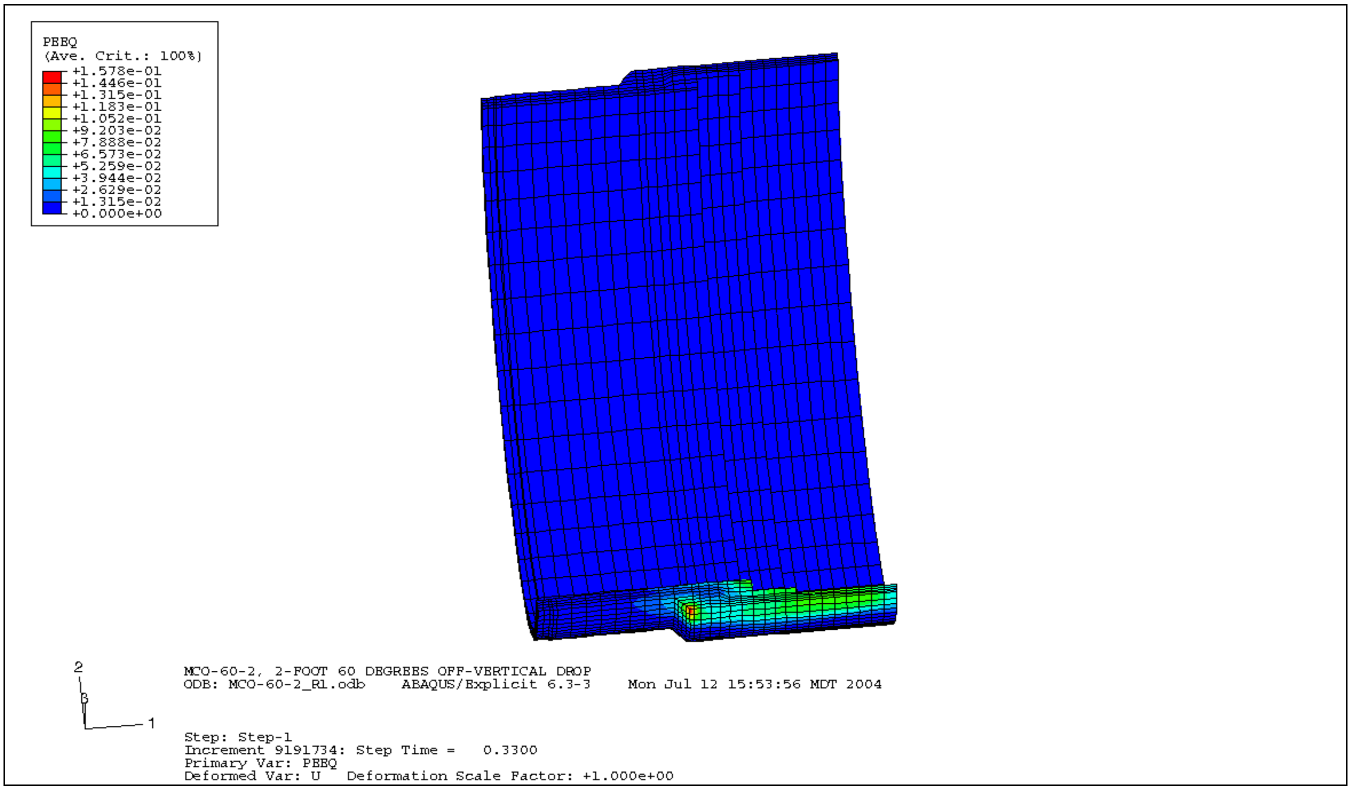


Figure 37. Test MCO-60-2 Collar PEEQ Strains

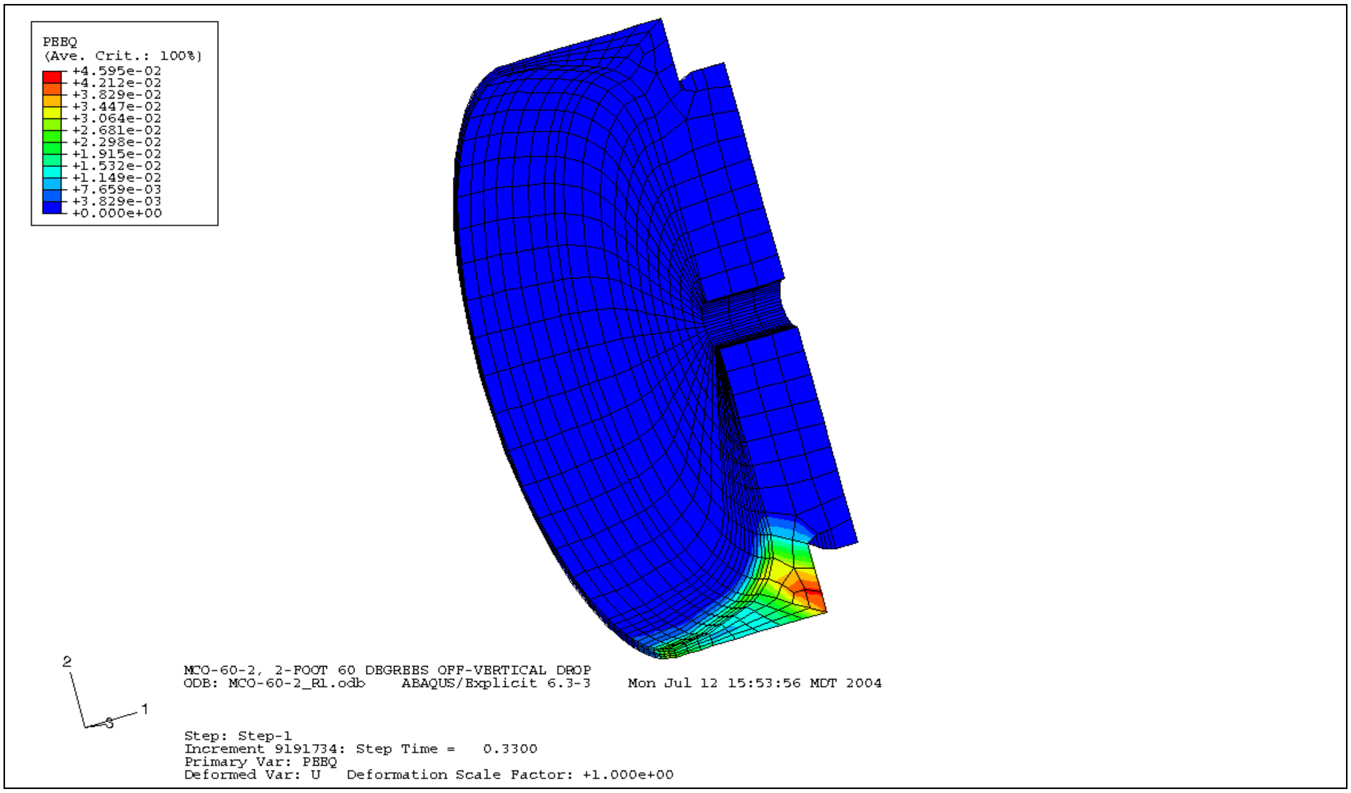


Figure 38. Test MCO-60-2 Cover PEEQ Strains

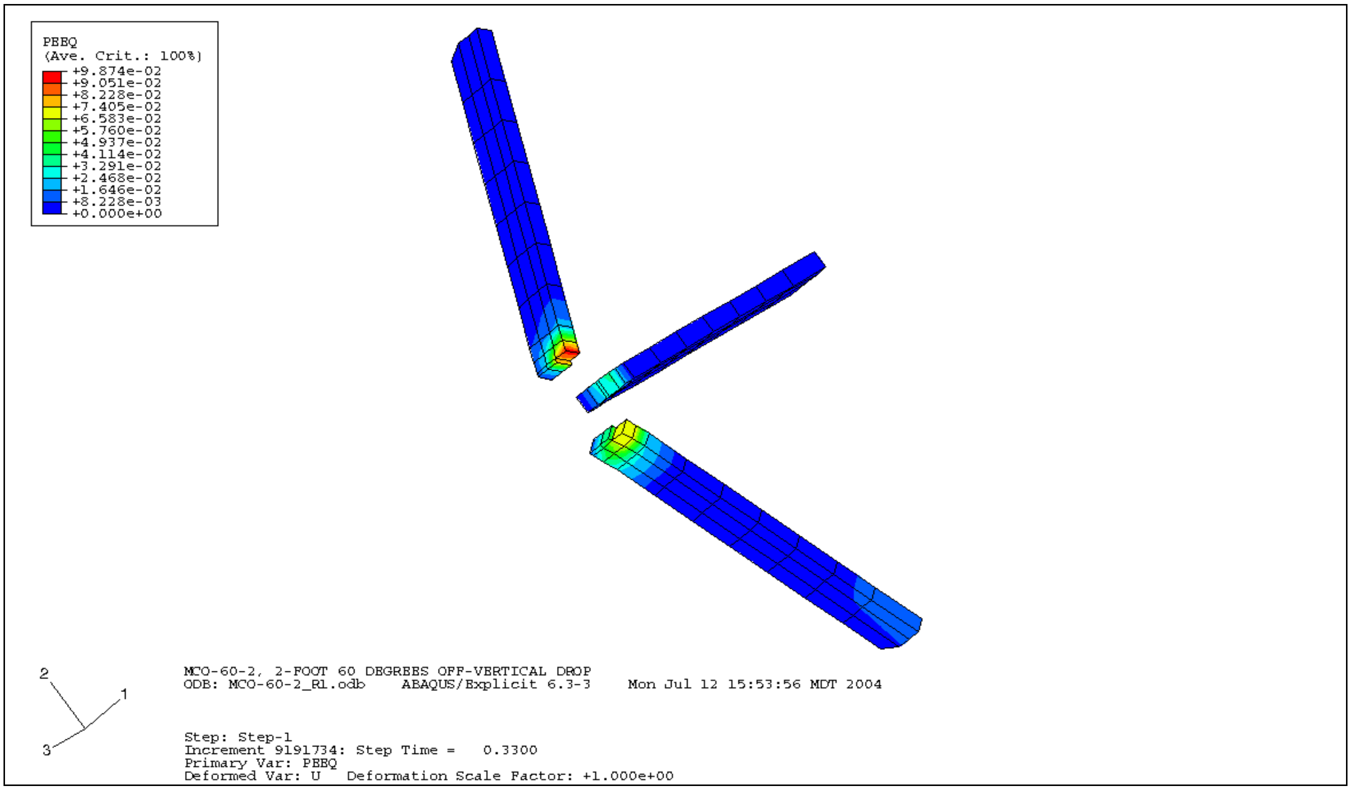


Figure 39. Test MCO-60-2 Basket Support Bars PEEQ Strains

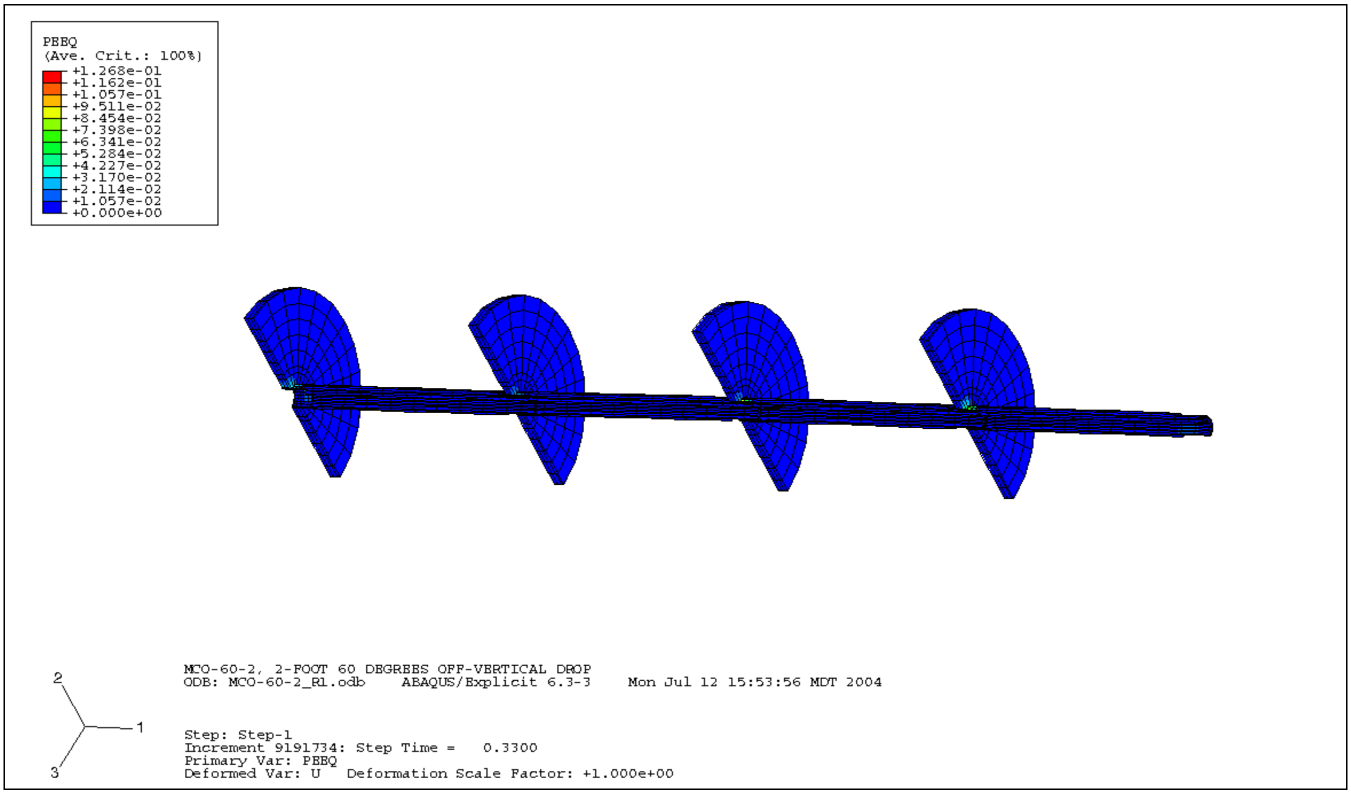


Figure 40. Test MCO-60-2 Bottom Four Basket Bases & Center Posts PEEQ Strains

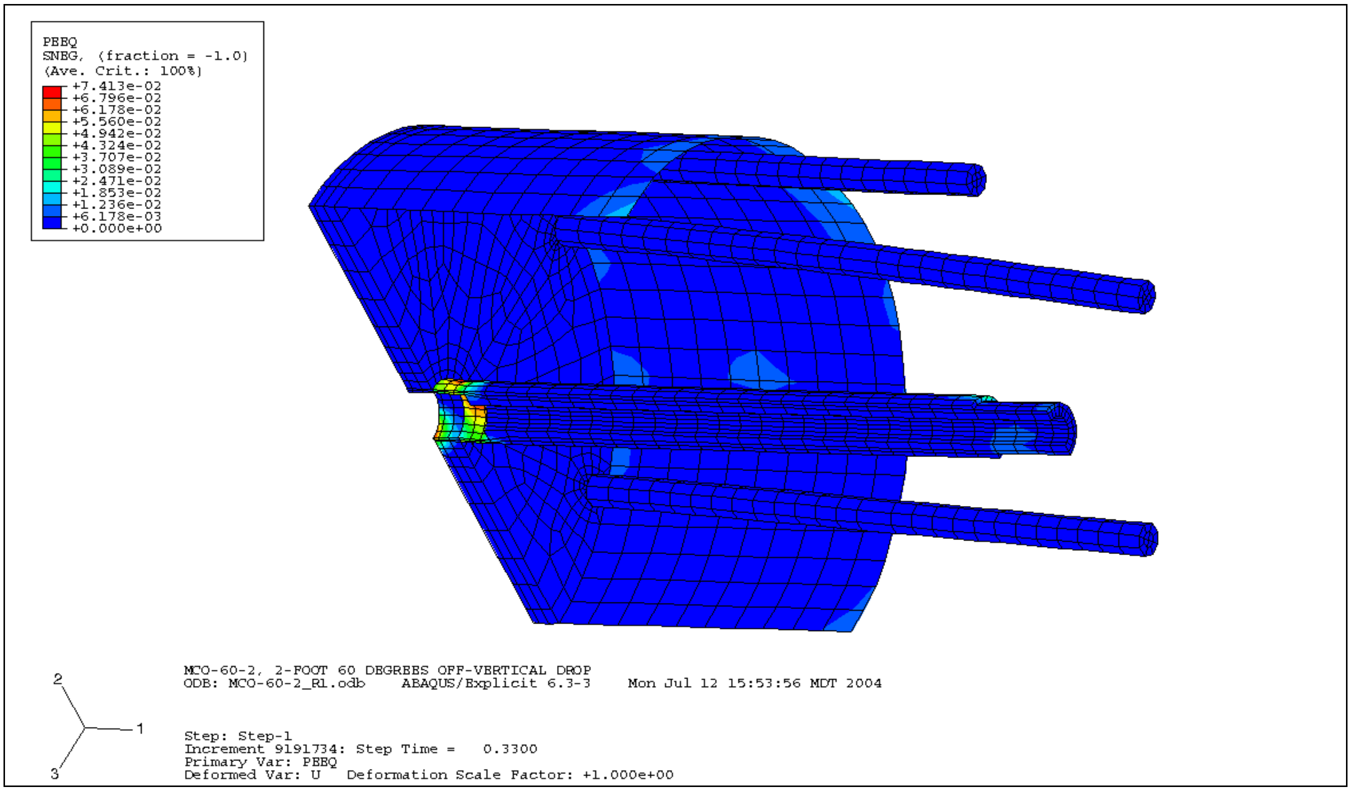


Figure 41. Test MCO-60-2 Top Basket PEEQ Strains

The question at this point was whether the strains shown in Table 11 in the test MCO-60-2 containment components were high enough that rupture was predicted to occur. Table 3 showed a minimum elongation of 54% for the materials used in the test MCO-60-2 containment components, while Table 4 showed a minimum rupture strain of 119%. These strain values reflected that the test MCO-60-2 materials could uniformly (uniaxially) strain in tension in approaching the 54% value. Continued material straining would then focus to a smaller volume (e.g., necking in a tensile test coupon) and rapidly proceed to the minimum fracture strain of 119%. Bi-axial tension in the material could reduce the uniform strain limit and minimum fracture strain level (insufficient data available to quantify the reduction) where tension in one axis and compression in the other could increase these values (insufficient data, again, to quantify these). Because of the lack of more detailed material data with respect to bi-axial strain states in a high strain rate scenario, this evaluation used the 54% elongation value as the conservative through-wall strain limit for evaluating (preventing) potential MCO containment leakage. This was consistent with the analyses of References 3 and 4.

All containment boundary components of the analytical model for test MCO-60-2 had peak strains that were 20% or below. Additionally, these strains were localized – only at the locations of impact. Therefore, rupture of test MCO-60-2 was not predicted for the specified 2-foot 60-degree off-vertical drop event.

No evidence of material failure was noted in the actual test MCO-60-2 after drop testing. Post-drop helium leak testing, to be discussed later in this report, confirmed that the test MCO-60-2 maintained a leaktight containment (leak rate of less than 10^{-7} std cc/sec.) after the drop event.

11.5. Pre-Drop Test Predicted Strains vs. Test MCO Derived Strains

During pre-drop test preparations, markings were placed on the two test MCOs at various locations to provide a way to measure local deformations at points of interest on the test MCO exterior. From these local deformations, “derived strains,” consisting of the change in distance between two marks divided by the original distance, were calculated. [Derived strains were true strains, calculated as {ln (1+ change in length/original length)}.] It was not the objective of this evaluation to exactly match the measured to calculated strains, only to show that the average strains over the area of marking were similar - roughly within the same range.

The markings consisted of a small indentation at the four corners of a square pattern, about ¾-inch between each indentation. The distance between each mark was measured with a digital caliper (to an accuracy of x.xxx) before and after drop testing. (Because of the ¾-inch distance between markings, only peak strains that occurred over distances ¾-inch or larger would be accurately reflected with these marks.) Appendices B and C list the pre-drop and post-drop measurements. Note that the measurements were just point-to-point (linear), and did not take into account any contour of the marked component. Therefore, the measurements were only valid where the component contour began flat or reasonably flat (from one measured point to another) and remained flat or reasonably so during the drop event, and only approximate at best for all other conditions. (The following showed that the resulting strains in the test MCOs were less than 10%, so the drop tests did not provide an exceptional opportunity to see how the analysis could predict high plastic strains.)

11.5.1. Test MCO-00-1 Derived Strains vs. Pre-Drop Test Predicted Strains

Figure 42 shows the pattern of strain markings on the bottom of test MCO-00-1 and the measured “% strains” derived from pre-drop and post drop measurements. As discussed above, the distance between indentations was measured before and after the drop testing. “Strain” on Figure 42 was the change in measured dimension divided by the original dimension. Because the drop was vertical, the four strain markings on the 4-inch circumferential line should have given similar results. Results for the 6-inch and 8-inch lines should also have been similar. The variations shown on Figure 42 were considered due to the small magnitudes of plastic strains involved and the limits of the method. (Note that each square on the figure connects four indentations. The numbers next to the horizontal lines on each box represent the circumferential strain between the two indentations, where the numbers next to the vertical lines on each box represent the longitudinal strain between the two indentations.)

Figure 43 shows that the PEEQ strains on the main shell (outside surface) in the area of the strain markings were in the range of 1% to 2-1/2%. As discussed earlier, PEEQ strains were the accumulated strains without regard to direction – related but not necessarily equivalent to the measured strains (longitudinal and circumferential). In order to output strains in the longitudinal and circumferential directions for direct comparison a post-drop model run with a cylindrical coordinate system would be required.

On average, the measured strains (Figure 42) were as follows:
-4-inch Line: -1.5% longitudinal, -1.1% circumferential
-6-inch Line: -1.9% longitudinal, -0.7% circumferential
-8-inch Line: -2.6% longitudinal, -1.4% circumferential

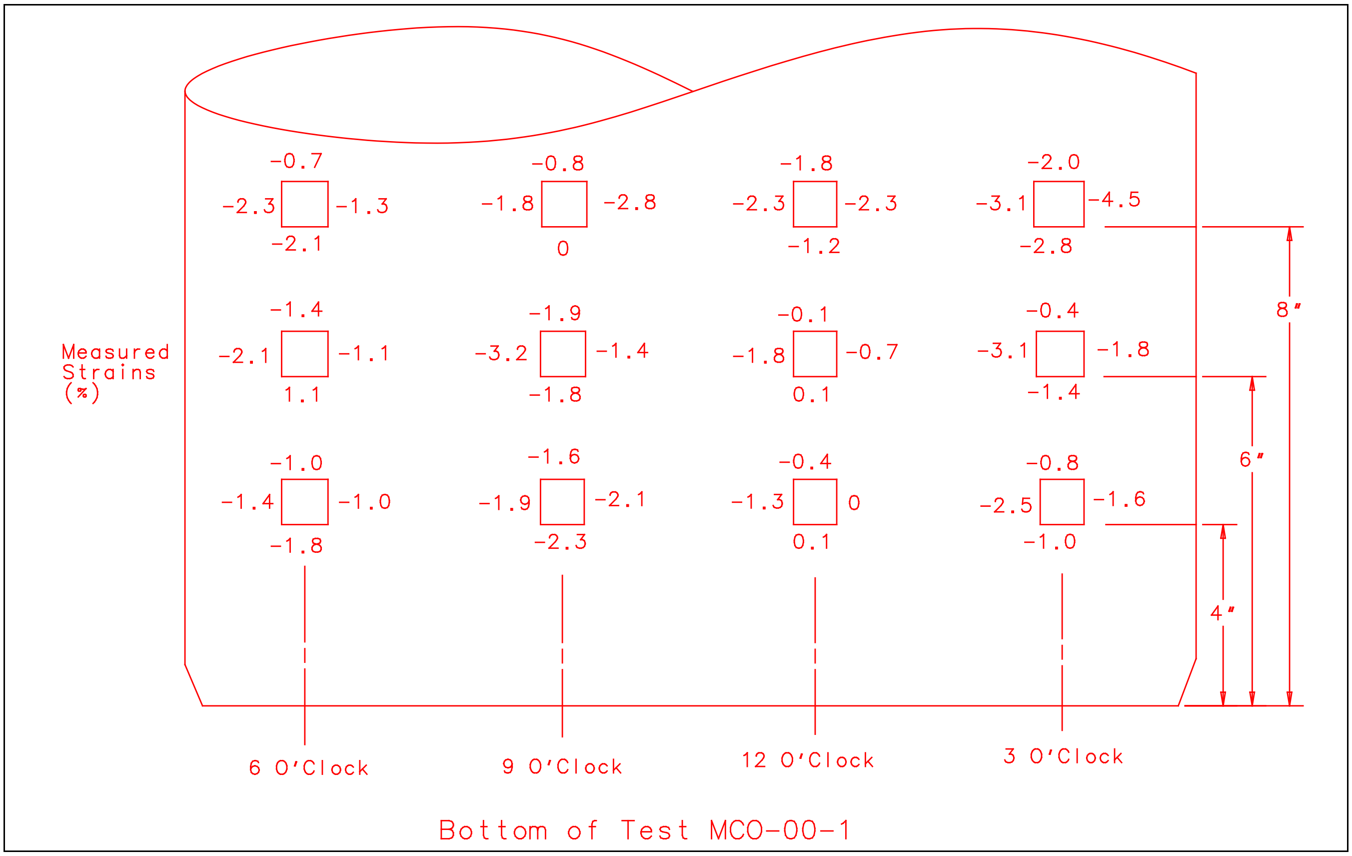


Figure 42. Derived Strain at Bottom & Main Shell of Test MCO-00-1, From Strain Marks

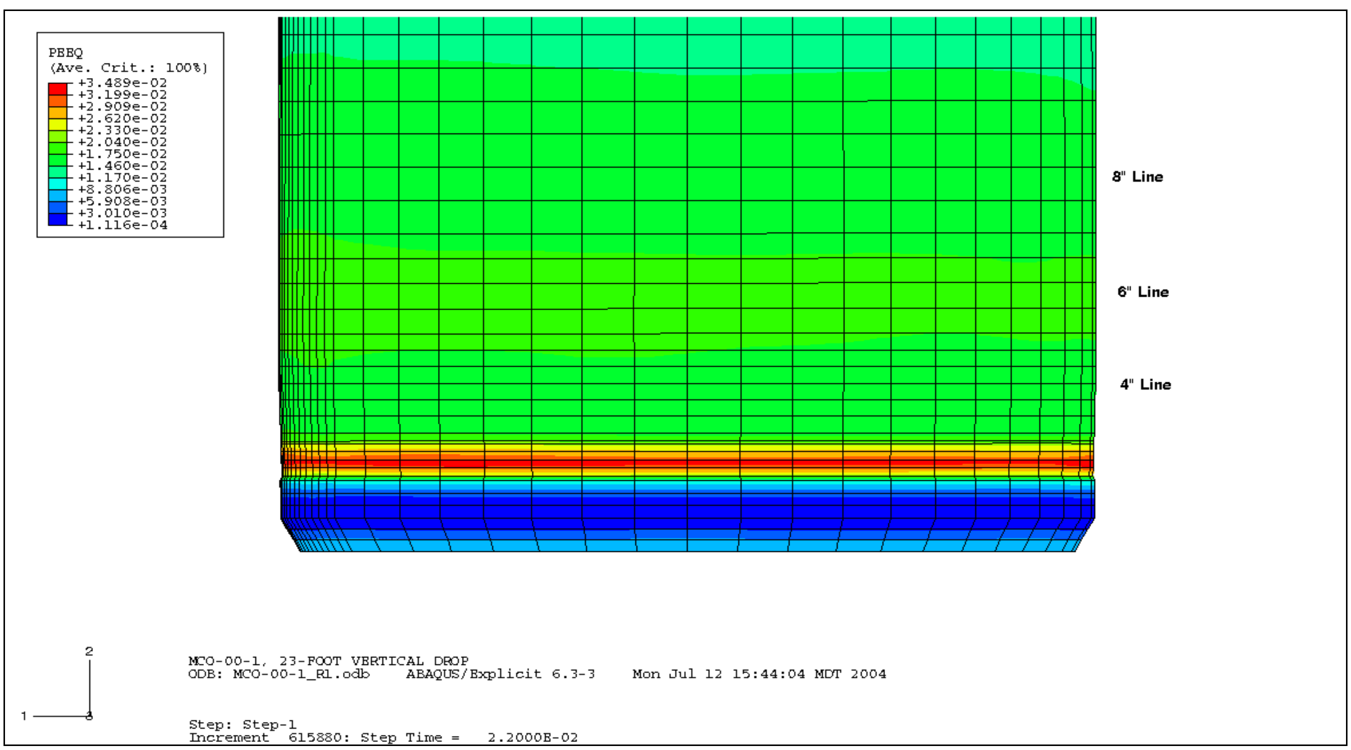


Figure 43. PEEQ Strain at Bottom & Main Shell of Test MCO-00-1, From Pre-Drop Model

In other words, the average derived strains were approximately within the 1% to 2-1/2% PEEQ range – considered a good match between derived strains and model-predicted strains.

A post-drop evaluation of the analytical model using a cylindrical reference coordinate system would be expected to give the strain components in about the same range as well. Therefore, a more in-depth evaluation was not considered necessary.

11.5.2. Test MCO-60-2 Derived Strains vs. Pre-Drop Test Predicted Strains

Figure 44 shows the pattern of strain markings on test MCO-60-2 and the measured "% strains" derived from pre-drop and post drop measurements. As discussed above, the distance between indentations was measured before and after the drop testing, using point-to-point linear methods. "Strain" on Figure 44 was the change in measured dimension divided by the original dimension. Figure 45 shows that the PEEQ strains on the main shell (outside surface) in the area of the lower strain markings were in the range of 2% or less at the 4-inch line and <1% for the 6-inch and 8-inch lines. This was comparable to the Figure 44 measured strains in the longitudinal and circumferential directions. (Note that each square on the figure connects four indentations. The numbers next to the horizontal lines on each box represent the longitudinal strain between the two indentations, where the numbers next to the vertical lines on each box represent the circumferential strain between the two indentations.)

Figure 46 shows the collar and cover region of test MCO-60-2 with PEEQ strains displayed. The 3-inch and 17-inch lines were on either side of the collar area that experienced the maximum strain. Both areas were in a <2% PEEQ range on Figure 46, where the Figure 44 measured circumferential and longitudinal strains were on average 1% or less.

Because the measured and calculated strains, though not necessarily equivalent, were in the same general range, a more in-depth evaluation was not considered necessary.

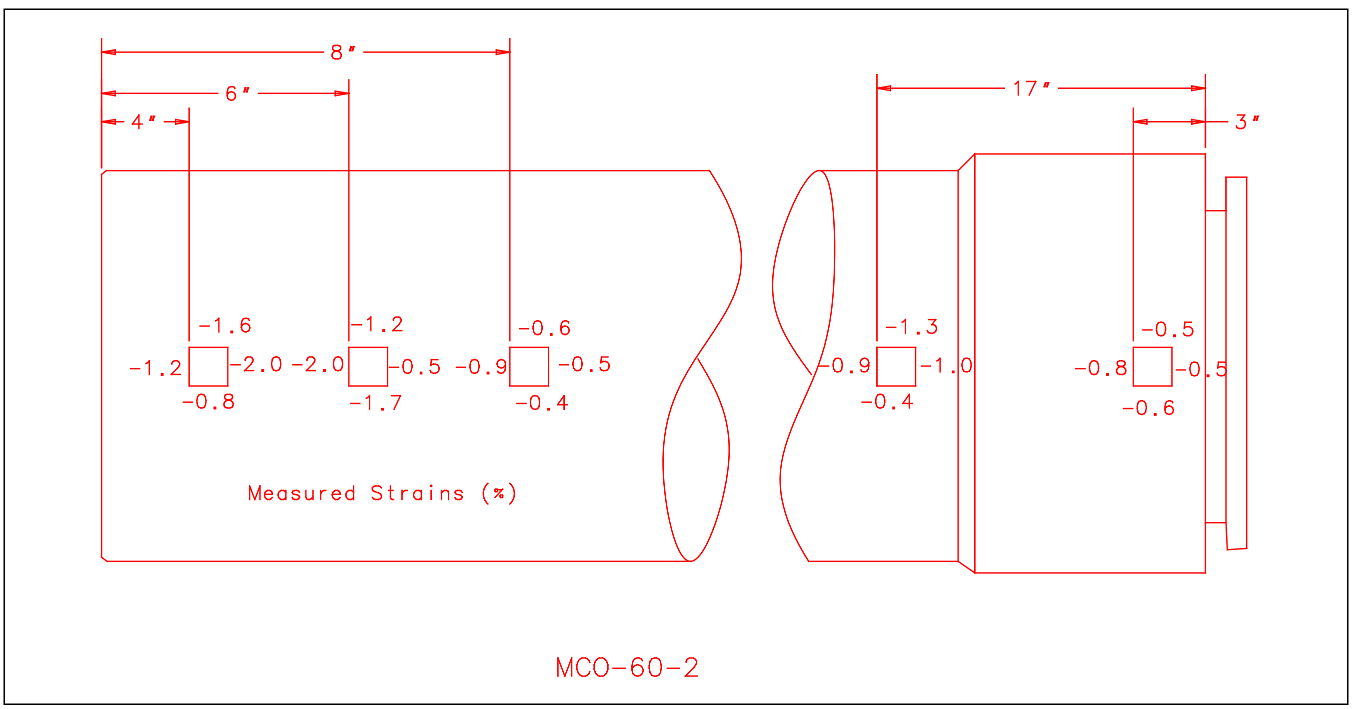


Figure 44. Measured Strain on Test MCO-60-2, From Strain Marks

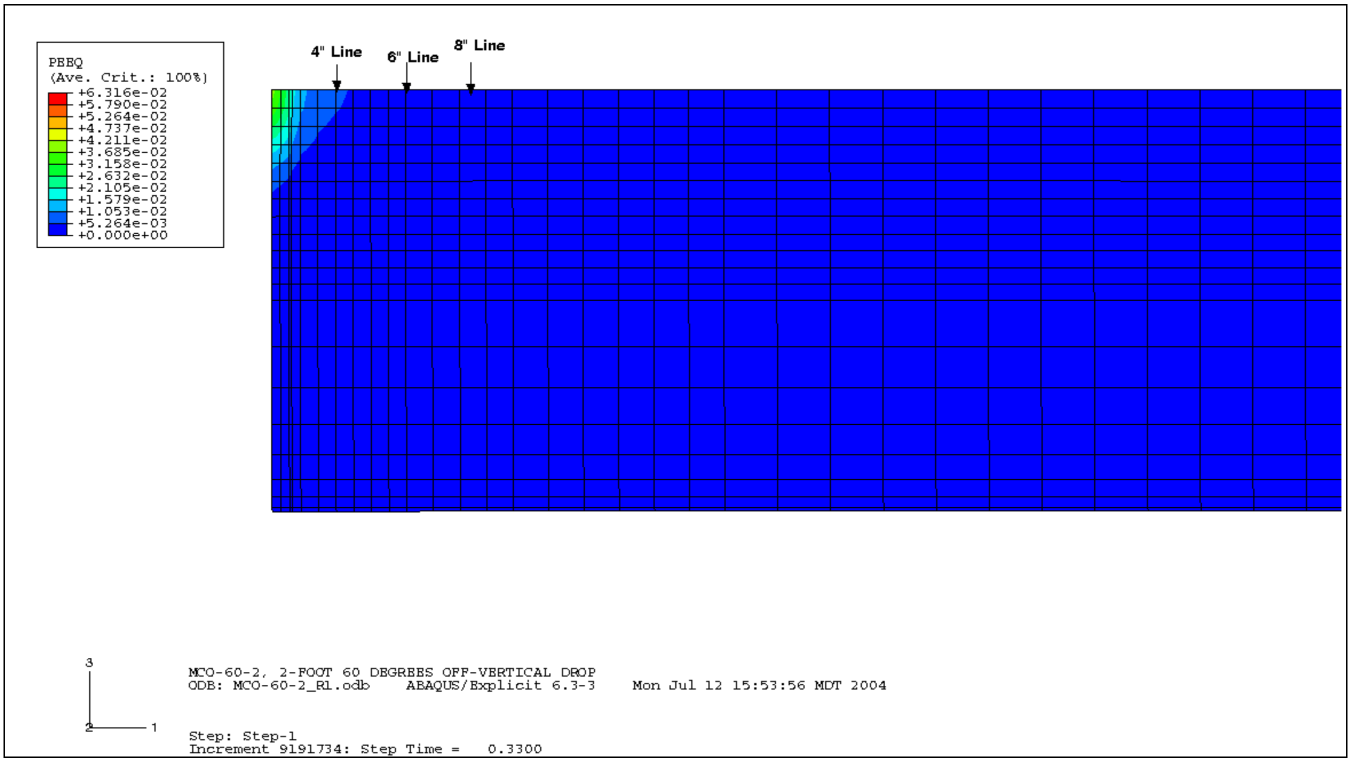


Figure 45. PEEQ Strain on Test MCO-60-2 Lower Shell, From Pre-Drop Model

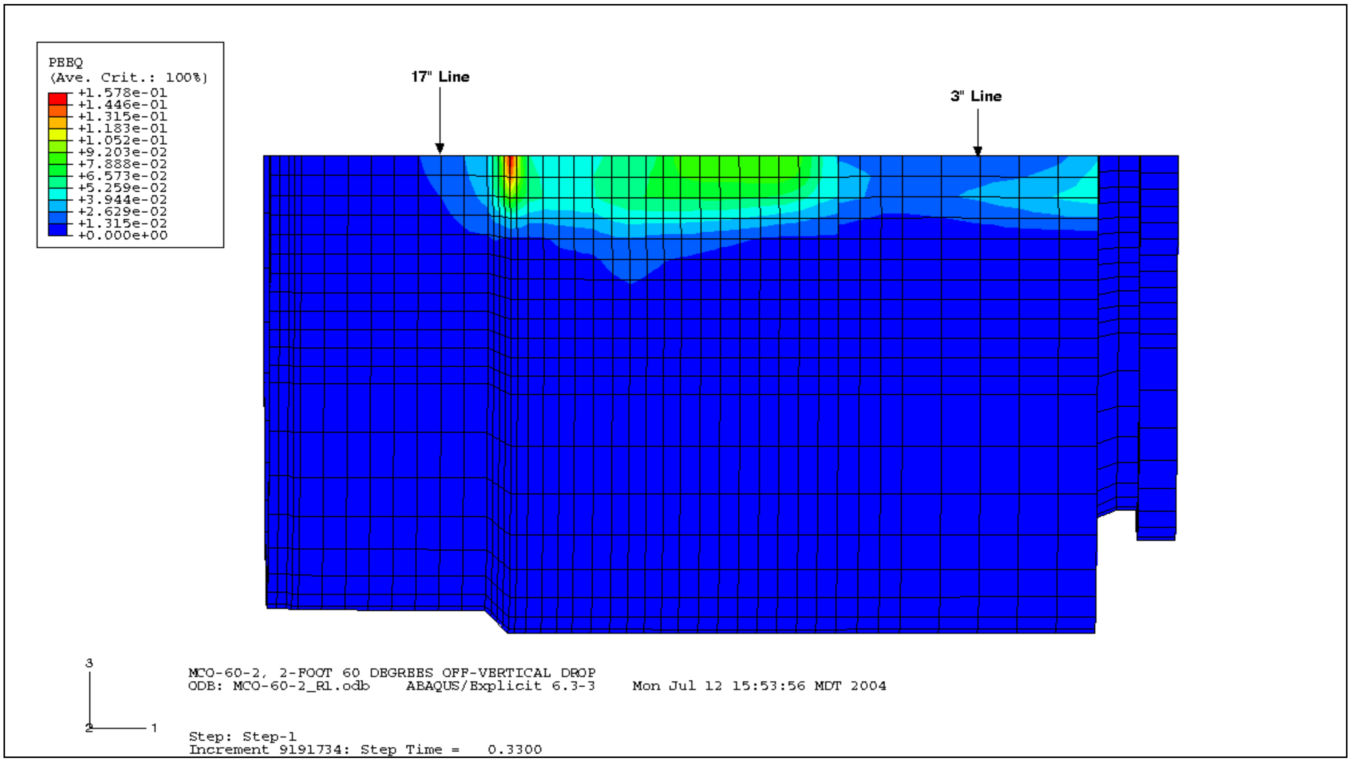


Figure 46. PEEQ Strain on Test MCO-60-2 Collar/Cover, From Pre-Drop Model

12. POST-DROP TEST ANALYTICAL EVALUATIONS

Post-drop modification to the pre-drop test analytical modeling would be justified, for the purposes of this report, to evaluate the following:

1. The change in calculated test MCO deformations incorporating the actual test MCO angle at impact rather than the target angle,
2. The effect of the lifting lugs on the calculated test MCO deformations,
3. The calculated strain components in the longitudinal and circumferential directions to measured/derived strains from the pre-test markings placed on the canisters (instead of PEEQ strains as were used in the pre-drop evaluation).
4. The test MCO-00-1 bottom basket calculated deformations caused by reorienting the basket support bars (on the MCO bottom) so that one bar was directly over the main shell longitudinal weld seam (this actual position was determined from post-drop destructive evaluations). This would mean that the bottom basket perimeter bars were not directly over a basket support bar (as was pre-drop modeled), but instead half-way between basket support bars. (See Subsection 10.1 for more discussion on this topic.)

12.1. Post-Drop Evaluation of Impact Angles

The actual impact angle of test MCO-00-1 was 0 (vertical, as listed in Table 6), which exactly matched the target angle of 0 degrees used in the pre-drop test evaluations. The actual impact angle of test MCO-60-2 was 60-1/2 degrees off-vertical (as listed in Table 6), which was ½-degree greater than the target angle of 60 degrees off-vertical used in the pre-drop test evaluations. This ½ degree difference was considered negligible. Post-drop test analytical evaluations were not justified because of impact angle variations.

12.2. Post-Drop Evaluation of Lifting Lugs

One lifting lug of substantial size (6 x 6 x 1-inch stainless steel plate with a 1-3/4-inch hole) was welded to the cover of test MCO-00-1 for lifting and test orienting purposes. (See Appendix C for a sketch of the lug and its mounting location.) Because the lug was located on the cover, the only effect it would have on the test MCO-00-1 was to add less than 10 pounds to the total weight. This was considered negligible.

Two lifting lugs of substantial size (6 x 6 x 1-inch stainless steel plate with a 1-3/4-inch hole) were welded to the main shell and collar, one about 7 inches from the bottom and the other about 7-inches from the cover full diameter top edge (not including the lifting portion of the cover) of this test MCO for lifting and test orienting purposes. (See Appendix C for a sketch of the lug and its mounting location.) These lugs were positioned on the 12 o'clock line, which placed them 180 degrees away from the impact area (on the 6 o'clock line). Because the drop height (2 feet) and the resulting deformations were so small, the stiffening effects of these lugs on the test MCO were considered negligible.

Post-drop test analytical evaluations were not justified for the test MCOs because of the lifting lugs.

12.3. Post-Drop Evaluation of Measured Strains - Comparison

Subsection 11.5 of this report discussed the measured longitudinal and circumferential strains from test MCO markings compared to the non-directional PEEQ strains from the pre-drop analytical modeling. In order to compare the longitudinal and circumferential strain components from the analytical modeling to the measured strains, post-drop model evaluations with a cylindrical reference coordinate system was required. However, measured strains were in the same range as the PEEQ strains, which sufficiently met the objective discussed in that subsection.

Post-drop test analytical evaluations were not justified for these test MCOs for the purpose of comparing measured strains to analytically predicted strains.

12.4. Post-Drop Evaluation of Bottom Basket Deformations on Test MCO-00-1

The pre-drop modeling of test MCO-00-1 oriented the six basket support bars so as to place the main shell longitudinal seam weld half-way between two of the bars. This meant that a basket support bar was directly below each bottom basket perimeter bar. However, the actual test MCO-00-1 had the basket support bars oriented so as to place one bar directly on the main shell seam weld (this determined from post-drop destructive examination of this test MCO). This resulted in the actual test MCO-00-1 having a significantly deformed bottom basket base plate where the pre-drop model predicted very little deformation of the bottom basket base plate (see Figure 20).

The orientation of the bottom basket relative to the basket support bars was not considered important during the pre-drop evaluations of test MCO-00-1 because the deformations and resulting strains of the containment components were expected to be-unaffected by the bottom basket orientation. However, analytically demonstrating that the drop energy of the internal components would be absorbed essentially completely through plastic deformation of the bottom basket was of interest. The precise positioning of the basket support bars relative to the bottom basket perimeter bars was not known until the post-drop examination (the drop test deformations kept the bottom basket pinched onto the guide cone on the MCO bottom, so that < 2° of post-drop rotation occurred). Analytically placing the bottom basket perimeter bars directly over the basket support bars in the pre-drop test model was considered the best way to attempt to transfer internal component drop energy to the MCO bottom (this would minimize bottom basket base plate deformations and provide a path for causing plastic deformation of the bottom under the basket support bars – if the internals drop energy was not simply absorbed by the bottom basket center post and perimeter bars).

The pre-drop model results showed that the MCO-00-1 bottom under the basket support bars experienced negligible strains (<1%, see Figure 26). Additionally, the main shell showed no localized straining due to the deformation of the bottom basket perimeter bars (these bars did not deform into the main shell). This demonstrated that the majority of the drop energy of the internal components was absorbed by the bottom basket and not the MCO bottom or main shell – the bottom basket orientation did not significantly affect the resulting strains in the containment components as expected.

After the actual drop testing was completed, NSNFP project personnel expressed an interest in seeing a comparison between the actual deformations of the test MCO-00-1 bottom basket to those of a post-drop calculation. Therefore, the pre-drop model was modified to orient the basket support bars so that the bottom basket perimeter bars were half-way between two support bars. Additionally, in order to allow for non-symmetric deformation/displacement of the bottom basket simulated fuel rods, the center post, and the perimeter bars, the model was reflected so that no planes of symmetry were imposed (i.e., a whole model was used instead of a half model with a symmetry plane). No other changes were made from the pre-drop modeling.

Figure 47 shows a photo of the deformed test MCO-00-1 bottom basket with the simulated SNF (2-1/2-inch diameter bars) removed. Figure 48 shows the same view of the post-drop model bottom basket deformed shape. It was evident from the figures that the perimeter bars of both the actual basket and the post-drop modeled basket buckled into remarkably similar "S" shapes. However, the actual basket perimeter bars buckled in a circumferential direction with the tops bending over while the post-drop modeled perimeter bars buckled somewhat inward toward the center post with the tops not bending over as much. This was not unexpected since buckling is very sensitive to things such as component position, flaws, etc., of even a very small order. The post-drop model placed all "flawless" components in their "ideal" position where the actual basket components were only comparatively approximate. The "S" shapes of the actual and post-drop modeled perimeter bars were, therefore, very similar but could not be exactly the same because they were each deforming into a slightly different location and/or arrangement of the simulated fuel rods.

Figures 47 and 48 also show that the actual and post-drop modeled bottom basket center posts both shortened and thickened due to compression, but did not buckle. Figures 49 and 50 were a photo of the actual bottom basket and a plot of the post-drop modeled bottom basket in a side view. These figures showed that the bottom basket base plate in the actual and post-drop model deformed similarly over the basket support bars due to the basket perimeter bar loads.

Table 12 compares several bottom basket dimensions from the post-drop model to those of the actual deformed basket. (Appendix C lists the actual dimensions from post-drop measurements.)

Table 12. Post-Drop Model vs. Actual MCO-00-1 Bottom Basket Dimensions

Dimension Location	Post-Drop Model Dimension (in., at 70 °F.)	Actual Dimension (in., at 20 °F.)
Center Post – length* from top of basket base to top of post	25.337	25-1/8
Center Post – diameters** near base plate near transition at top at reduced top	 3.047 3.043 2.506	 3.008 – 3.025 3.027 – 3.444 2.444 – 2.446
Perimeter Bars – distance from top of center post to top of perimeter bars	2.919	2.5 – 2.9375

*Original length was 29.278 inches, **Original diameter was 2.835 – 2.849 inches based on the Reference 7 drawings, but modeled as 2.840 inches. Difference in model and actual temperatures would cause negliglble changes in the measured values.

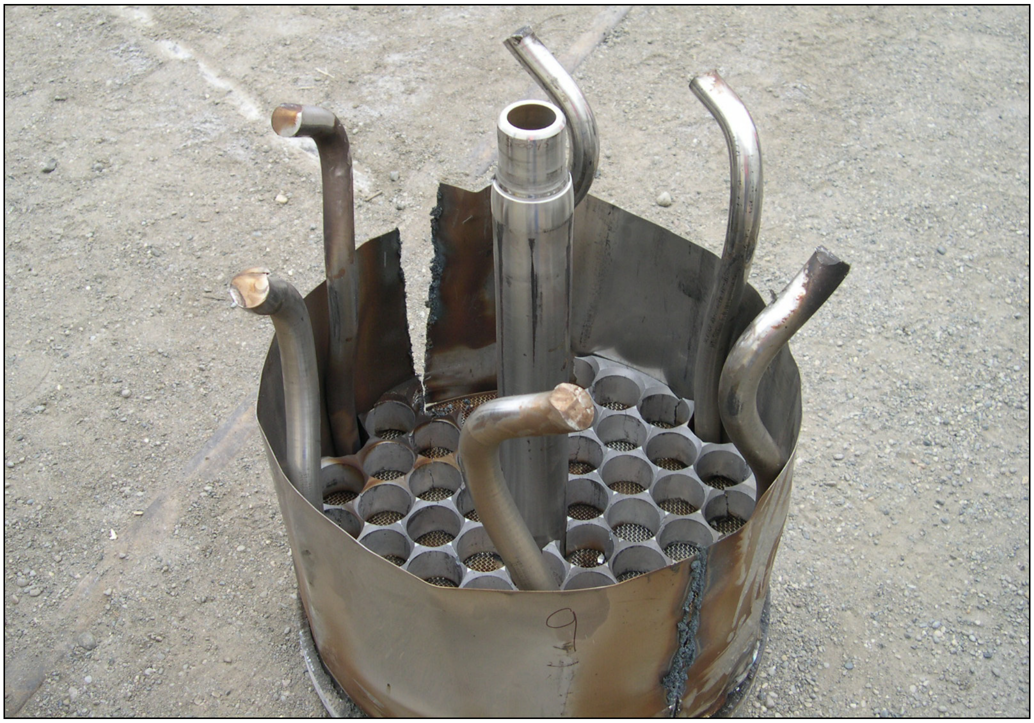


Figure 47. Test MCO-00-1 Bottom Basket Deformations

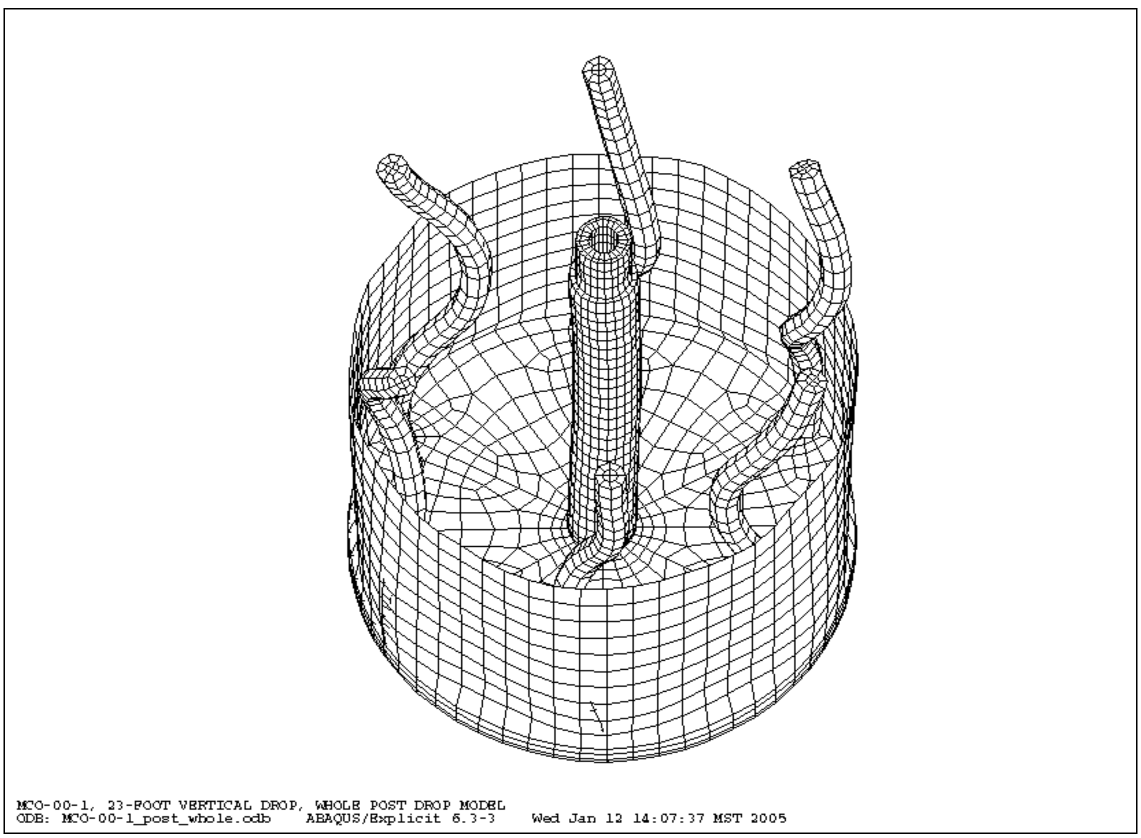


Figure 48. Post-Drop Model of Test MCO-00-1 Bottom Basket Deformations

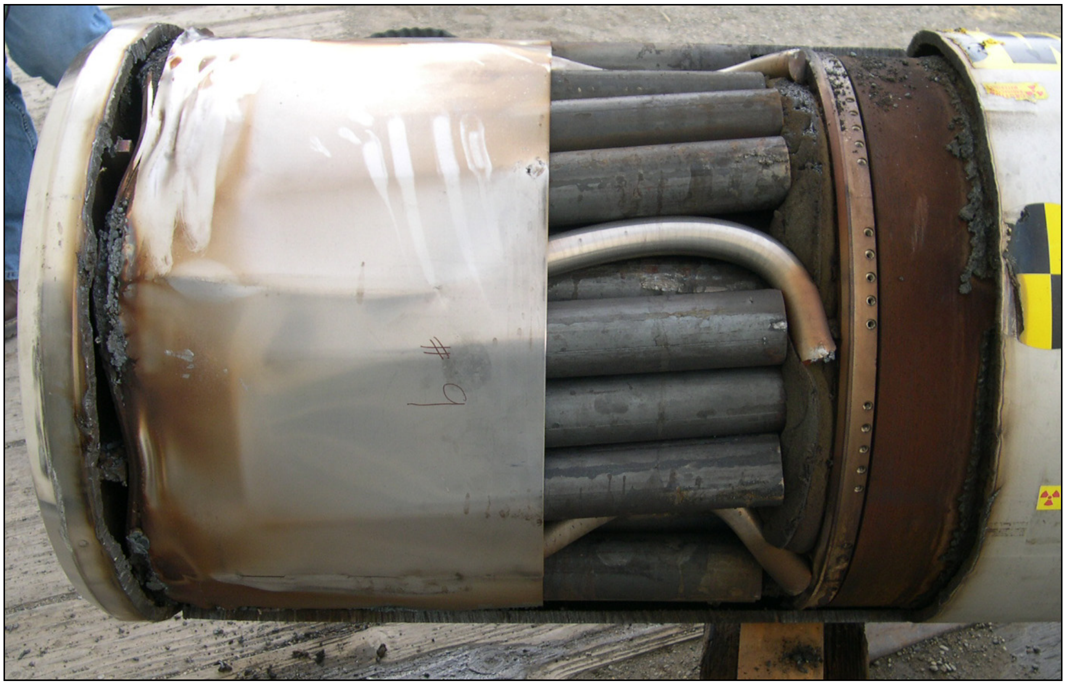


Figure 49. Test MCO-00-1 Bottom Basket Deformations (Side)

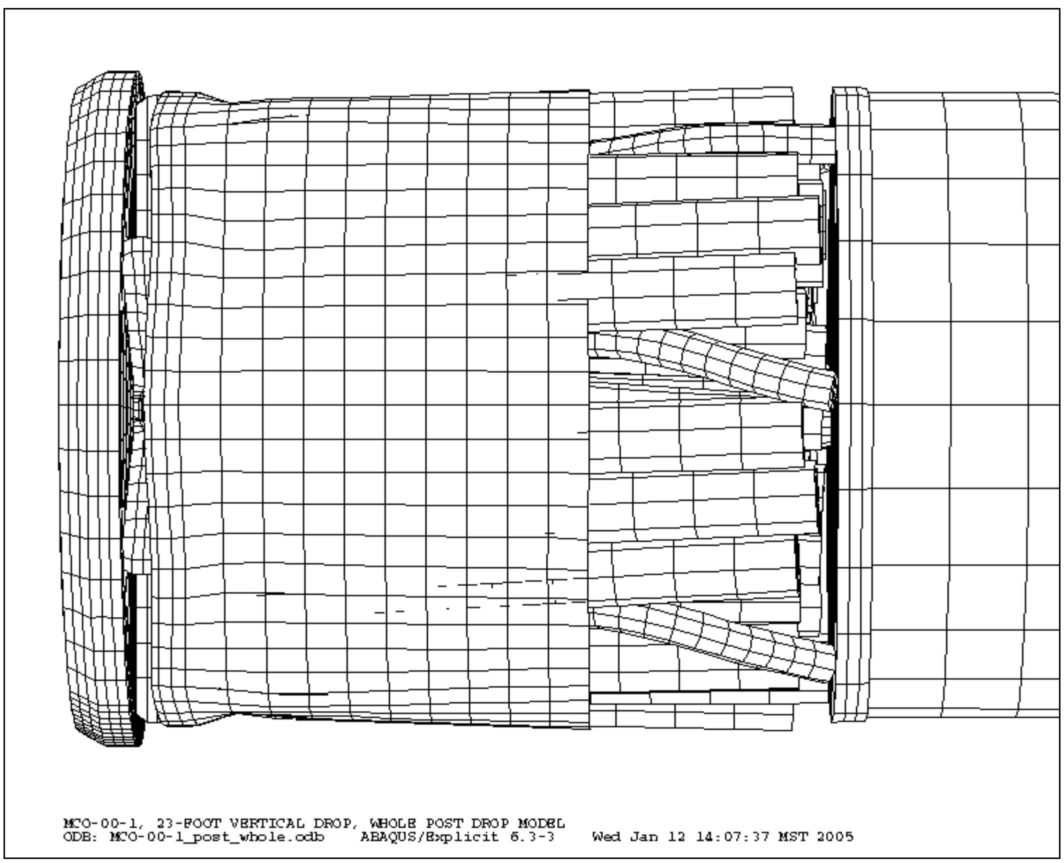


Figure 50. Post-Drop Model of Test MCO-00-1 Bottom Basket Deformations (Side)

The Table 12 post-drop model bottom basket deformations matched very well to those of the actual MCO-00-1 bottom basket. (An even better match could have been made if actual basket material properties were used in the post-drop model instead of the typical properties discussed in Subsection 8.2.)

The previous table did not give a comparison of the actual basket base plate deformations to those of the post-drop model. The post-drop model was simplified to exclude the numerous holes in the actual base plate, giving a modeled base plate that was stiffer than the actual plate (model deformations were approximately half those of the actual base plate).

In summary, the post-drop model calculated deformations of the bottom basket of test MCO-00-1 were in excellent agreement with those of the actual deformed basket.

13. TEST MCO CYLINDRICITY

Reference 20 indicated that the MCOs were to fit within a perfect cylindrical envelope that was at least 13.66 feet long and a minimum of 26.31 inches inside diameter. Undamaged MCOs (maximum outer diameter of 25.3 inches) should fit easily within this envelope. The question here was whether these test MCOs, one dropped vertically from 23 feet and the other 60 degrees off-vertical from 2 feet onto a rigid (flat) surface, would likely fit within that envelope. The actual deformed diameters of the test MCOs reported herein were at most 1/8-inch larger than their original dimensions. No further evaluation was performed.

These test MCOs were expected to fit within the specified cylindrical envelope.

14. PRESSURE AND LEAK TESTING

After the drop testing of test MCO-00-1 and test MCO-60-2 at SNL, the test MCOs were returned to the INEEL where pressure and leak testing were performed by Mr. J. A. Dowalo, certified Level III inspector of INEEL Quality Assurance Operations. Appendix D contains the pressure and leak testing reports.

14.1. Post-Drop Pressure Testing

On November 10, 2004, the test MCOs were pressurized to at least 50 psig with air, and then isolated from the pressure source. This was accomplished within the Warm Shop at TAN 607 at the INEEL site under constant conditions (i.e., changes in ambient temperature were not noted, no solar heating, etc.). The internal pressure was monitored in each test MCO, and after one hour it was noted that the pressure had not dropped in either test MCO. This pressure testing was performed by request of the NSNFP to provide consistency with the FY1999 post-drop testing.

14.2. Post-Drop Helium Leak Testing

After the post-drop pressure testing, the test MCOs were scheduled to be helium leak tested at the INEEL. The objective of the leak testing was to determine the leak rate for the entire test MCO containment boundary (not just the cover weld). Two helium leak test processes were available at the INEEL; the preferred method which could show a leak rate of less than 1 x 10^{-7} std cc/sec. (required for a containment to be considered “leaktight”), and an alternate method that would only show a leak rate of less than 1 x 10^{-4} to 1 x 10^{-5} std cc/sec. The preferred method (Hood Technique) required drawing a vacuum on the inside of a test MCO and sampling from the inside while surrounding the MCO exterior with helium (confined by way of bagging the exterior). The alternate method (Detector Probe - Sniffer - Method) required flooding the interior of a test MCO with helium and sampling the exterior (exterior confined within a bag).

The inspector began the leak testing by first sampling the interior of the two test MCOs. Unfortunately, the helium levels in the two test MCOs were still quite high after the pressure tests. [Hanford’s procedures for production MCOs required a helium leak test after the cover was welded to the collar. Therefore, a Hanford pre-drop leak test was performed to check this cover-to-collar weld on the two test MCOs. This was done by backfilling the test MCOs with helium and pulling a vacuum on the outside – only in the local area around the subject weld. Reference 9 gave the results of the helium leak test on this weld for both test MCOs (<10^{-7} std cc/sec).] It was the opinion of the inspector that test MCO-00-1 had internal helium levels that were too high for a successful test using the preferred method. Therefore, the alternate leak test method was performed on test MCO-00-1 on November 11, 2004, and the results showed a leak rate not greater than 1 x 10^{-5} std cc/sec.

With respect to test MCO-60-2, the inspector was of the opinion that it might be successful in a leak test using the preferred method because the post-pressure test interior helium level was not as high as test MCO-00-1. After three days of effort (including multiple vacuum/flooding with air cycles in an attempt to eliminate the existing interior helium), a successful leak test using the preferred method was performed on November 17, 2004, and test MCO-60-2 was shown to have a leak rate of less than 1×10^{-7} std cc/sec. Test MCO-60-2 was, therefore, leaktight.

15. MEASURED ACCELERATION DATA

Reference 10 includes acceleration data taken by SNL during the drop testing. No comparative evaluation was made between the test data and that available in the analytical models.

16. CONCLUSIONS

The two test MCOs were dropped, one from 23 feet in a vertical orientation and one from 2 feet oriented at 60 degrees off-vertical, onto a rigid, flat surface. Post-drop pressure testing showed that both MCOs maintained a 50 psig pressure for one hour after the drop testing. Post-drop helium leak testing demonstrated that the 60-degree dropped MCO (MCO-60-2) was leaktight, having a leak rate of less than 1×10^{-7} std cc/sec. Due to internal helium contamination issues associated with pre-drop helium leak testing performed during assembly, the vertically-dropped MCO (MCO-00-1) was only able to be shown to have a leak rate of not greater than 1×10^{-5} std cc/sec.

Pre-drop analytical modeling of the drop events accurately predicted the actual deformed test MCO geometries. Pre-drop analytical modeling also predicted that the test MCOs would maintain their containment boundary. Post-drop analytical modeling of test MCO-00-1, employing the actual orientation of the basket support bars (determined during post-drop destructive evaluations), produced bottom basket deformations that closely matched those from the actual drop test.

17. REFERENCES

1. B. D. Lorenz, et. al., *Multi-Canister Overpack Topical Report*, HNF-SD-SARR-005, Rev. 1, November 1999.

2. L. H. Goldmann, et. al., *Multi-Canister Overpack Design Report*, HNF-SD-SNF-DR-003, Rev. 3, February 2000, with Rev. 3A (July 2000) and Rev. 3B (April 2002).

3. S. D. Snow, *Analytical Evaluation of the MCO for Repository-Defined and Other Related Drop Events*, EDF-NSNF-029, Rev. 0, September 30, 2003.

4. S. D. Snow, *Analytical Evaluation of the MCO for Puncture Drop Events*, EDF-NSNF-039, Rev. 0, May 2004.

5. National Spent Nuclear Fuel Program, Program Procedure, *Testing*, NSNFP 11.01, Revision 2, October 22, 2004.

6. D. K. Morton, *Test Plans for the Department of Energy Spent Nuclear Fuel Canister and Basket Development Project,* DOE/SNF-PP-039, Rev. 2, June 2004.

7. Drawings (see Table 1 of Reference 3), U.S. Department of Energy, Richland Operations Office, Duke Engineering & Services Hanford, Inc.

8. *Task Management Agreement for Canister Basket Tasks to be Performed by Fluor Hanford*, DOE/SNF/TMA-012, Rev. 0, April 2004.

9. *INEEL MCO Data Package MCO-00-1 and MCO-60-2 & Video*, Fluor Hanford, July 2004 (a copy of this data package is stored in the NSNFP Document Control Center).

10. *Representative Spent Nuclear Fuel Canister Basket Drop Tests – Data Package (Volume 1) and Photos & Video (Volume 2)*, Sandia National Laboratories, August 2004 (a copy of these volumes are stored in the NSNFP Document Control Center).

11. Structural Alloys Handbook, CINDAS/Purdue University, 1995 Edition.

12. D. K. Morton, S. D. Snow, and T. E. Rahl, *FY1999 Drop Testing Report for the 18-Inch Standardized DOE SNF Canisters*, EDF-NSNF-007, Rev. 2, September 5, 2002.

13. American Society of Mechanical Engineers, *Boiler and Pressure Vessel Code*, Section II, Part D, 2001 Edition.

14. I-DEAS 10 NX Series, Unigraphics Solutions, Inc., Electronic Data Systems Corp., 2002.

15. ABAQUS/Explicit User's Manual, Volumes I and II, Version 6.3-3, Hibbitt, Karlsson, and Sorensen, Inc., 1080 Main Street, Pawtucket, RI.

16. S. D. Snow, *Software Report for ABAQUS/Explicit Version 6.3*-3, DOE/SNF/REP-085, Revision 2, June 2003.

17. S. D. Snow, et. al., *Preliminary Drop Testing Results to Validate an Analysis Methodology for Accidental Drop Events of Containers for Radioactive Materials,* ASME PVP-Vol. 425, Transportation, Storage, and Disposal of Radioactive Materials – 2001, American Society of Mechanical Engineers 2001.

18. *Control of the Electronic Management of Information*, NSNFP 19.03, Rev. 1, 10/22/2004.

19. *Task Management Agreement for Canister Basket Tasks to be Performed by Sandia National Laboratories*, DOE/SNF/TMA-010, Rev. 0, March 2004.

20. *Integrated Interface Control Document Volume 1: U.S. Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste to the Monitored Geologic Repository,* WOE/RW-0511, Rev. 1, March 2002.

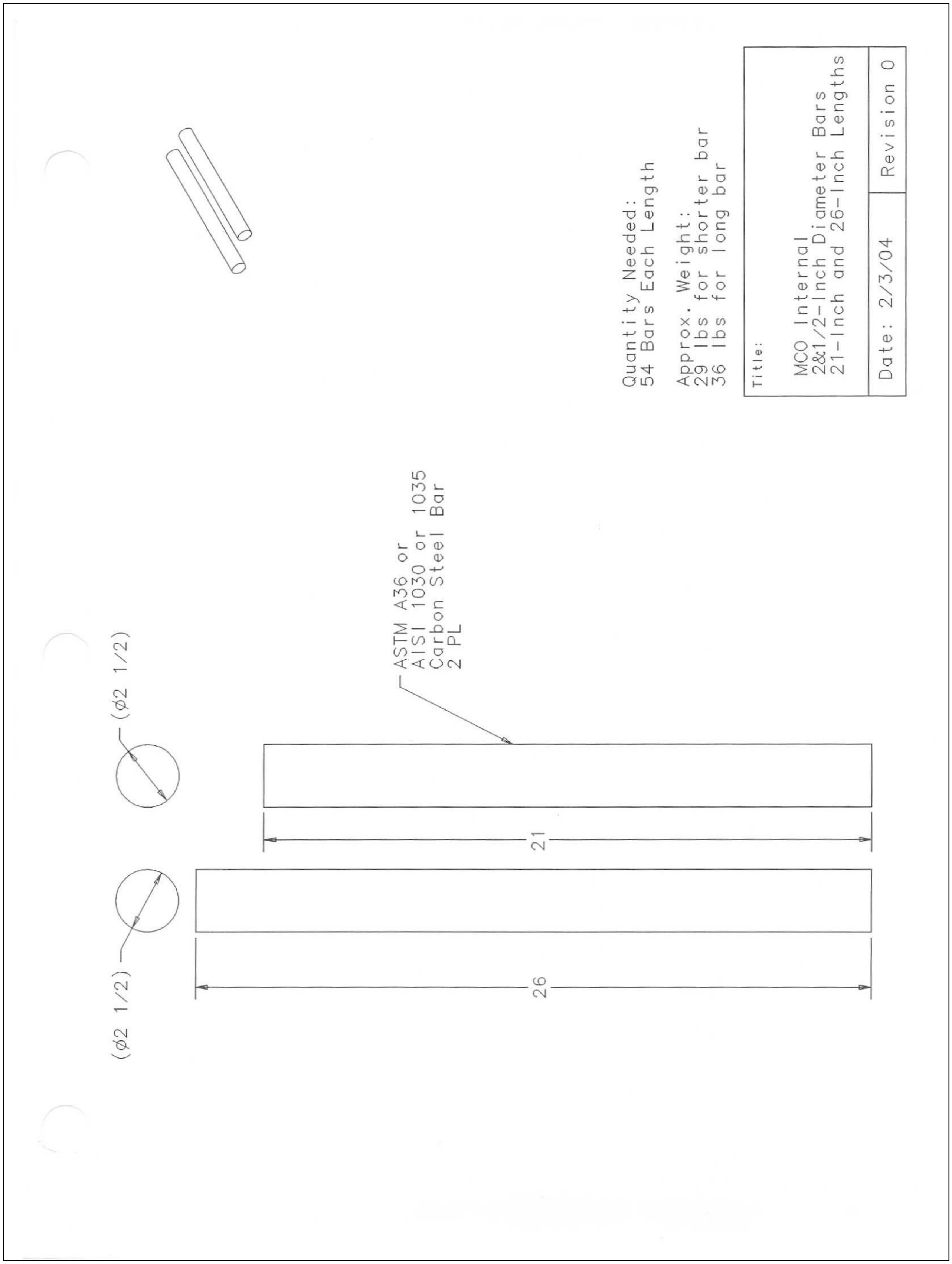
18. ANALYTICAL MODEL FILES

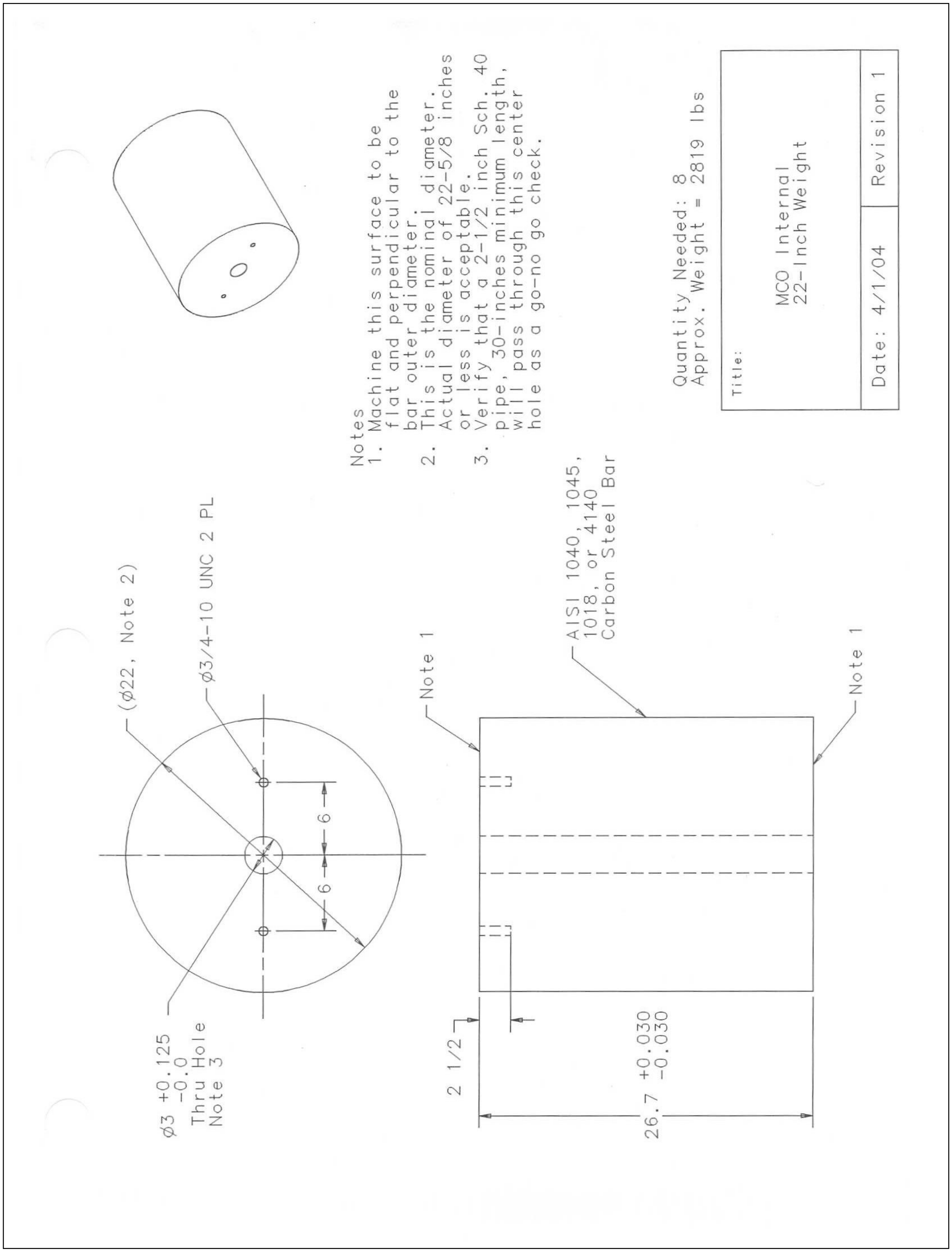
The following table lists the names and dates for the analytical models employed in this report, as written out to a DVD. This data is being provided in accordance with NSNFP 19.03 (Reference 18). Mr. D. K. Morton checked the DVD for readability.

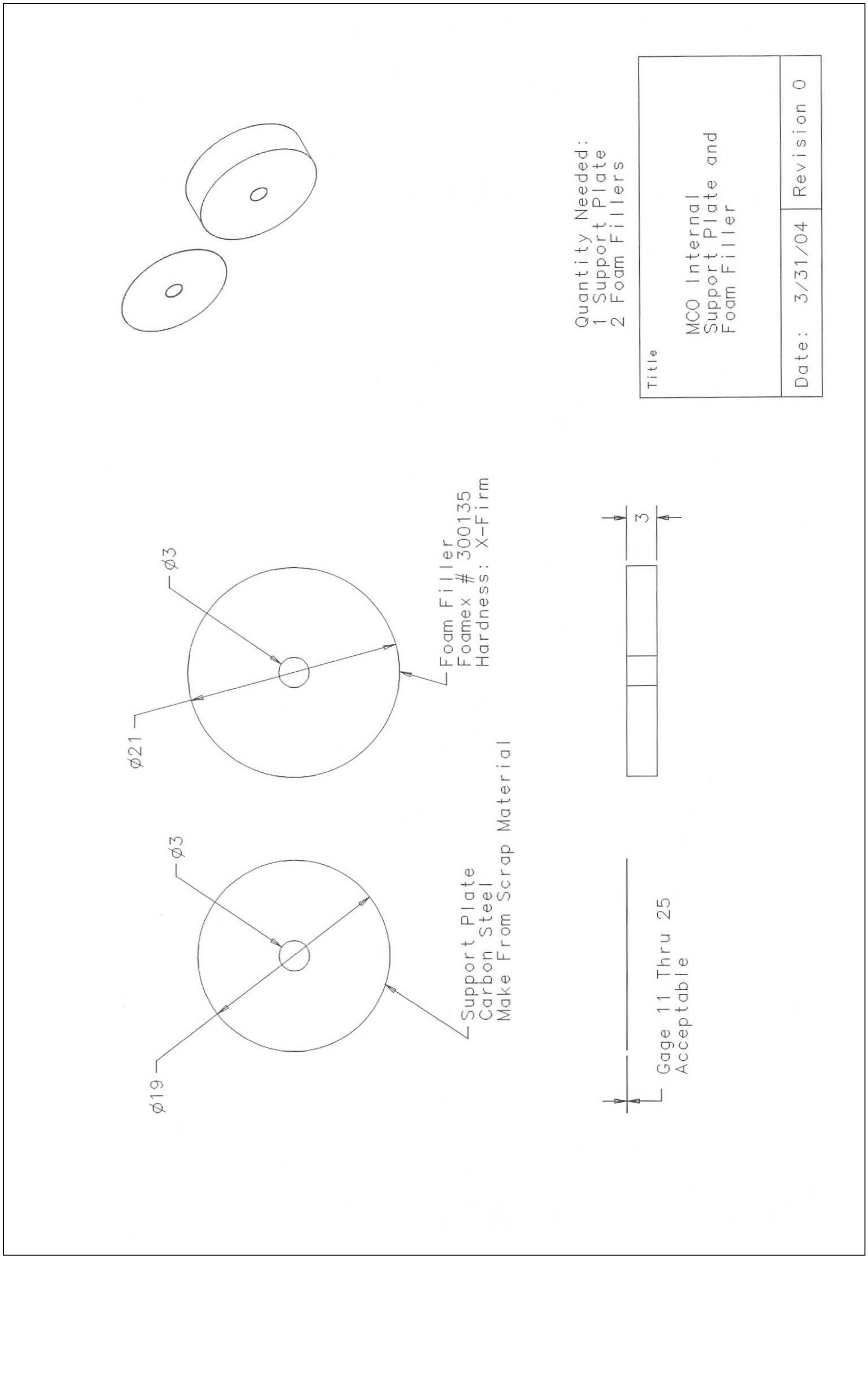
Table 13. Pre-Drop & Post-Drop Test Analytical Model Files

Files Currently on the CD				
MCO-00-1_post_whole.inp	10,932 KB	INP File	1/12/2005 8:45 PM	Files Currently on the CD
MCO-00-1_post_whole.odb	239,437 KB	ABAQUS ODB File	1/16/2005 5:29 PM	Files Currently on the CD
MCO-00-1_post_whole.sta	70 KB	STA File	1/14/2005 1:51 PM	Files Currently on the CD
MCO-00-1_R1.inp	5,625 KB	INP File	7/12/2004 9:26 PM	Files Currently on the CD
MCO-00-1_R1.odb	124,818 KB	ABAQUS ODB File	7/16/2004 1:07 AM	Files Currently on the CD
MCO-00-1_R1.sta	155 KB	STA File	7/16/2004 1:07 AM	Files Currently on the CD
MCO-60-2_R1.inp	5,628 KB	INP File	7/15/2004 9:00 PM	Files Currently on the CD
MCO-60-2_R1.odb	349,184 KB	ABAQUS ODB File	9/10/2004 6:41 PM	Files Currently on the CD
MCO-60-2_R1.sta	146 KB	STA File	9/10/2004 7:20 PM	Files Currently on the CD

APPENDIX A. TEST MCO INTERNALS DESIGN/FABRICATION SKETCHES


Quantity Needed:
54 Bars Each Length
Approx. Weight:
29 lbs for shorter bar
36 lbs for long bar
Title:
MCO Internal
2&1/2-Inch Diameter Bars
21-Inch and 26-Inch Lengths
Date: 2/3/04
Revision 0
ASTM A36 or
AISI 1030 or 1035
Carbon Steel Bar
2 PL
(Ø2 1/2)
21
(Ø2 1/2)
26


(Ø22, Note 2)
Ø3/4-10 UNC 2 PL
6
6
Ø3 +0.125 -0.0
Thru Hole
Note 3
Note 1
AISI 1040, 1045, 1018, or 4140 Carbon Steel Bar
Note 1
2 1/2
26.7 +0.030 -0.030
Notes
1. Machine this surface to be flat and perpendicular to the bar outer diameter.
2. This is the nominal diameter. Actual diameter of 22-5/8 inches or less is acceptable.
3. Verify that a 2-1/2 inch Sch. 40 pipe, 30-inches minimum length, will pass through this center hole as a go-no go check.
Quantity Needed: 8
Approx. Weight = 2819 lbs
Title:
MCO Internal
22-Inch Weight
Date: 4/1/04
Revision 1


Ø19
Ø3
Support Plate
Carbon Steel
Make From Scrap Material
Ø21
Ø3
Foam Filler
Foamex # 300135
Hardness: X-Firm
Gage 11 Thru 25
Acceptable
3
Quantity Needed:
1 Support Plate
2 Foam Fillers
Title
MCO Internal
Support Plate and
Foam Filler
Date: 3/31/04
Revision 0

APPENDIX B. PRE-DROP TEST MCO & INTERNALS DATA SHEETS

Pre-Drop Measurements
Representative MCO Internal Components

Required Data: Before loading into ten Mark IV baskets.

Component	Measurement	Instruments Used	Measurement Taken By / Date	Measurement Checked By / Date
Internal Weights	Weights Labeled? (Y/N) Y	NA	NA	NA
Internal Weight #1	Outer Diameter (top) = 22 1/4 (in.)	tape measure	TER / 4/8/04	RKB / 4/8/04
	Overall Length = 26 11/16 (in.)	tape measure	TER / 4/8/08	RKB / 4/8/04
	Weight = SDS 4/8/04 ~~2922~~ 2904 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weight #2	Outer Diameter (top) = 22 1/4 (in.)	tape measure	TER 4/8/04	RKB / 4/8/04
	Overall Length = 26 11/16 (in.)	tape measure	TER 4/8/04	RKB / 4/8/04
	Weight = SDS 4/8/04 ~~2930~~ 2912 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weight #3	Outer Diameter (top) = 22 1/4 (in.)	tape measure	TER 4/8/04	RKB / 4/8/04
	Overall Length = 26 11/16 (in.)	tape measure	TER 4/8/04	RKB / 4/8/04
	Weight = SDS 4/8/04 ~~2934~~ 2916 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weight #4	Outer Diameter (top) = 22 1/4 (in.)	tape measure	TER 4/8/04	RKB / 4/8/04
	Overall Length = 26 5/8 (in.)	tape measure	TER 4/8/04	RKB / 4/8/04
	Weight = SDS 4/8/04 ~~2916~~ 2898 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weight #5	Outer Diameter (top) = 22 1/4 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Overall Length = 26 5/8 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Weight = SDS 4/8/04 ~~2919~~ 2901 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04

(Pre-Drop Measurements - Representative MCO Internal Components)

Required Data: Before loading into ten Mark IV baskets.

Component	Measurement	Instruments Used	Measurement Taken By / Date	Measurement Checked By / Date
Internal Weight #6	Outer Diameter (top) = 22 1/4 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Overall Length = 26 11/16 (in.)	tap measure	RKB 4/8/04	SDS 4/8/04
	Weight = ~~2924~~ SDS 4/8/04 2906 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weight #7	Outer Diameter (top) = 22 1/4 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Overall Length = 26 11/16 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Weight = 2921 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weight #8	Outer Diameter (top) = 22 1/4 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Overall Length = 26 11/16 (in.)	tape measure	RKB 4/8/04	SDS 4/8/04
	Weight = 2906 (lbs)	# 721514 Interface # 721516 5K cell	TER 4/8/04	SDS 4/8/04
Internal Weights #9 (21-inch long bars, 54 total)	Typical Bar Diameter = ~~21~~ SDS 4/6/04 2 1/2 (in.)	tape measure	SDS 4/6/04	DKM 4/6/04
	Typical Bar Length = 21 (in.)	tape measure	SDS 4/6/04	DKM 4/6/04
	Weight of 54 Bars = 1592 (lbs)	# 721514 interface ~~# 721516~~ 5K cell # 721516 SDS 4/6/04	SDS 4/6/04	DKM 4/6/04
Internal Weight #10 (26-inch long bars, 54 total)	Typical Bar Diameter = 2 1/2 (in.)	tape measure	SDS 4/6/04	DKM 4/6/04
	Typical Bar Length = 26 (in.)	tape measure	SDS 4/6/04	DKM 4/6/04
	Weight of 54 Bars = ~~2052~~ SDS 4/6/04 1979 (lbs)	# 721514 interface # 721516 5K cell	SDS 4/6/04	DKM 4/6/04
Foam Support plate	weight = 10.5 lbs	# 721514 interface # 721882 500 lb cell	SDS 4/6/04	DKM 4/6/04

Data Received from Kim. Smith of Fluor Hanford on 4/28/04.

Table 1. Component and Assembly Measured Weights (Information Only)

Component or Assembly	Measured Weight (lbs)	Measurement Instrument Used	Calibration Identification*
MCO-00-1 Bottom, main shell, collar, Locking ring assembly	MCO+Rigging 2360 Rigging -66 **MCO 2294**	Note 2	Note 2
Shield plug	1055	Note 2	Note 2
Locking ring	375	Note 2	Note 2
Cover	500		
MCO-60-2 Bottom, main shell, collar, Locking ring assembly	2315	Note 2	Note 2
Shield plug	1050	Note 2	Note 2
Locking ring	380	Note 2	Note 2
Cover	495		
Empty scrap basket #1	154.2	Note 1	Note 1
Empty scrap basket #2	154.0	Note 1	Note 1
Empty scrap basket #3	154.0	Note 1	Note 1
Empty scrap basket #4	154.2	Note 1	Note 1
Empty scrap basket #5	154.2	Note 1	Note 1
Empty scrap basket #6	154.2	Note 1	Note 1
Empty scrap basket #7	154.0	Note 1	Note 1
Empty scrap basket #8	153.8	Note 1	Note 1
Empty fuel basket #9	252.0	Note 1	Note 1
Empty fuel basket #10	252.4	Note 1	Note 1
Loaded fuel basket #9 (w/ 54 bars, 21-inches long, plate and foam)	1860	Note 2	Note 2
Loaded fuel basket #10 (w/ 54 bars, 26-inches long)	2225	Note 2	Note 2
MCO-00-1 final assembly	17,890	MHM LOAD CELL	
MCO-60-2 final assembly	18,235	MHM LOAD CELL	

*Calibration data sheets to be attached, including measurement tolerances

Note 1 0-500 Load Cell ID# 819-29-06-004 +/- .5lbs Cal due date 8-13-04
Note 2 0-5000 Load Cell ID# 815-29-06-057 +/- 5 lbs Cal due date 9-16-04

Pre-Drop Measurements – MCO-00-1 Test Canister

Describe Contents of MCO-00-01 Baskets (from data provided by Fluor Hanford):

Bottom Basket (#9):

Simulated fuel basket, a total of 54 bars each 21 inches long, Foam support plate with 2 layers foam
(total weight = 1860 lbs)

Second Basket (#1):

Scrap basket bottom plate (154.2 lbs) and center post, weight #1 (2904 lbs)

Third Basket (#2):

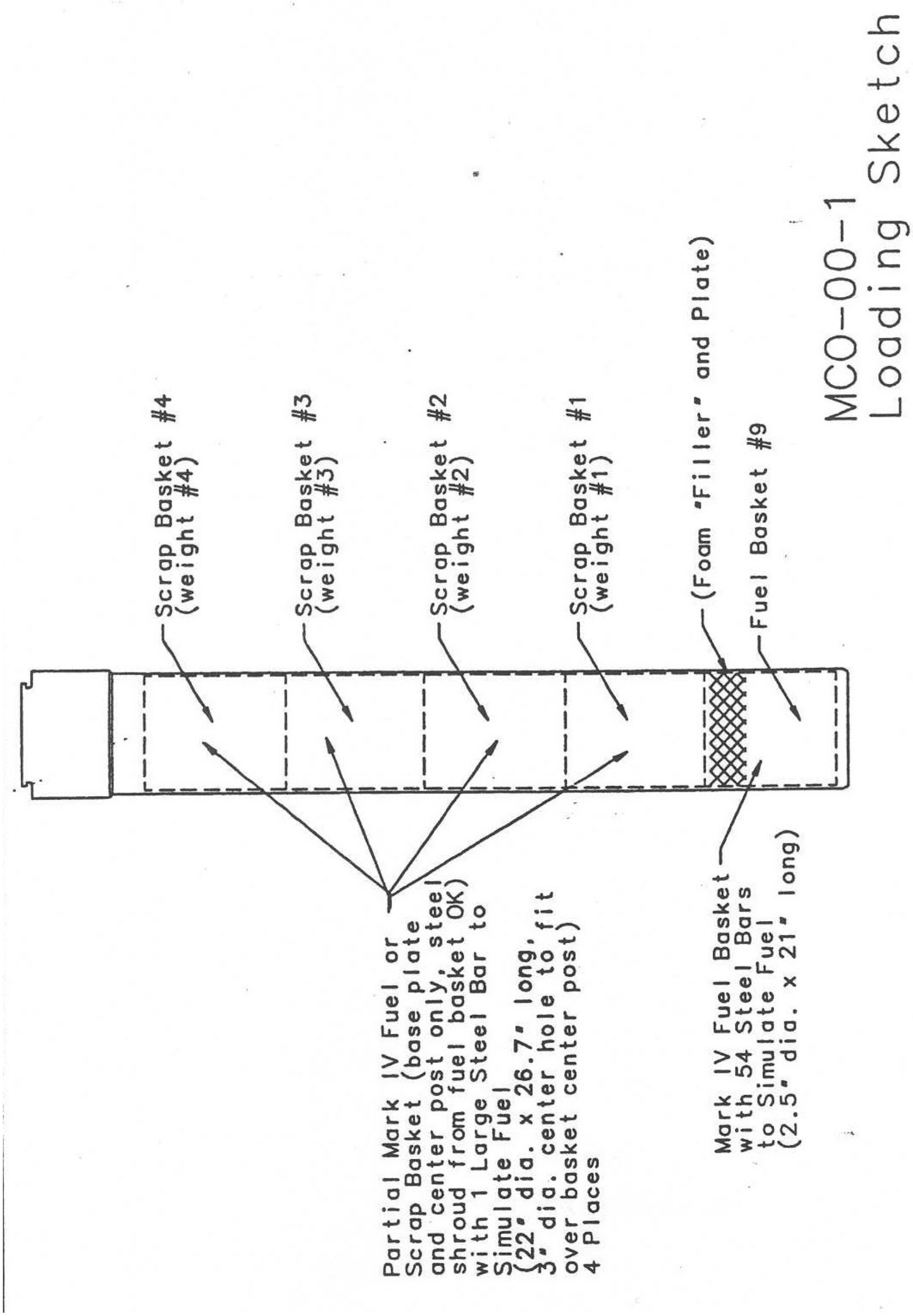
Scrap basket bottom plate (154 lbs) and center post, weight #2 (2912 lbs)

Fourth Basket (#3):

Scrap basket bottom plate (154 lbs) and center post, weight #3 (2916 lbs)

Top Basket (#4):

Scrap basket bottom plate (154.2 lbs) and center post, weight #4 (2898 lbs)


MCO-00-1
Loading Sketch
Scrap Basket #4 (weight #4)
Scrap Basket #3 (weight #3)
Scrap Basket #2 (weight #2)
Scrap Basket #1 (weight #1)
(Foam "Filler" and Plate)
Fuel Basket #9
Partial Mark IV Fuel or Scrap Basket (base plate and center post only, steel shroud from fuel basket OK) with 1 Large Steel Bar to Simulate Fuel
(22" dia. x 26.7" long, 3" dia. center hole to fit over basket center post)
4 Places
Mark IV Fuel Basket with 54 Steel Bars to Simulate Fuel
(2.5" dia. x 21" long)

(Pre-Drop Measurements – MCO-00-1 Test Canister)

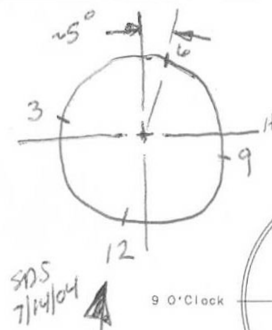
Required Data: After MCO assembly and final closure weld.

Component	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Completed Canister MCO-00-1	Weight = 17 884 (lbs)	#721517 25K load cell	TER 7/13/04	SDS 7/13/04
	Center of Gravity Location (from bottom end) = 84 15/16 (in.)	tape measure	SDS 7/13/04	TER 7/13/04
	Overall Length = 166 1/16 (in.)	tape measure	SDS 7/13/04	TER 7/13/04
Etch Circumferential Lines	1-1/2 in. up from bottom: Etched? (Y/N) Y *	tape measure ~~NA~~ SDS 7/13/04	SDS 7/13/04 ~~NA~~	~~NA~~ TER 7/13/04
	4 in. up from bottom: Etched? (Y/N) Y	tape measure ~~NA~~ SDS 7/13/04	SDS 7/13/04 ~~NA~~	~~NA~~ TSR 7/13/04
	6 in. up from bottom: Etched? (Y/N) Y	tape measure ~~NA~~ SDS 7/13/04	SDS 7/13/04 ~~NA~~	~~NA~~ TSR 7/13/04
	24 in. up from bottom: Etched? (Y/N) Y	tape measure ~~NA~~ SDS 7/13/04	SDS 7/13/04 ~~NA~~	~~NA~~ TER 7/13/04
	83 in. up from bottom: Etched? (Y/N) Y	tape measure ~~NA~~ SDS 7/13/04	SDS 7/13/04 ~~NA~~	~~NA~~ TER 7/13/04
	17 in. down from top: Etched? (Y/N) Y **	tape measure	SDS 7/13/04	TER 7/13/04
	3 in. down from top: Etched? (Y/N) ** ~~Y~~ ~~N~~ Yes SDS 7/13/04	tape measure	SDS 7/13/04 ~~NA~~	~~NA~~ TER 7/13/04
Mark Impact Location On Canister Bottom	Locaton Marked? (Y/N) Y (impact location on bottom just under the shell longitudinal weld seam)	~~Y~~ NA	NA	NA
Canister Identifier Labels	Applied? (Y/N) Y	NA	NA	NA

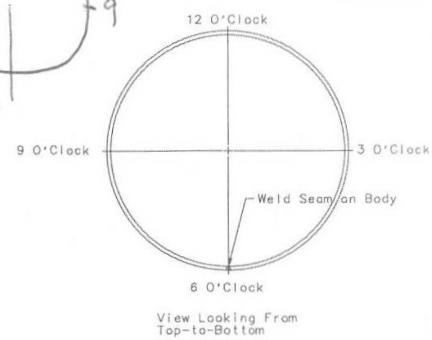
Other Details:
* Line not etched, but marks made at 12, 1:30, 3, 4:30, 6, 7:30, 9, 10:30 @ 1 1/2 inches from end.
~~** measured from top at full O.D.~~ SDS 7/13/04 ** Measured from top at full O.D. (which is 2 3/16 inches below actual top)

Data taken by: NA Date: NA

Data verified by: NA Date: NA



Final Pre-Drop Measurements – MCO-00-1 Test Canister



All of the final pre-drop measurements below will be taken and checked by NSNFP personnel. A certified dimensional inspector will then independently take ten of those measurements (chosen at random) for comparison. If the inspector measurements match the NSNFP measurements within +/- 1/16-inch, then the NSNFP PSO Quality Engineer shall approve all NSNFP final pre-drop measurements (by his signature and date) and release NSNFP personnel to continue canister pre-drop activities.

Required Data: Diameter Measurements (at clock positions) Top: 29 1/4 inches (OD flat, not lifting lug)

(All diameter measurements taken with the canister horizontal, saddles about Bottom: 29 inches inches from ~~each~~ end. Canister seam weld in 6 o'clock position as shown above.) SDS 7/14/04

Component	Position	Measurement		Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Canister Positioning	Canister/Saddles Positioned Correctly? (Y/N)			Y	NA	NA
Bottom (1 1/2-inches from bottom edge)	12 - 6	NSNFP = 24.071	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = NA	(in.)	NA	NA	
	1:30 – 7:30	NSNFP = 24.068	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = 24.071	(in.)	721438	PC Roberts 7/12/04	
	3 - 9	NSNFP = 24.068	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = NA	(in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.068	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = 24.069	(in.)	721438	PC Roberts 7/12/04	

(Final Pre-Drop Measurements – MCO-00-1 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Lower Shell (4-inches from bottom edge)	12 - 6	NSNFP = 24.022 (in.)	721438	DKM 7/12/04	TR 7/12/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 23.917 (in.)	721436	DKM 7/12/04	TR 7/12/04
		Inspector = 23.915 (in.)	721436	PC Roberts 7/12/04	
	3 - 9	NSNFP = 23.962 (in.)	721436	DKM 7/12/04	TR 7/12/04
		Inspector = 23.963 (in.)	721436	PC Roberts 7/12/04	
	4:30 – 10:30	NSNFP = 24.002 (in.)	721438	DKM 7/12/04	TR 7/12/04
		Inspector = NA (in.)	NA	NA	
Lower Shell (6-inches from bottom edge)	12 - 6	NSNFP = 24.014 (in.)	721438	DKM 7/12/04	TR 7/12/04
		Inspector = 24.013 (in.)	721438	PC Roberts 7/12/04	
	1:30 – 7:30	NSNFP = 23.934 (in.)	721436	DKM 7/12/04	TR 7/12/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 23.978 (in.)	721436	DKM 7/12/04	TR 7/12/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.007 (in.)	721438	DKM 7/12/04	TR 7/12/04
		Inspector = 24.009 (in.)	721438	PC Roberts 7/12/04	

(Final Pre-Drop Measurements – MCO-00-1 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Canister Mid-Shell (83-inches from bottom edge)	12 - 6	NSNFP = 23.965 (in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = 23.965 (in.)	721436	PC Roberts 7/12/04	
	1:30 – 7:30	NSNFP = 23.927 (in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = 23.927 (in.)	721436	PC Roberts 7/12/04	
	3 - 9	NSNFP = 24.022 (in.)	721438	DKM 7/12/04	TEA 7/12/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.026 (in.)	721438	DKM 7/12/04	TEA 7/12/04
		Inspector = NA (in.)	NA	NA	
Collar (17-inches below top edge)	12 - 6	NSNFP = 24.067 (in.)	721438	DKM 7/12/04	TEA 7/12/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 24.071 (in.)	721438	DKM 7/12/04	TEA 7/12/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.067 (in.)	721438	DKM 7/12/04	TEA 7/12/04
		Inspector = 24.068 (in.)	721438	PC Roberts 7/12/04	
	4:30 – 10:30	NSNFP = 24.059 (in.)	721438	DKM 7/12/04	TEA 7/12/04
		Inspector = 24.060 (in.)	721438	PC Roberts 7/12/04	

(Final Pre-Drop Measurements – MCO-00-1 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement		Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Cover (3-inches below top edge)	12 - 6	NSNFP = 25.292	(in.)	721438	DKM 7/12/04	TRR 7/12/04
		Inspector = 25.294	(in.)	721438	PC Roberts 7/12/04	
	1:30 – 7:30	NSNFP = 25.283	(in.)	721438	DKM 7/12/04	TRR 7/12/04
		Inspector = NA	(in.)	NA	NA	
	3 - 9	NSNFP = 25.287	(in.)	721438	DKM 7/12/04	TRR 7/14/04 7/12/04 PR
		Inspector = 25.288	(in.)	721438	PC Roberts 7/14 7/12/04	
	4:30 – 10:30	NSNFP = 25.289	(in.)	721438	DKM 7/12/04	TRR 7/12/04
		Inspector = NA	(in.)	NA	NA	
24-inches from bottom	12-6	NSNFP 23.939 in.		721436	DKM 7/12/04	TRR 7/12/04
		Insp. NA		NA	NA	
	1:30-7:30	NSNFP 23.970 in.		721436	DKM 7/12/04	TRR 7/12/04
		Insp. 23.969 in.		721436	PC Roberts 7/12/04	
	3-9	NSNFP 24.015 in.		721438	DKM 7/12/04	TRR 7/12/04
		Inp. NA		NA	NA	
	4:30-10:30	NSNFP 24.015 in.		721438	DKM 7/12/04	TRR 7/12/04
		Insp. 24.019 in.		721438	PC Roberts 7/12/04	

NSNFP PSO QE acceptance of all Final Pre-Drop Measurements Neal S. MacKay Date: 7/13/04

NEAL S. MACKAY

MCO-CO-1

STRAIN GAGE PUNCH MARKS – Distance between marks*:

Measurements made with digital caliper #721714

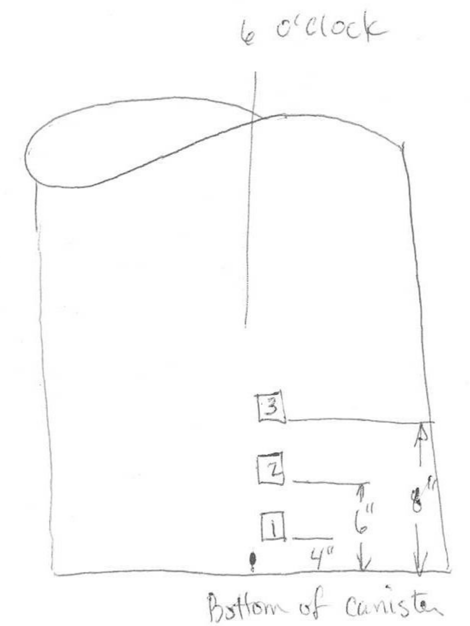
* measurement value includes caliper tip offset of 0.400. sps 11/4/04

ON THE 6 O'CLOCK LINE

① 4" up from bottom — top: 0.7660; left: 0.7650; right: 0.7650; bottom: 0.7695 (4")

② 6" up from bottom — top: 0.7715; left: 0.7630; right: 0.7625; bottom: 0.7465 (6")

③ 8" up from bottom — top: 0.7680; left: 0.7685; right: 0.7660; bottom: 0.7700 (8")



#4-6 @ 3 o'clock
#7-9 @ 9 o'clock
#10-12 @ 12 o'clock
(same as above at 6 o'clock)

Data Taken By: TE Rahl 7/13/04
Data Verified By: SDSnow 7/13/04

MCO-CO-1

STRAIN GAGE PUNCH MARKS – DISTANCE BETWEEN MARKS CONTINUED.

Measurements made with digital caliper #721714

On The 3 O'Clock Line

(4) 4" up from bottom — top 0.7620; left 0.7630; right 0.7625; bottom 0.7615 — 4"

(5) 6" up from bottom — top 0.7590; left 0.7680; right 0.7630; bottom 0.7670 — 6"

(6) 8" up from bottom — top 0.7670; left 0.7705; right 0.7855; bottom 0.7785 — 8"

On the 9 O'Clock Line

(7) 4" up from bottom — top 0.7670; left 0.7615; right 0.7710; bottom 0.7715 — 4"

(8) 6" up from bottom — top 0.7685; left 0.7695; right 0.7640; bottom 0.7690 — 6"

(9) 8" up from bottom — top 0.7610; left 0.7595; right ~~0.7540~~ 0.7755 SDS 7/13/04; bottom 0.7620 — 8"

On the 12 O'Clock Line

(10) 4" up from bottom — top 0.7610; left 0.7585; right 0.7540; bottom 0.7580 — 4"

(11) 6" up from bottom — top 0.7620; left 0.7615; right 0.7595; bottom 0.7600 — 6"

(12) 8" up from bottom — top 0.7790; left 0.7645; right 0.7725; bottom 0.7640 — 8"

Data taken by: TE Rahl 7/13/04
Data verified by: SD Snow 7/13/04

Pre-Drop Measurements – MCO-60-2 Test Canister

Describe Contents of MCO-60-2 Baskets (from data provided by Fluor Hanford):

Bottom Basket (#5):

scrap basket bottom plate (154.2 lbs) and Center post, weight #5 (2901 lbs)

Second Basket (#6):

scrap basket bottom plate (154.4 lbs) and center post, weight #6 (2906 lbs)

Third Basket (#7):

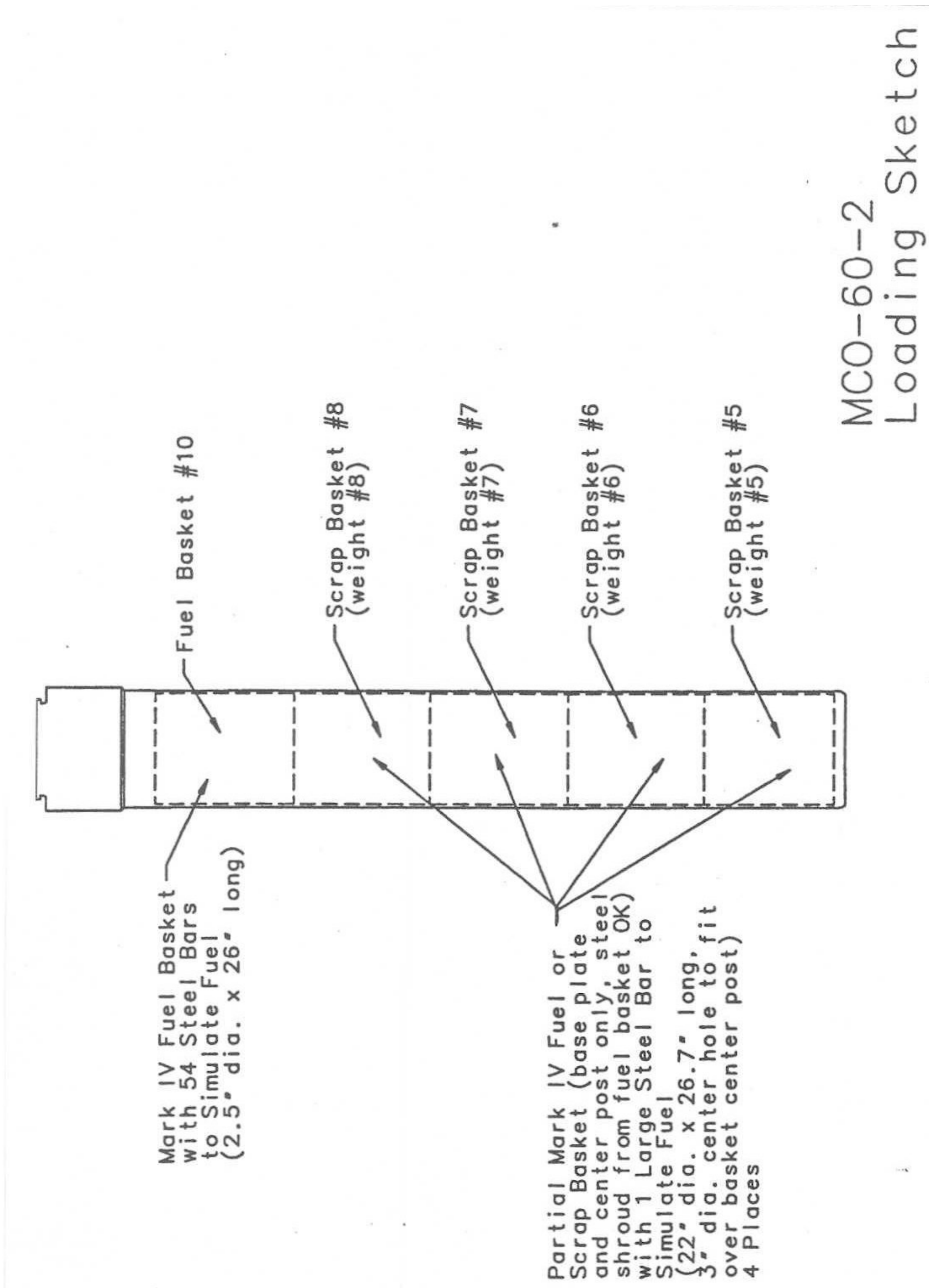
scrap basket bottom plate (154 lbs) and centerpost, weight #7 (2921 lbs)

Fourth Basket (#8):

scrap basket bottom plate (153.8 lbs) and center post, weight #8 (2906 lbs)

Top Basket (#10):

Simulated fuel basket, a total of 54 bars each 26 inches long (total weight = 2225 lbs)


MCO-60-2
Loading Sketch
Fuel Basket #10
Scrap Basket #8
(weight #8)
Scrap Basket #7
(weight #7)
Scrap Basket #6
(weight #6)
Scrap Basket #5
(weight #5)
Mark IV Fuel Basket
with 54 Steel Bars
to Simulate Fuel
(2.5" dia. x 26" long)
Partial Mark IV Fuel or
Scrap Basket (base plate
and center post only, steel
shroud from fuel basket OK)
with 1 Large Steel Bar to
Simulate Fuel
(22" dia. x 26.7" long,
3" dia. center hole to fit
over basket center post)
4 Places

(Pre-Drop Measurements – MCO-60-2 Test Canister)

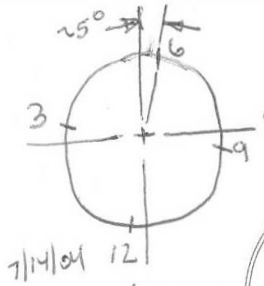
Required Data: After MCO assembly and final closure weld.

Component	Measurement		Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Completed Canister MCO-60-2	Weight = 18247 (lbs)		#721517 25 K load cell	T2R 7/13/04	SDS 7/13/04
	Center of Gravity Location (from bottom end) = 78 13/16 (in.)		tape measure	SDS 7/13/04	T2R 7/13/04
	Overall Length = 166 1/16 (in.)		tape measure	SDS 7/13/04	TSR 7/13/04
Etch Circumferential Lines	1-1/2 in. up from bottom: Etched? (Y/N)	Y*	tape measure	SDS 7/13/04	TSR 7/13/04
	4 in. up from bottom: Etched? (Y/N)	Y	tape measure	SDS 7/13/04	TSR 7/13/04
	6 in. up from bottom: Etched? (Y/N)	Y	tape measure	SDS 7/13/04	TSR 7/13/04
	24 in. up from bottom: Etched? (Y/N)	Y	tape measure	SDS 7/13/04	TSR 7/13/04
	83 in. up from bottom: Etched? (Y/N)	Y	tape measure	SDS 7/13/04	TSR 7/13/04
	17 in. down from top: Etched? (Y/N)	Y**	tape measure	SDS 7/13/04	TSR 7/13/04
	3 in. down from top: Etched? (Y/N)	Y**	tape measure	SDS 7/13/04	TSR 7/13/04
Mark Impact Location On Canister Bottom	Locaton Marked? (Y/N) (impact location on bottom just under the shell longitudinal weld seam)	Y	NA	NA	NA
Canister Identifier Labels	Applied? (Y/N)	Y	NA	NA	NA

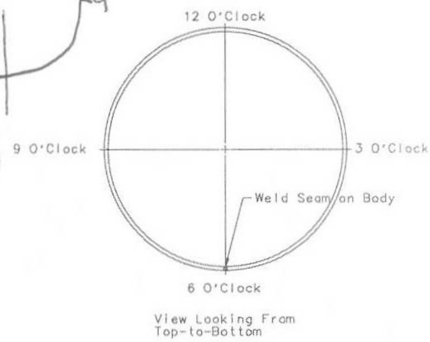
Other Details:
* Line not etched, but marks made at 12, 1:30, 3, 4:30, 6, 7:30, 9, 10:30 @ 1 1/2 inches from end.
** Measured from top at full O.D. (2 3/16 inches below actual top)

Data taken by: NA Date: NA

Data verified by: NA Date: NA



Final Pre-Drop Measurements – MCO-60-2 Test Canister



All of the final pre-drop measurements below will be taken and checked by NSNFP personnel. A certified dimensional inspector will then independently take ten of those measurements (chosen at random) for comparison. If the inspector measurements match the NSNFP measurements within +/- 1/16-inch, then the NSNFP PSO Quality Engineer shall approve all NSNFP final pre-drop measurements (by his signature and date) and release NSNFP personnel to continue canister pre-drop activities.

Required Data: Diameter Measurements (at clock positions) Top: 30 1/2 inches (OD flat, not lifting lug?)

(All diameter measurements taken with the canister horizontal, saddles about Bottom: 27 1/2 inches from ~~each~~ end. Canister seam weld in 6 o'clock position as shown above.) SDS 7/14/04

Component	Position	Measurement		Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Canister Positioning	Canister/Saddles Positioned Correctly? (Y/N)			Y	NA	NA
Bottom (1 1/2-inches from bottom edge)	12 - 6	NSNFP = 24.071	(in.)	721438	DKM 7/12/04	TEL 7/12/04
		Inspector = 24.074	(in.)	721438	PC Roberts 7/12/04	
	1:30 – 7:30	NSNFP = 24.067	(in.)	721438	DKM 7/12/04	TEL 7/12/04
		Inspector = NA	(in.)	NA	NA	
	3 - 9	NSNFP = 24.069	(in.)	721438	DKM 7/12/04	TEL 7/12/04
		Inspector = 24.071	(in.)	721438	PC Roberts 7/12/04	
	4:30 – 10:30	NSNFP = 24.070	(in.)	721438	DKM 7/12/04	TEL 7/12/04
		Inspector = NA	(in.)	NA	NA	

(Final Pre-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement		Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Lower Shell (4-inches from bottom edge)	12 - 6	NSNFP = 23.983	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = NA	(in.)	NA	NA	
	1:30 – 7:30	NSNFP = 23.958	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = NA	(in.)	NA	NA	
	3 - 9	NSNFP = 23.996	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = 23.997	(in.)	721436	PC Roberts 7/12/04	
	4:30 – 10:30	NSNFP = 23.996	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = 23.997	(in.)	721436	PC Roberts 7/12/04	
Lower Shell (6-inches from bottom edge)	12 - 6	NSNFP = 23.985	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = 23.990	(in.)	721436	PC Roberts 7/12/04	
	1:30 – 7:30	NSNFP = 23.966	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = 23.971	(in.)	721436	PC Roberts 7/12/04	
	3 - 9	NSNFP = 23.999	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = NA	(in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.006	(in.)	721436	DKM 7/12/04	TEA 7/12/04
		Inspector = NA	(in.)	NA	NA	

(Final Pre-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement		Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Canister Mid-Body (83-inches from bottom edge)	12 - 6	NSNFP = 23.994	(in.)	721436	DKM 7/12/04	TER 7/12/04
		Inspector = 23.993	(in.)	721436	PC Roberts 7/12/04	
	1:30 – 7:30	NSNFP = 23.989	(in.)	721436	DKM 7/12/04	TER 7/12/04
		Inspector = NA	(in.)	NA	NA	
	3 - 9	NSNFP = 23.949	(in.)	721436	DKM 7/12/04	TER 7/12/04
		Inspector = NA	(in.)	NA	NA	
	4:30 – 10:30	NSNFP = 23.968	(in.)	721436	DKM 7/12/04	TER 7/12/04
		Inspector = 23.968	(in.)	721436	PC Roberts 7/12/04	
Collar (17-inches below top edge)	12 - 6	NSNFP = 24.084	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = NA	(in.)	NA	NA	
	1:30 – 7:30	NSNFP = 24.048	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = 24.046	(in.)	721438	PC Roberts ~~[illegible]~~ 7/12/04 (PR 7/12/04)	
	3 - 9	NSNFP = 24.066	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = NA	(in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.100	(in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = 24.101	(in.)	721438	PC Roberts 7/12/04	

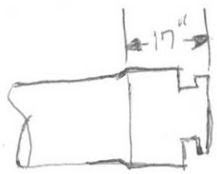
(Final Pre-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Cover (3-inches below top edge)	12 - 6	NSNFP = 25.288 (in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 25.284 (in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = 25.280 (in.)	721438	PC Roberts 7/12/04	
	3 - 9	NSNFP = 25.289 (in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 25.280 (in.)	721438	DKM 7/12/04	TER 7/12/04
		Inspector = 25.283 (in.)	721438	PC Roberts 7/12/04	
24-inches above bottom	12 - 6	NSNFP 23.950 in.	721436	DKM 7/12/04	TER 7/12/04
		INSP. 23.951 in.	721436	PC Roberts 7/12/04	
	1:30 - 7:30	NSNFP 23.975 in.	721436	DKM 7/12/04	TER 7/12/04
		INSP.	NA	NA	
	3 - 9	NSNFP 24.008 in	721438	DKM 7/12/04	TER 7/12/04
		INSP. 24.009	721438	PC Roberts 7/12/04	
	4:30 - 10:30	NSNFP 23.987 in	721436	DKM 7/12/04	TER 7/12/04
		Insp.	NA	NA	

NSNFP PSO QE acceptance of all Final Pre-Drop Measurements Neil S. MacKay Date: 7/13/04

NEIL S. MACKAY



MCO-60-2

Additional Measurements on a Circumferential line.

Canister Component	position	Measurement	Instrument Used	Measurement Taken BY /Date	Measurement Checked By/Date
17 inches below actual top	12-6	NSNFP = 25.304 (in.)	#721438	SDS 7/13/04	TER 7/13/04
	1:30-7:30	NSNFP = 25.280 (in.)	#721438	SDS 7/13/04	TER 7/13/04
	3-9	NSNFP = 25.289 (in.)	#721438.	SDS 7/13/04	TER 7/13/04
	4:30-10:30	NSNFP = 25.315 (in.)	#721438	SDS 7/13/04	TER 7/13/04
Collar-to-cover weld	12-6	NSNFP = 25.331 (in.)	#721438	SDS 7/13/04	TER 7/13/04
	3-9	NSNFP = 25.337 (in.)	#721438	SDS 7/13/04	TER 7/13/04

MCO-60-2

STRAIN GAGE PUNCH MARKS – DISTANCE BETWEEN MARKS:

Measurements made with digital caliper # 72714

ON THE 6 O'CLOCK LINE

① 4" up from bottom
- Top: 0.7705
- Left: 0.7665
- Right: 0.7665
- Bottom: 0.7650
- ↑ 4"

② 6" up from bottom
- Top: 0.7640
- Left: 0.7625
- Right: 0.7680
- Bottom: 0.7715
- ↑ 6"

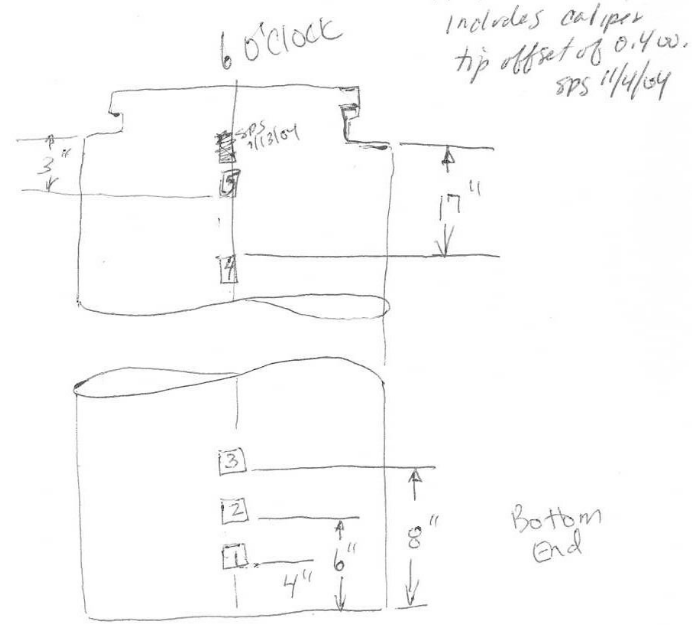
③ 8" up from bottom
- Top: 0.7610
- Left: 0.7555
- Right: 0.7610
- Bottom: 0.7635
- ↑ 8"

④ 17" below top @ full diameter
- Top: 0.7600
- Left: 0.7590
- Right: 0.7610
- Bottom: 0.7595
- ↑ 17"

⑤ ~~3" below top @ full diameter~~ SDS 7/13/04

⑤ 3" below top @ full diameter
- Top: 0.7620
- Left: 0.7575
- Right: 0.7635
- Bottom: 0.7630
- ↑ 3"

Measured value includes caliper tip offset of 0.400. SDS 11/4/04



Data Taken by: T.E. Rahl 7/13/04
Data Verified by: SDSnow 7/13/04

414.73
10/01/99
Rev. 03

BBWI PERSONNEL CERTIFICATION DATA FORM

02Roberts PC MECH CERT

Page 1 of 1

SECTION I – Request (To be filled out by Applicant's Supervisor)

Applicant: **Roberts, P. C.** S#: **56113** Current certification expires: **10/2002** Date: **9/2002**

Inspection activity candidate will be performing: Inspection for conformance for the INEEL to quality requirements employing general observation, procedure compliance, or test verification methods and report results.

SECTION II – Processing Documentation and Evaluations: (To be filled out by Level II and others as requested.)

1. Discipline: **Mechanical** Method: **Mechanical** Level: **Inspector** **Inspector**
Limits: **None**

2. **Physical/Vision Examination** Ref. MCP-535 Appendix I — **Applicant's Education Level**

Due Date 5/6/03	A. Near Vision	B. Far Vision	C. Color Discrimination	☐ 4 Yr. Degree	☐ 2 Yr. Degree
Requirement	20/25 Snellen	N/a	OMP exam	☐ H.S./Equal	☒ Other
Corrected/Uncorrected	Corrected	Corrected	Satisfactory	Note: 4 yr. Tech. School - USN "A" School, Aviation Mechanic and NDE +3 yr Tech Sch. U of I AAS Certfiicates in Quality Assurance, 12/88; Mechanical Design, 6/15/92 and; Waste Managment, 1/94..	

3. **Training:** * Sub Exp. = additional experience permitted to substitute for formal training as specified in Appendix F or G

MCP-535 Appendix B, F, or G	Class Hr. by Education Level			Training Acquired (Ref. MCP-535 Appendix D)		
Subject/Topic/Description	H.S.	+ 2 Yr.	Sub Exp.*	Hr.	Sub Exp.	Description
Piping ANSI	4		1000	-	1000	1/86 to 1/90 WINCO (INEEL-ICPP) ANSI Piping Insp.
Piping ASME	2		350	-	350	1/95 to 1/96 LMITCO (INEEL-TRA) ASME III Piping
Piping Components	2		525	-	525	7/85 to 1/86 NNRS (INEEL-NRF) Pipe Component Insp
Piping Drawings	2		N/A	2	-	6/15/92 U of I Mechanical Design Certificate included course Ited262 Piping Design 3 Sem. Cr. and covered drawings.
Piping Pressure Testing	2		N/A	2	-	6/15/92 U of I Mechanical Design Certfiicate included course Ited336 Fluid System Design and covered pressure testing
Dimensional Dwg	1		175	1	-	1988 UofI Inspection and Gauging course QA certificate.
Dimensional hand Equip	1		175	1	-	1988 UofI Inspection and Gauging course QA certificate.
CMM	1		175	1	-	1988 UofI Inspection and Gauging course QA certificate.
Contour Projector	1		175	1		1988 UofI Inspection and Gauging course QA certificate.
Mechanical Sys HVAC, mach, Etc..	4		1000		1000	1/86 to 1/90 WINCO (INEEL-ICPP) Project/Maint. inspection.

3a. **OJT/Self Study:**

Type & Activity/Objective Required	Req. Hr.	Date	Hr.	Reference Documentation and Comments:
QA Program Manual (S.S.)	1	3/14/88 4/12/88 3/23/92 1/6/93	R.L.	0915E00001 GI Reading List ref: 00Roberts PC TRN HIST 5 0900L00010 NCR-SDR-CAR-CR ref: 00Roberts PC TRN HIST 5 3000V45001 QA Ref: 00Roberts PC TRN HIST 4 0900L00031 DOE 5700.6C QA Ref 00Roberts PC TRN HIST 3
Pressure testing OJT	10hr/Sub.	1/86	>10	WINCO (INEEL-ICPP) Piping Inspector assignment
Dimensional Dwg OJT	4hr/Sub.	7/28/93	.5	0900L00035 QA Basic B.P. Ref 00Roberts PC TRN HIST 2
Dimensional hand Equip. OJT	4hr/Sub.	3/10/87	.5	0902L00002 EPRI VT DIM Tools Ref: 00Roberts PC TRN HIST 5
CMM OJT	4hr/Sub.	1986	4	WINCO (INEEL-ICPP) receiving inspection assignment
Mechanical Systems HVAC,Mech., OJT	525hr/Sub.	1/90 to 1/91	525	WINCO (INEEL-ICPP) Piping Inspector assignment
Piping INEEL A/E Standards Self Study	2hr/525hr	1986 to 90	525	WINCO (INEEL-ICPP) Piping Inspector assignment

4. **Experience:**

Hr. Required			Required Experience	Experience Obtained	
H.S.	+ 2 Yr.	Other	Description	Hr.	Reference/Documentation
2000	1000		Piping	>1000	1/86 to 1/97 WINCO (INEEL-ICPP) Certified Mechanical Inspection
2000	1000		Dimensional	N/A	N/A
2000	1000		Mechanical sys	>1000	1/86 to 1/97 WINCO (INEEL-ICPP) Certified Mechanical Inspection

5. **Examination Results:**

TEST TYPE	INDIVIDUAL TEST SCORES: Written Examinations & Min Number Questions*			Practical Examinations			COMPOSITE SCORE
	Gen. /( )	Spec. /( )	Combined W. E. 10/(51)	Demo	Oral	Other	
Description	N/A	N/A	02Roberts PC MECH WE	02Roberts PC MECH DEMO	N/A	N/A	
SCORES			98	100			99
DATE			10/2/2002	10/3/2002			

* The Minimum number of examination questions is reduced when the scope of qualification is LIMITED MCP-535 Appendix A & D. Min # questions/(actual # questions)

6. Additional Training Required Prior to Re-examination: None

Minimum up-date or re-certification training:			
Hours	Subject Required	Hours	Ref. Documentation

7. **The "Applicant" is Certified in accordance with MCP-535 to perform the above Discipline – Method.**

Certifying Level III: J. A. Dowalo — Date: 10/9/2002	Effective Date of Certification: **10/8/2002**	Certification Expiration Date: **10/8/2005**

8. Certificate/Endorsement Issued: (Initials & Date) ______ Entered into Database: (Initials & Date) ______

414.73
02/20/2003
Rev. 04
Use with MCP-535

BBWI PERSONNEL CERTIFICATION DATA FORM

SECTION I – Request (To be filled out by Applicant's Supervisor)

Applicant: **Roberts, P.C.** S#: **56113** Current certification expires: **7/1/2003** Date: **6/9/2003**

Inspection activity candidate will be performing: Inspection for conformance for the INEEL to quality requirements employing general observation, procedure compliance, or test verification methods and report results.

SECTION II – Processing Documentation and Evaluations: (To be filled out by Level II and others as requested.)

1. Discipline: **General** Method: **Inspector** Level: **Inspector**
Limits: **None**

2. **Physical/Vision Examination** Ref. MCP-535 Appendix I

Due Date 12/23/2003	A. Near Vision	B. Far Vision	C. Color Discrimination	Applicant's Education Level	
				☐ 4 Yr. Degree	☒ 2 Yr. Degree
Requirement	20/25 Snellen	NA		☐ H.S./Equal	☐ Other
Corrected/Uncorrected	Corrected	Corrected		Note: : USN "A" School, Aviation Mechanic and NDE + UofI Certificate QA, WM, Mech	

3. **Training:** * Sub Exp. = additional experience permitted to substitute for formal training as specified in Appendix F or G

MCP-535 Appendix B, F, or G	Class Hr. by Education Level			Training Acquired (Ref. MCP-535 Appendix D)	
Subject/Topic/Description	H.S.	+ 2 Yr.	Sub Exp.*	Hr.	Description

3a. **OJT/Self Study:**

Type & Activity/Objective Required	Req. Hr.	Date	Hr.	Reference Documentation and Comments:
QA Program Manual (S.S.)	R. L.	3/14/88 4/12/88 3/23/92 1/6/93	R.L.	0915E00001 GI Reading List ref: 00Roberts PC TRN HIST 5 0900L00010 NCR-SDR-CAR-CR ref: 00Roberts PC TRN HIST 5 3000V45001 QA Ref: 00Roberts PC TRN HIST 4 0900L00031 DOE 5700.6C QA Ref 00Roberts PC TRN HIST 3
MCP-535, Insp. and NDE Personnel Cert. (C.R.)	.5	8/17/99	.5	Tailgate training provided by J. Dowalo Ref file:\ 99TG8-17GI
MCP-2482, Inspection for Conformance (C.R.)	.5	8/17/99	.5	Tailgate training provided by J. Dowalo Ref file:\ 99TG8-17GI
MCP-195, NDE Equip. & Proc. Qual. (C.R/ S.S.)	.5	8/17/99	.5	Tailgate training provided by J. Dowalo Ref file:\ 99TG8-17GI
TPR-4960, Receiving Inspection (C.R.)	.5	8/17/99	.5	Tailgate training provided by J. Dowalo Ref file:\ 99TG8-17GI
Blue-print reading, Misc. Dimensional Exam. (C.R. or OJT)	.5 .5	7/28/93 3/10/87	.5 .5	0900L00035 QA Basic B.P. Ref 00Roberts PC TRN HIST 2 0902L00002 EPRI VT DIM Tools Ref: 00Roberts PC TRN HIST 5
Suspect/counterfeit item indoctrination (C.R.)	.5	8/17/99	.5	TG000106 Ref file99TG8-17GI
Specific Job Field Experience (OJT) Form 414.17 Equivalency	80	4/19/88	80	0915E00004 GI DEMO Ref: 00Roberts PC TRN HIST 5

4. **Experience:** Ref. MCP-535 Appendix A, B, F or G

Hr. Required			Required Experience	Experience Obtained	
H.S.	+ 2 Yr.	Other	Description	Hr.	Reference/Documentation
6000	2000	none	Inspection or related industrial experience in quality verification activities	>2000 18K	5/71 to 5/84 USN Certified Inspector copies on file. 1986 to 1996 INEEL Inspection Activities

5. **Examination Results:**

TEST TYPE	INDIVIDUAL TEST SCORES						COMPOSITE SCORE
	Written Examinations & Min Number Questions*			Practical Examinations			
	Gen. /( )	Spec. /( )	Other /( )	Demo	Oral	Other	
Description							
Scores							
Date							

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BBWI PERSONNEL CERTIFICATION DATA FORM

* The Minimum number of examination questions is reduced when the scope of qualification is LIMITED MCP-535 Appendix A & D. Min # questions/(actual # questic

6.

Additional Training Required Prior to Re-examination:	Minimum up-date or re-certification training:			
None	Hours	Subject Required	Hours	Ref. Documentation

7. **The "Applicant" is Certified in accordance with MCP-535 to perform the above Discipline – Method.**

Effective Date of Certification:	Certification Expiration Date:	TRAIN Qualification Code:
7/1/2003	Refer to TRAIN database	QLGENERL

J Stone	JStone	6/11/03
Principle Level III Examiner Print/Type Name	Principle Level III Examiner Signature	Date

APPENDIX C. POST-DROP TEST MCO & INTERNALS DATA SHEETS

Post-Drop Measurements - Test Canister MCO-00-1

BOTTOM END DEFORMATIONS:

No visible deformations.

SDSnow 11/3/04
DKM 11/3/04

Top End Deformations:

No visible Deformations.

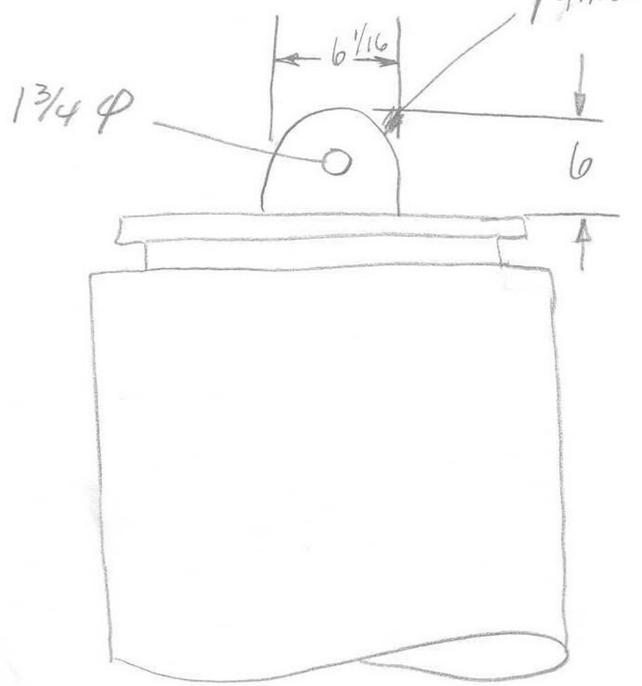
SDSnow 11/3/04
DKM 11/3/04

Instrument Used: NA
Data taken by: See above Date:
Data verified by: Date:

(Post-Drop Measurements - Test Canister MCO-00-1)

OTHER DETAILS

Top end lug: centered on cover

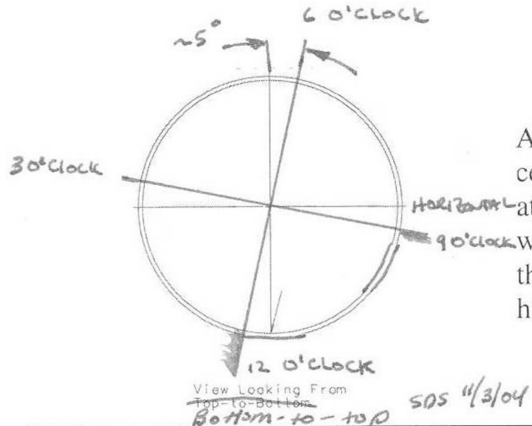


Instrument Used: Tape measure

Data taken by: D K Morton Date: 11/3/04

Data verified by: SD Snow Date: 11/3/04

(Post-Drop Measurements – MCO-00-1 Test Canister)



All of the post-drop measurements below will be taken and checked by NSNFP personnel. A certified dimensional inspector will then independently take ten of those measurements (chosen at random) for comparison. If the inspector measurements match the NSNFP measurements within +/- 1/8-inch for tape measurements and +/-1/16-inch for micrometer measurements, then the NSNFP PSO Quality Engineer shall approve all NSNFP final post-drop measurements (by his signature and date) and release NSNFP personnel to continue canister post-drop activities.

Required Data: Diameter Measurements (at clock positions) ½ SDS 11/3/04

(All diameter measurements taken with the canister horizontal, saddles about ~~29~~ ½ inches from each end. Canister seam weld in 6 o'clock position as shown above.)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Canister Positioning	Canister/Saddles Positioned Correctly? (Y/N)		Y	NA	NA
Bottom (1 1/2-inches from bottom edge)	12 - 6	NSNFP = 24.077 (in.)	~~24.077~~ 721438 DKM 11/3/04	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 24.076 (in.)	~~24.076~~ 721438 DKM 11/3/04	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.075 (in.)	~~24.075~~ 721438 DKM 11/3/04	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.075 (in.)	721438	[signature] 11/9/04	
	4:30 – 10:30	NSNFP = 24.076 (in.)	~~24.076~~ 721438 DKM 11/3/04	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.079 (in.)	721438	[signature] 11/9/04	

(Post-Drop Measurements – MCO-00-1 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Lower Shell (4-inches from bottom edge)	12 - 6	NSNFP = 24.074 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.072 (in.)	721438	[illegible] 11/9/04	
	1:30 – 7:30	NSNFP = 23.9513 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.014 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.054 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.054 (in.)	721438	[illegible] 11/9/04	
Lower Shell (6-inches from bottom edge)	12 - 6	NSNFP = 24.101 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 23.9868 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.989 (in.)	721436	[illegible] 11/9/04	
	3 - 9	NSNFP = 24.037 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.093 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	

(Post-Drop Measurements – MCO-00-1 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
SDS 1/24/05 Lower Canister ~~Mid-~~ Shell (24-inches from bottom edge)	12 - 6	NSNFP = 23.9201 (in.)	~~23.9201~~ 721436 DKM 11/3/04	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 23.9573 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.092 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.140 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
Canister Mid-Shell SDS 1/24/05 ~~Collar~~ (83-inches from bottom edge)	12 - 6	NSNFP = 23.9737 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.972 (in.)	721436	[illegible] 11/9/04	
	1:30 – 7:30	NSNFP = 23.9820 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.071 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.077 (in.)	721438	[illegible] 11/9/04	
	4:30 – 10:30	NSNFP = 24.001 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.002 (in.)	721438	[illegible] 11/9/04	

(Post-Drop Measurements – MCO-00-1 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
SDS 1/24/05 Collar ~~Cover~~ (17-inches below top edge at full O.D.)	12 - 6	NSNFP = 24.056 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 24.063 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.067 (in.)	721438	[signature] 11/9/04	
	3 - 9	NSNFP = 24.064 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 24.066 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
Cover (3-inches below top edge at full O.D.)	12 - 6	NSNFP = 25.291 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 25.285 (in.)	721438	[signature] 11/9/04	
	1:30 – 7:30	NSNFP = 25.289 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 25.289 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 25.285 (in.)	721438	[signature] 11/9/04	
	4:30 – 10:30	NSNFP = 25.292 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	

NSNFP PSO QE acceptance of all Post-Drop Measurements [signature] Date: 11/10/04

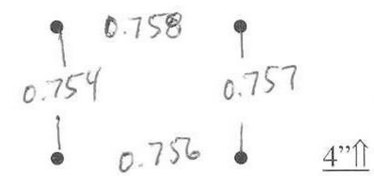
(Post-Drop Measurements - Test Canister MCO-00-1)

BOTTOM END

Strain Gage Punch Marks – Distance Between Marks:

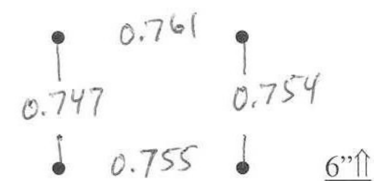
On the 6 O'Clock Line

(1) 4-inches up from bottom:



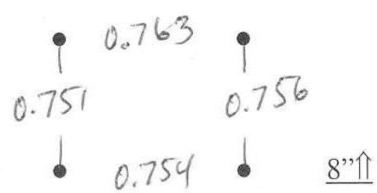
DKM 11/3/04
SDS 11/3/04

(2) 6-inches up from bottom:



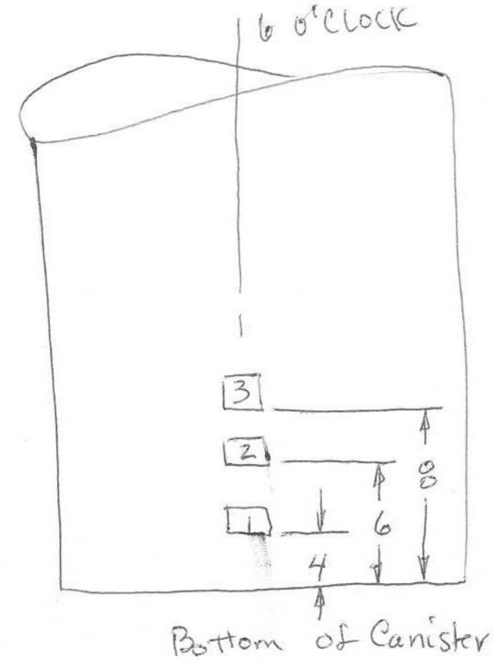
DKM 11/3/04
SDS 11/3/04

(3) 8-inches up from bottom:



DKM 11/3/04
SDS 11/3/04

measured dimensions include the caliper tip offset of 0.375. SDS 11/3/04



Same pattern as above:
#4 – 6 @ 3 O'Clock Line
#7 – 9 @ 9 O'Clock Line
#10 – 12 @ 12 O'Clock Line

Instrument Used: Caliper # 716309

Data taken by: see above Date:

Data verified by: see above Date:

(Post-Drop Measurements - Test Canister MCO-00-1)

BOTTOM END CONTINUED

Strain Gage Punch Marks – Distance Between Marks:

<u>On the 3 O'Clock Line</u>

(4) 4-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.756; Left: 0.744; Right: 0.750; Bottom: 0.754 — 4"⇑

(5) 6-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.756; Left: 0.744; Right: 0.749; Bottom: 0.756 — 6"⇑

(6) 8-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.752; Left: 0.746; Right: 0.749; Bottom: 0.757 — 8"⇑

<u>On the 9 O'Clock Line</u>

(7) 4-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.755; Left: 0.747; Right: 0.755; Bottom: 0.754 — 4"⇑

(8) 6-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.754; Left: 0.744; Right: 0.753; Bottom: 0.755 — 6"⇑

(9) 8-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.755; Left: 0.746; Right: 0.754; Bottom: 0.755 — 8"⇑

Measured dimensions include the caliper tip offset of 0.375. SDS 11/3/04

Instrument Used: Caliper 716309

Data taken by: See above Date:

Data verified by: See above Date:

(Post-Drop Measurements - Test Canister MCO-00-1)

BOTTOM END CONTINUED

Strain Gage Punch Marks – Distance Between Marks:

On the 12 O'Clock Line

(10) 4-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.758
Left: 0.749 Right: 0.754
Bottom: 0.759

4"⇑

(11) 6-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.761
Left: 0.749 Right: 0.754
Bottom: 0.761

6"⇑

(12) 8-inches up from bottom:

DKM 11/3/04
SDS 11/3/04

Top: 0.761
Left: 0.747 Right: 0.755
Bottom: 0.755

8"⇑

Measured dimensions include the caliper tip offset of 0.375. SDS 11/3/04

Instrument Used: Caliper # 716309

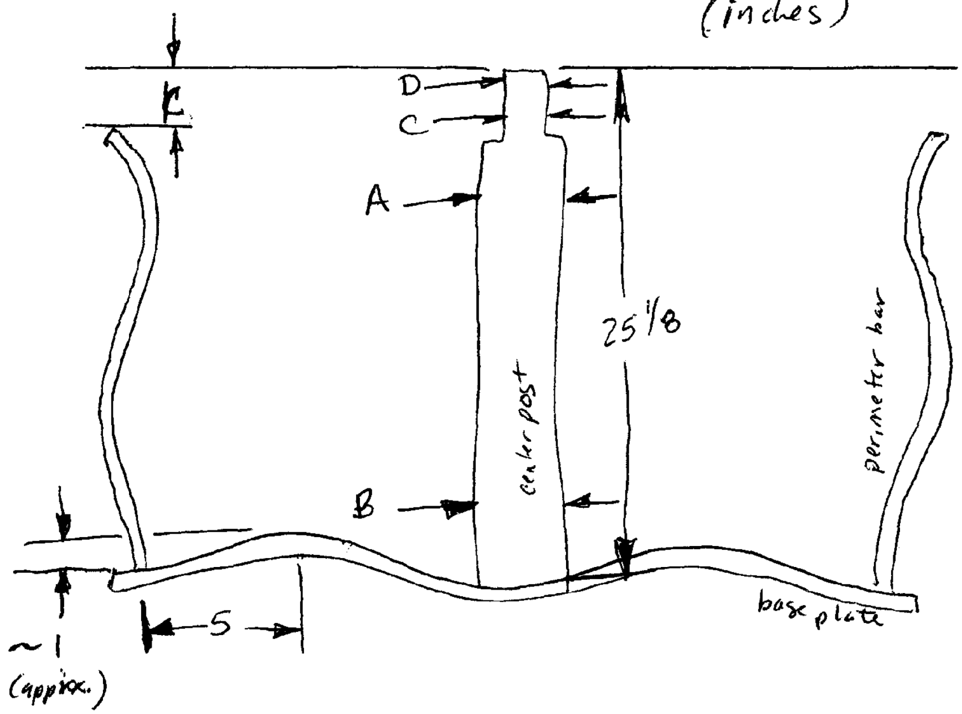
Data taken by: see above Date:

Data verified by: see above Date:

(Post-Drop Measurements - Test Canister MCO-00-1)

OTHER DETAILS

Bottom Basket Deformed Dimensions:
(inches)



Center Post Diameters: (in.)

A = 3.027 and 3.044 (90°)

B = 3.025 and 3.008 (90°)

C = 2.444 and 2.446 (90°)

D = 2.401 and 2.414 (90°)

Distance from top of Center Post to top of Perimeter Bars (K)

Clockwise looking down

Bar	dimension (in.)
1 (orange)	2 15/16
2	2 5/8
3	2 1/2
4	2 9/16
5	2 1/2
6	2 3/4

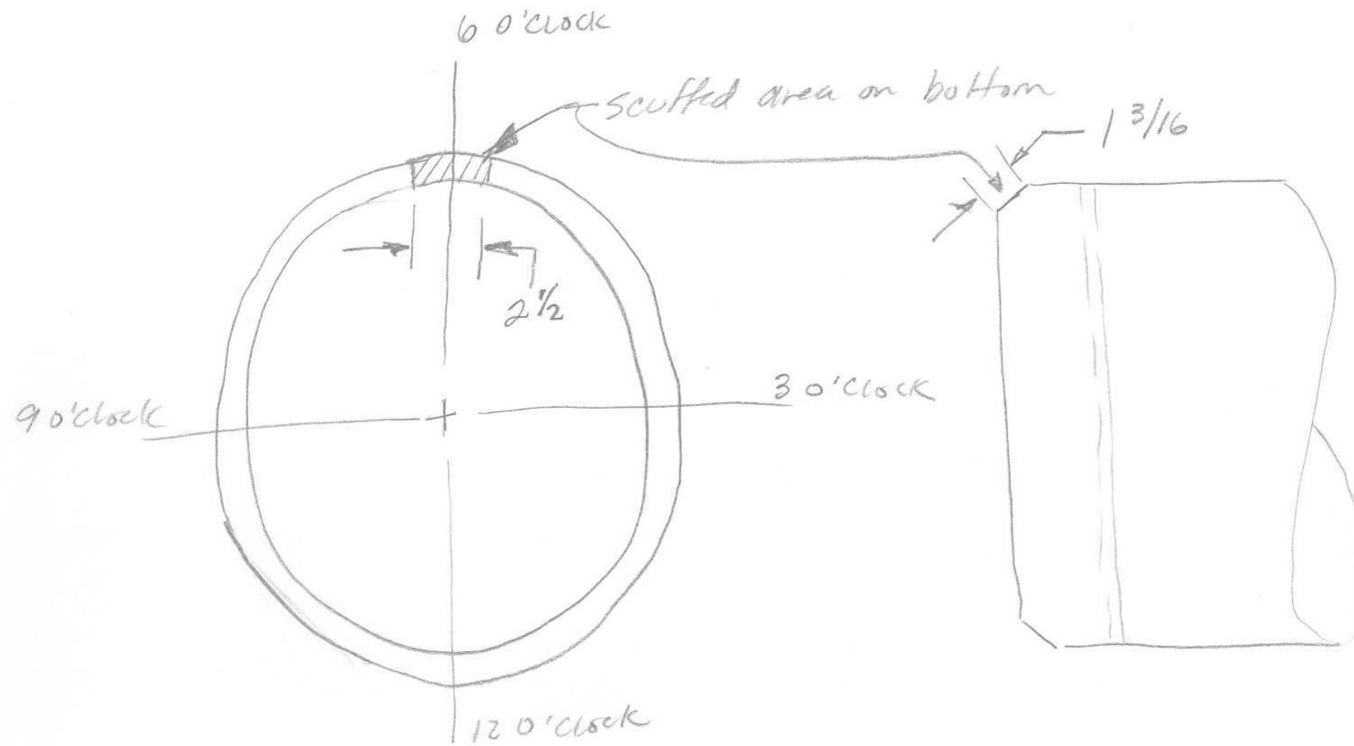
Instrument Used: Caliper # 721714 and tape measure

Data taken by: TE Rahl Date: 1/18/2005

Data verified by: D K Morton Date: 1/18/2005

Post-Drop Measurements - Test Canister MCO-60-2

BOTTOM END DEFORMATIONS



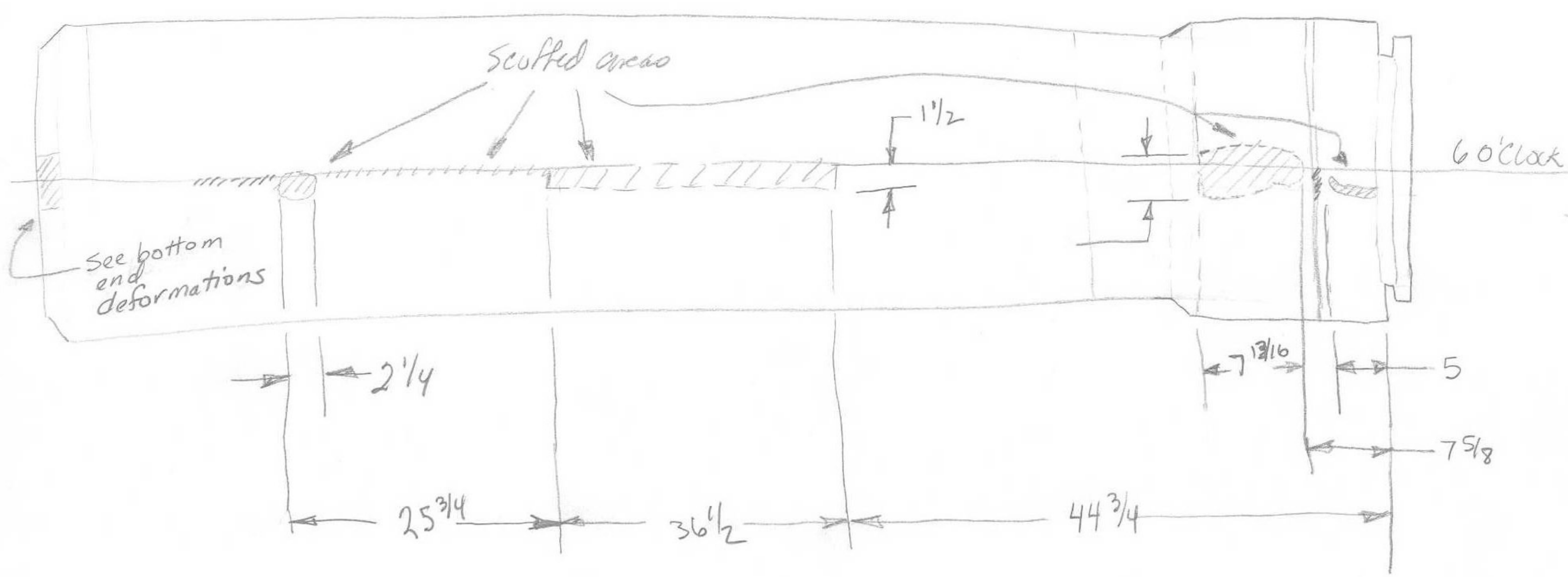
Instrument Used: tape measure

Data taken by: D. K. Morton Date: 11/3/04

Data verified by: SD Snow Date: 11/3/04

(Post-Drop Measurements - Test Canister MCO-60-2)

TOP END DEFORMATIONS



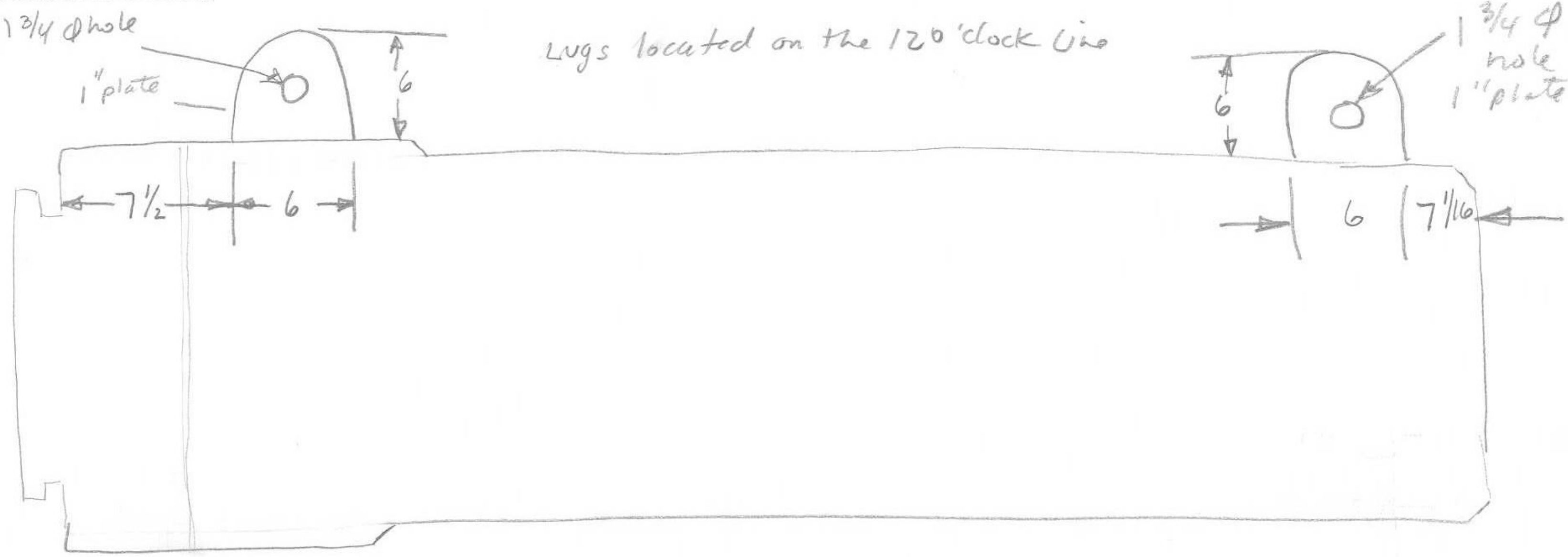
Instrument Used: tape measure

Data taken by: D.K. Morton Date: 11/3/04

Data verified by: SD Snow Date: 11/3/04

(Post-Drop Measurements - Test Canister MCO-60-2)

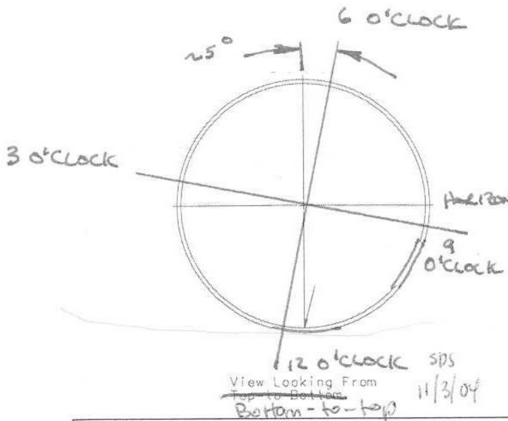
OTHER DETAILS



Instrument Used: tape measure

Data taken by: D K Morton Date: 11/3/04

Data verified by: SD Snow Date: 11/3/04



(Post-Drop Measurements – MCO-60-2 Test Canister)

All of the post-drop measurements below will be taken and checked by NSNFP personnel. A certified dimensional inspector will then independently take ten of those measurements (chosen at random) for comparison. If the inspector measurements match the NSNFP measurements within +/- 1/8-inch for tape measurements and +/-1/16-inch for micrometer measurements, then the NSNFP PSO Quality Engineer shall approve all NSNFP final post-drop measurements (by his signature and date) and release NSNFP personnel to continue canister post-drop activities.

Required Data: Diameter Measurements (at clock positions)
(All diameter measurements taken with the canister horizontal, saddles about ~~30-1/2~~ 32-1/2 SDS 11/3/04 inches from the top end and ~~27-1/2~~ 29-1/2 SDS 11/3/04 inches from the bottom end. Canister seam weld in 6 o'clock position as shown above.)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Canister Positioning	Canister/Saddles Positioned Correctly? (Y/N)		Y	NA	NA
Bottom (1 1/2-inches from bottom edge)	12 - 6	NSNFP = 24.067 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.071 (in.)	721438	[signature] 11/9/04	
	1:30 – 7:30	NSNFP = 24.070 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.071 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.072 (in.)	721438	[signature] 11/9/04	
	4:30 – 10:30	NSNFP = 24.072 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	

(Post-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Lower Shell (4-inches from bottom edge)	12 - 6	NSNFP = 23.9739 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 23.9632 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.965 (in.)	721436	[illegible] 11/9/04	
	3 - 9	NSNFP = 23.9952 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 23.9989 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.999 (in.)	721436	[illegible] 11/9/04	
Lower Shell (6-inches from bottom edge)	12 - 6	NSNFP = 23.9444 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.948 (in.)	721436	[illegible] 11/9/04	
	1:30 – 7:30	NSNFP = 23.9736 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 23.9985 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = ~~23.~~ 24.004 (in.)	721436	[illegible] 11/9/04	
	4:30 – 10:30	NSNFP = 24.006 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	

(Post-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
SDS 11/3/04 Canister ~~Mid-~~ Lower Shell (24-inches from bottom edge)	12 - 6	NSNFP = 23.9692 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 23.9816 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.986 (in.)	721436	[signature] 11/9/04	
	3 - 9	NSNFP = 23.9913 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 23.9786 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.981 (in.)	721436	[signature] 11/9/04	
SDS 11/3/04 Canister Mid-Shell ~~Collar~~ (83-inches from bottom edge)	12 - 6	NSNFP = 24.055 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.058 (in.)	721438	[signature] 11/9/04	
	1:30 – 7:30	NSNFP = 23.9814 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 23.8841 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.887 (in.)	721436	[signature] 11/9/04	
	4:30 – 10:30	NSNFP = 23.9738 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = 23.979 (in.)	721436	[signature] 11/9/04	

(Post-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
Collar SDS 1/24/05 ~~Cover~~ (17-inches below top edge at full O.D.)	12 - 6	NSNFP = 23.9885 (in.)	721436	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	1:30 – 7:30	NSNFP = 24.066 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 24.044 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.049 (in.)	721438	[signature] 11/9/04	
	4:30 – 10:30	NSNFP = 24.140 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 24.143 (in.)	721438	[signature] 11/9/04	
Cover (3-inches below top edge at full O.D.)	12 - 6	NSNFP = 25.278 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = ~~25.306~~ 25.280 [initials] 11/9/04 (in.)	721438	[signature] 11/9/04	
	1:30 – 7:30	NSNFP = 25.284 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 25.291 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 25.281 (in.)	721438	[signature] 11/9/04	
	4:30 – 10:30	NSNFP = 25.288 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	

(Post-Drop Measurements – MCO-60-2 Test Canister)

Required Data: Diameter Measurements (at clock positions)

Component	Position	Measurement	Instrument Used	Measurement Taken By / Date	Measurement Checked By / Date
SDS 11/3/04 Collar ~~Cover~~ (17-inches below top of cover – 2-3/16-inches above full O.D.)	12 - 6	NSNFP = 25.203 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = 25.200 (in.)	721438	J. Donalo 11/9/04	
	1:30 – 7:30	NSNFP = 25.303 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 25.276 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	4:30 – 10:30	NSNFP = 25.359 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
Collar-to-Cover Weld	12 - 6	NSNFP = 25.313 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	
	3 - 9	NSNFP = 25.342 (in.)	721438	SDS 11/3/04	DKM 11/3/04
		Inspector = NA (in.)	NA	NA	

NSNFP PSO QE acceptance of all Post-Drop Measurements [signature] Date: 11/10/04

(Post-Drop Measurements - Test Canister MCO-60-2)

Measured dimensions include the caliper tip offset of 0.375. SPS 11/3/04

Strain Gage Punch Marks – Distance Between Marks:

On the 6 O'Clock Line

(1) 4-inches up from bottom: DKM 11/3/04, SPS 11/3/04

Top 0.755; left 0.754; right 0.760; bottom 0.756 — 4"⇑

(2) 6-inches up from bottom: DKM 11/3/04, SPS 11/3/04

Top 0.760; left 0.753; right 0.755; bottom 0.756 — 6"⇑

(3) 8-inches up from bottom: DKM 11/3/04, SPS 11/3/04

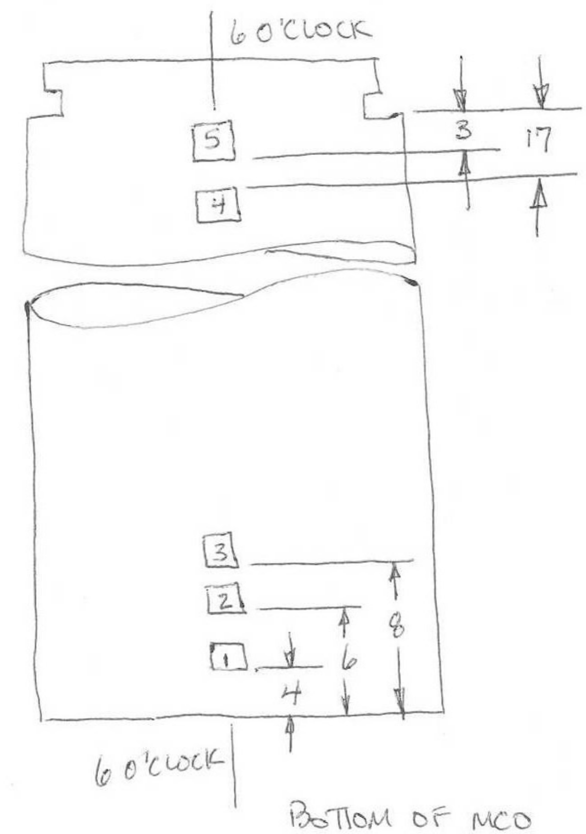
Top 0.757; left 0.751; right 0.758; bottom 0.757 — 8"⇑

(4) 17-inches below top: (at full diameter) DKM 11/3/04, SDS 11/3/04

Top 0.753; left 0.749; right 0.758; bottom 0.753 — 17"⇑

(5) 3-inches below top: (at full diameter) DKM 11/3/04, SPS 11/3/04

Top 0.758; left 0.754; right 0.759; bottom 0.757 — 3"⇑



Instrument Used: Caliper # 716309

Data taken by: see above Date:

Data verified by: see above Date:

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BBWI PERSONNEL CERTIFICATION DATA FORM

02Dowalo JA MECH-LTE CERT.doc

SECTION I – Request (To be filled out by Applicant's Supervisor)

Applicant: **Dowalo, J. A.** S#: **45866** Current certification expires: Initial with BBWI Date: 8/27/02

Inspection activity candidate will be performing Perform and document training, qualification and certification activities when requested by the Certification Administrator or PLTE. Evaluate or provide technical interpretations within the specified method of existing implementing procedures and advise PLTE of actions that are beyond the scope of or change existing procedures and techniques. *(MCP535 para. 4.1.5)*

SECTION II – Processing Documentation and Evaluations: (To be filled out by Level II and others as requested.)

1. Discipline: **Mechanical** Method: **Mechanical and Precision Dimensional** Level: **III** **Inspector**
Limits: **None**

2. **Physical/Vision Examination** Ref. MCP-535 Appendix I — **Applicant's Education Level**

Due Date **9/4/2002**	A. Near Vision	B. Far Vision	C. Color Discrimination	☐ 4 Yr. Degree	☒ 2 Yr. Degree
Requirement	20/25 Snellen	N/A	OMP Color exam	☐ H.S./Equal	☐ Other
Corrected/Uncorrected	Uncorrected	Corrected	No restrictions noted	Note: 1981 UofI Certificate of Proficiency QA	

3. **Training:** * Sub Exp. = additional experience permitted to substitute for formal training as specified in Appendix F or G

MCP-535 Appendix B, F, or G	Class Hr. by Education Level			Training Acquired (Ref. MCP-535 Appendix D)	
Subject/Topic/Description	H.S.	+ 2 Yr.	Sub Exp.*	Hr.	Description
[Mechanical & Dimensional] Technologies QA/QC Training	N/A	N/A	N/A	96 8 16	1973 NSC QC Inspection Training Ref: 73Dowalo JA NDE TRN NSC 1972 NSC Drawing Training Ref: 73Dowalo JA NDE TRN NSC 1981 U of I 1 Semester course Inspection and Gauging. Ref U of I Transcript

3a. **OJT/Self Study:**

Type & Activity/Objective Required	Req. Hr.	Date	Hr.	Reference Documentation and Comments:
Nuclear inspection experience or training specific to Nuclear QA program aspects.	4000 or sufficient training		N/A 48000	2001 INEEL Qualified QE DOE/RW-0333P QARD for SNF Ref: Train Qualification code QL-0333P 1972 to 1996 Nuclear Industry QA Experience.

4. **Experience:** Ref. MCP-535 Appendix A, B, F or G

	Hr. Required			Required Experience	Experience Obtained	
	H.S.	+ 2 Yr.	+ 4 Yr.	Description	Hr.	Reference/Documentation
	Base LTE requirement: Experience from both row B1 and B2. (Experience listed in B1 and B2 plus experience in the Applicable discipline equal a minimum of 10 years.					
B1	-	-	-	Organization and administration of certification and qualification programs.	>10000	1974 Commonwealth Assoc. Level III Examiner Ref: 74Dowalo JA NDE CERT CAI 1978 Conam Inspection Level III Ref: 78Dowalo JA NDE CERT pg1 1994 INEEL WINCO Level III Examiner 1996 INEEL LMITCO Level III Examiner Ref: ASNT certification No. JM1655 1995 to 1999 INEEL Development of Mechanical Inspection Certification program
B2	8000	8000	10000	Experience in respective engineering discipline or QA/QC functions Plus requirements from qualifying discipline below	48000	1972 to 1996 qualified NDE Level II in RT, MT, PT, VT, LT, UT and Qulaified ANSI N 45.2.6 Inspector Mechanical Discipline Reference previous certification record.

5. **Examination Results:**

TEST TYPE	INDIVIDUAL TEST SCORES: Written Examinations & Min Number Questions*			Practical Examinations			COMPOSITE SCORE
	ASNT Level III	LTE Spec. 10/(20)	[NDE Method] Spec10/( )	Demo	Oral	Other	
Description	JM1655	00Dowalo JA LTE SPEC	Appendix E Table	Appendix E Table			
SCORES	Pass	100	N/A	N/A			90
DATE	1992		N/A	N/A			

* The Minimum number of examination questions is reduced when the scope of qualification is LIMITED MCP-535 Appendix A & D. Min # questions/(actual # questions)

6.

Additional Training Required Prior to Re-examination:	Minimum up-date or re-certification training:			
None	Hours	Subject Required	Hours	Ref. Documentation

7. **The "Applicant" is Certified in accordance with MCP-535 to perform the above Discipline –Method.**

Certifying Certification Administrator:	Effective Date of Certification:	Certification Expiration Date:
J. S. Stone [signature] Date: 8/27/2002	**8/27/2002**	**8/27/2007***

*Certification expiration date based on Professional Certification expiration date or 5 years, whichever occurs first.

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BBWI PERSONNEL CERTIFICATION DATA FORM

01Dowalo JA GI-LTE CERT

SECTION I – Request (To be filled out by Applicant's Supervisor)

Applicant: **Dowalo, J. A.** S#: **45866** Current certification expires: Initial with BBWI Date: 2/23/02

Inspection activity candidate will be performing Perform and document training, qualification and certification activities when requested by the Certification Administrator or PLTE. Evaluate or provide technical interpretations within the specified method of existing implementing procedures and advise PLTE of actions that are beyond the scope of or change existing procedures and techniques. *(MCP535 para. 4.1.5)*

SECTION II – Processing Documentation and Evaluations: (To be filled out by Level II and others as requested.)

1. Discipline: **General** Method: **General** Level: **III** **Inspector**
Limits: **None**

2. **Physical/Vision Examination** Ref. MCP-535 Appendix I — **Applicant's Education Level**

Due Date 9/4/2002	A. Near Vision	B. Far Vision	C. Color Discrimination	☐ 4 Yr. Degree	☒ 2 Yr. Degree
Requirement	20/25 Snellen	N/A	OMP Color exam	☐ H.S./Equal	☐ Other
Corrected/Uncorrected	Uncorrected	Corrected	No restrictions noted	Note: 1981 Uofl Certificate of Proficiency QA	

3. **Training:** * Sub Exp. = additional experience permitted to substitute for formal training as specified in Appendix F or G

MCP-535 Appendix B, F, or G	Class Hr. by Education Level			Training Acquired (Ref. MCP-535 Appendix D)	
Subject/Topic/Description	H.S.	+ 2 Yr.	Sub Exp.*	Hr.	Description
[General Inspection] Technologies QA/QC Training	N/A	N/A	N/A	96 8	1973 NSC QC Inspection Training Ref: 73Dowalo JA NDE TRN NSC 1972 NSC Drawing Training Ref: 73Dowalo JA NDE TRN NSC

3a. **OJT/Self Study:**

Type & Activity/Objective Required	Req. Hr.	Date	Hr.	Reference Documentation and Comments:
Nuclear inspection experience or training specific to Nuclear QA program aspects.	4000 or sufficient training		N/A 48000	2001 INEEL Qualified QE DOE/RW-0333P QARD for SNF Ref: Train Qualification code QL-0333P 1972 to 1996 Nuclear Industry QA Experience.

4. **Experience:** Ref. MCP-535 Appendix A, B, F or G

	Hr. Required			Required Experience	Experience Obtained	
	H.S.	+ 2 Yr.	+ 4 Yr.	Description	Hr.	Reference/Documentation
	Base LTE requirement: Experience from both row B1 and B2. (Experience listed in B1 and B2 plus experience in the Applicable discipline equal a minimum of 10 years.					
B1	-	-	-	Organization and administration of certification and qualification programs.	YES	1974 Commonwealth Assoc. Level III Examiner Ref: 74Dowalo JA NDE CERT CAI 1978 Conam Inspection Level III Ref: 78Dowalo JA NDE CERT pg1 1994 INEEL WINCO Level III Examiner 1996 INEEL LMITCO Level III Examiner Ref: ASNT certification No. JM1655
B2	8000	8000	10000	Experience in respective engineering discipline or QA/QC functions Plus requirements from qualifying discipline below	48000	1972 to 1996 qualified NDE Level II in RT, MT, PT, VT, LT, UT and Qulaified ANSI N 45.2.6 Inspector Mechanical Discipline Reference previous certification record.

5. **Examination Results:**

TEST TYPE	INDIVIDUAL TEST SCORES						COMPOSITE SCORE
	Written Examinations & Min Number Questions*			Practical Examinations			
	ASNT Level III	LTE Spec. 10/(20)	[NDE Method] Spec10/( )	Demo	Oral	Other	
Description	JM1655	00Dowalo JA LTE SPEC	Appendix E Table	Appendix E Table			
SCORES	Pass	100	N/A	N/A			90
DATE	1992		N/A	N/A			

* The Minimum number of examination questions is reduced when the scope of qualification is LIMITED MCP-535 Appendix A & D. Min # questions/(actual # questions)

6.

Additional Training Required Prior to Re-examination:	Minimum up-date or re-certification training:			
None	Hours	Subject Required	Hours	Ref. Documentation

7. **The "Applicant" is Certified in accordance with MCP-535 to perform the above Discipline – Method.**

Certifying Certification Administrator:	Effective Date of Certification:	Certification Expiration Date:
J. S. Stone [signature] Date: 2/27/2002	**8/15/2001**	**8/15/2006***

*Certification expiration date based on Professional Certification expiration date or 5 years, whichever occurs first.

APPENDIX D. PRESSURE AND HELIUM LEAK TEST REPORTS

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PNEUMATIC PRESSURE TEST EXAMINATION REPORT

Page 1 of 1

E-file Name: SNF Canister 24MOD-45-1 Post Drop Pressure Test.doc

Shaded Areas Essential Variable Data

Examination Date: SEE DATE COLUMN IN TEST RESULTS TABLE   Project/W.O*: SNF Canister Drop Test   Report No. *: N/A

Inspection Instruction: SNF WO 73626

System: SNF Canister MULTIPLE   Component: SEE ITEM NAME BELOW   Drawings*: N/A

Test Method		Test Equipment Gages: (P – Pressure; V – Vacuum; T – Temp)					
Procedure No. / Rev.	TPR-Work order /	Type	Description	Range	Units	ID	Calib. Due
Procedure Appendix:		T	See work order record				
TEST SYSTEM CONTROLS	MANUAL ☒ AUTO/SOFTWARE ☐						

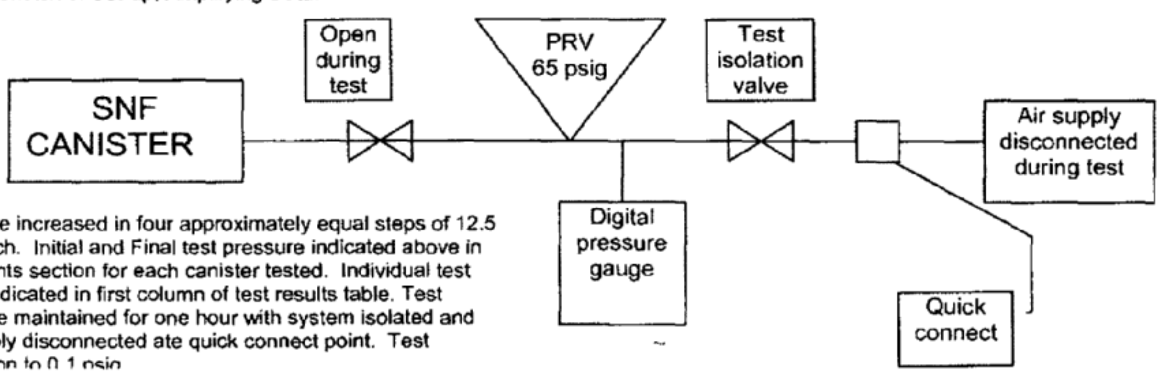
Vacuum Rate of Rise ☐		Direct Pressure ☒	
Variable	Description/Data	Variable	Description/Data
Test Gas:	AIR	Reference Volume CC	N/A Pneumatic pressure test only.
Ambient Temp. ° C	(73°F) 22.8°C	Test Volume CC:	N/A leak rate not calculated
Ambient Press Torr abs	N/A test pressure psig	Holding Time: MM:SS	60:00

Acceptance Procedure No. / Rev.	Paragraph/Appendix	Maximum Single Leak Rate	Maximum Sum of Leak Rates
TPR- /		LR ≤ N/A X 10⁻ cc/sec	Σ LR ≤ N/A X 10⁻ cc/sec

Test Results

No. * Date of Test	Item Name	Origin*	Terminus*	ACC	REJ	Comments*
10/25/04	**24-MOD-45-1**	CANISTER	Test system Isolation valve	Accept		50.9 psig start at 15:44 hrs. end pressure 50.9 psig at 16:44 hrs.
10/26/04	**24-MOD-70-2**	CANISTER	Test system isolation valve	Accept		51.0 psig start at 09:52 hrs. end pressure 51.0 psig at 11:02 hrs.
11/10/04	**MCO-60-2**	CANISTER	Test system isolation valve	Accept		50.4 psig start at 13:30 hrs. end pressure 50.4 psig at 14:30 hrs.
11/10/04	**MCO-00-1**	CANISTER	Test system isolation valve	Accept		50.7 psig start at 15:10 hrs. end pressure 50.7 psig at 16:10 hrs.

Results, Sketch of Set-up, Amplifying Data:



Pressure increased in four approximately equal steps of 12.5 psig each. Initial and Final test pressure indicated above in comments section for each canister tested. Individual test dates indicated in first column of test results table. Test pressure maintained for one hour with system isolated and air supply disconnected ate quick connect point. Test resolution to 0.1 psig

Use additional sheets as needed.

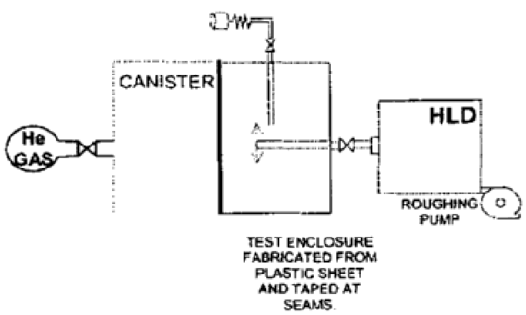
James A. Dowalo, Mechanical Level III	[signature]	12/20/2004
Inspector & Title Print/Type	Inspector Signature	Date

HELIUM MASS SPECTROMETER LEAK TESTING EXAMINATION REPORT

eFile Name: SNF Canister MCO-00-1 Post Drop Leak Test

Examination Date: 11/11/2004 73626 SNF Canister Drop Test		System Component: Canister **MCO-00-1**		Page 1 of Pages 2
Surface Conditional/Preparation: As fabricated (rolled, welded, machined)	Weld/Part No: MCO-00-1	N/A	N/A	Material Type: SST
Technique: Procedure: TPR-4976	Rev.: 0	Appendix: D - DETECTOR PROBE (SNIFFER) METHOD		Reference: **PQR-LT02**

Test System Sketch:



☐ INTERNAL ☒ EXTERNAL HLD STD LEAK: ID#: 702921 DUE: 3/19/05

☐ DETECTOR with HOOD ☐ DETECTOR without HOOD

☐ AUX ROUGHING PUMP ☒ HELIUM SNIFFER PROBE

☒ TRACER GAS ENCLOSURE ☐ TRACER GAS ENCL PUMP

☐ ORFICE TYPE SYS STD LEAK ☐ SYS STD LEAK AUX PUMP

SYSTEM STANDARD LEAK: ID#: 702921 DUE: 3/19/05

TRACERT GAS SUPPLY TYPE Helium; CONCENTRATION 99.98%

Temp. Gauge: Type: OAKTON InfaPro, ID #: 718037 Cal. due: 9/15/05 | Pressure Gauge: Type: E-manometer ID #: 715963Cal. due: N/A used for reference only

HLD Model: Varian 979 Ser,# Gov ID 356751 | Rough Pump Speed: 7 cfm

Test Hose Mat'l Tygon Tubing, Varian power probe P/N K9565301 | Size: 10 ft. long x 1/4 in. ID

HLD Pre-test Calibration Data: Time: 1:00 AM/PM Temperature (T): 75° F / 23.8 °C

Standard Leak Temp Dependent Value (STDV): 3.6e-08 std cc/s | HLD Background BG: 4.28e-11 std cc/s

Read std. Leak (CL): 3.04e-08std cc/s | Pre-test HLD Sensitivity = STDV / (CL-BG)=: 119%

System Pre-test Calibration Data: Time: 2:47 AM/PM Temperature (T_1): 73° F / 22.8 °C

Standard Leak Temp Dependent Value ($STDV_1$): 3.6e-08std cc/s | Read std. Leak (CL_1): 8.0e-08 std cc/s | Wait Time: 120 Sec

Sys Background BG: 5.1e-08 atm cc/s | Clean-up Time: 120Sec | Pre-test System Sensitivity $S_1 = STDV_1 / (CL_1 - BG)$= 124%

Tracer Gas Backfill Data: Time: 2:52 AM/PM Temperature: 73°F/ 22.8 °C Atmospheric Pressure: 634Torr abs

Start Vacuum (P_2): 1Torr abs | End Backfill Pressure (P_1): 744Torr abs | Torr abs $(P_1 - P_2) / P_1$ = % He*: | >95%

System Test Data (After Helium Backfill): Time: 2:57 AM/PM Temperature: 74° F / 23.3° C

HLD Response after Wait Time*: 1.2e-07 atm cc/s | Sys Background BG*: 1.2e-07 atm cc/s*** | Test result evaluated below

HLD Post-test Calibration Data: Time: 2:58 AM/PM Temperature (T_1): 72° F / 21.6° C

Std. Leak Temp Dependent Value ($STDV_2$): 3.6e-08 std cc/s | Reading with std. Leak open after wait time (CL_2): 2.94e-08 atm cc/s

Sys Background BG: 5.0e-atm cc/s | Clean-up Time: 20Sec | Pre-test System Sensitivity $S_2 = STDV_2 / (CL_2 - BG)$= 123%

Acceptance Criteria:	Rev.:	Appendix:	Code:	
Procedure: Spent Fuel Project Office Interim Staff Guidance 18 signed E. William Brach	May 2, 2003	N/A	ANSI N14.5097	Q = leak tight 1.0e-07 ref cc/sec

TEST	HLD Reading	Test BG atm cc/sec	~~LR~~ Reading atm cc/sec	S_1	S_2	Actual LR std cc/sec	LR ≤ Q ACC	LR ≤ Q REJ	Observation Description and Location*
1 Entire canister	1.2e-07***	1.2e-07	0.00Ee-07	N/A	N/A	No leakage	XX		*** The HLD panel display briefly rose above 7e-07 cc/sec when helium backfill was started and settled back to background level after 120 seconds. Leakage not greater than 1 x 10^{-05} std cc/sec.

*Sketches, if necessary, may be made on additional sheets, (refer to a NCRs). (If additional sheets are used ensure identity and pagination are traceable to this filled out report)

HELIUM MASS SPECTROMETER LEAK TESTING EXAMINATION REPORT

eFile Name: SNF Canister MCO-00-1 Post Drop Leak Test

Examination Date:	System Component:	Page	Pages
11/10/2004 SNF Canister Drop Test	Canister **MCO-00-1**	2 of	2

ANSI N14.5-97 rates the detector probe technique not greater than 1 x 10^{-05} cc/sec sensitivity. Although a calibrated leak in the 10^{-08} was used for calibration, the actual leakage rate cannot be measured using this method. The calibrated leak is used to only determine if the HLD is detecting helium and the technique only determines if there is or is not a leak detectable.

* Backfill helium concentration achieved by evacuating the canister to 1 Torr abs and backfilling with Helium up to 744 Torr abs (approx 100 Torr (2 psig) positive pressure, through the ½ FNPT test port in the canister head. Calculated 99.8% concentration He.

** The helium leak detector (HLD) was calibrated using external helium leak standard attached at the HLD test port. The detector probe (sniffer) was attached to the HLD test port and response checked using the external leak standard. Response above background of 3.0 x 10^{-08} was observed when placing the external leak standard (CL) within ½ inch of the sniffer. The enclosure was monitored with sniffer inside plastic enclosure for 2-min the background reading on the HLD panel was 1.2e-07. Response was again checked inside plastic enclosure by placing the CL inside enclosure for 2 min and inserting the sniffer probe into the plastic enclosure (CL on bottom of enclosure and sniffer into top of enclosure). The HLD responded with 1.4 x 10^{-07} cc/sec reading (2e-08 cc/sec above background).
The leak test was then conducted with the sniffer probe inserted into the enclosure while backfilling the canister with Helium as described above for backfill.

Calibration	HLD Pretest calibration	Sniffer Pretest response	HLD Posttest calibration
S	118.6%	124.1%	122.7%
CL	3.04E-08	8.00E-08	2.94E-08
BG	4.28E-11	5.10E-08	5.00E-11
STDV	3.60E-08	3.60E-08	3.60E-08

Canister MCO-00-1

Pretest and Posttest HLD calibration with external CL installed in test port. Pretest response with sniffer attached to test port and CL held within 1/2" of sniffer probe for 20 seconds.

Test conclusion: could not test canister to any higher sensitivity due to residual helium contamination internal to canister. **No detected leakage greater than 1 x 10^{-05} cc/sec helium from canister.**

Examiner: James A. Dowalo III / ASNT cert@ 33403 (NDE Level)	1/5/2005 (Date)	N/A

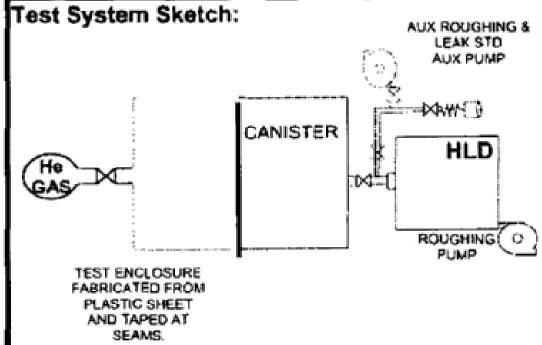
Shaded areas represent essential variables (ref. MCP-195)

HELIUM MASS SPECTROMETER
LEAK TESTING EXAMINATION REPORT

eFile Name: SNF Canister MCO-60-2 Post Drop Leak Test

Examination Date: 11/17/2004 73626 SNF Canister Drop Test	System Component: Canister **MCO-60-2**		Page 1 of Pages 2
Surface Conditional/Preparation: As fabricated (rolled, welded, machined)	Weld/Part No: MCO-60-2	N/A / N/A	Material Type: SST
Technique: Procedure:TPR-4976	Rev.: 0	Appendix: E, Hood technique	Reference: **PQR-LT12**

Test System Sketch:



☐ See Bombing Technique data in remarks section for modification of backfill gas data.

☐ INTERNAL ☒ EXTERNAL HLD STD LEAK: ID#: 702921 DUE: 3/19/05

☒ DETECTOR with HOOD ☐ DETECTOR without HOOD

☒ AUX ROUGHING PUMP ☐ HELIUM SNIFFER PROBE

☒ TRACER GAS ENCLOSURE ☐ TRACER GAS ENCL PUMP

☐ ORFICE TYPE SYS STD LEAK ☒ SYS STD LEAK AUX PUMP

SYSTEM STANDARD LEAK: ID#: 702921 DUE: 3/19/05

TRACERT GAS SUPPLY TYPE Helium; CONCENTRATION 99.98%

Temp. Gauge: Type: OAKTON InfaPro, ID #: 718037 Cal. due: 9/15/05 | Pressure Gauge: Type: E-manometer ID #: 715963Cal. due: N/A used for reference only

HLD Model: Varian 979 Ser,# Gov ID 356751 | Rough Pump Speed: 7 cfm*

Test Hose Mat'l rubber | Size: 3 ft. long x 1/2 in. ID

HLD Pre-test Calibration Data: Time: 14:22 ~~AM~~/PM Temperature (T): 73° F / 22.8 °C

Standard Leak Temp Dependent Value (STDV): 3.6e-08 std cc/s | HLD Background BG: 1.0e-12 std cc/s

Read std. Leak (CL): 2.13e-08std cc/s | Pre-test HLD Sensitivity = STDV / (CL-BG)=: 169%

System Pre-test Calibration Data: Time: 15:59 ~~AM~~/PM Temperature (T_1): 72°F/ 22.2 °C

Standard Leak Temp Dependent Value ($STDV_1$): 3.6e-08std cc/s | Read std. Leak (CL_1): 8.63e-08 std cc/s | Wait Time: 15 Sec

Sys Background BG: 7.57e-08 atm cc/s | Clean-up Time: 20Sec | Pre-test System Sensitivity $S_1 = STDV_1 / (CL_1 - BG)$= 170%

Tracer Gas Backfill Data: Time: 16:06 ~~AM~~/PM Temperature: 72°F/ 22.2 °C Atmospheric Pressure: 634Torr abs

Start Vacuum (P_2): 633Torr abs | End Backfill Pressure (P_1): 740Torr abs | Backfill helium concentration**: >90%

System Test Data (After Helium Backfill): Time: 16:15 ~~AM~~/PM Temperature : 72° F / 22.2° C

HLD Response after Wait Time*: 6.75e-08 atm cc/s | Sys Background BG*: 6.42e-08 atm cc/s | Test result evaluated below

System Post-test Calibration Data: Time: 16:17 ~~AM~~/PM Temperature (T_1): 72° F / 22.2° C

Std. Leak Temp Dependent Value ($STDV_2$): 3.6e-08 std cc/s | Reading with std. Leak open after wait time (CL_2): 7.53e-08 atm cc/s

Sys Background BG: 6.70e-08atm cc/s | Clean-up Time: 20Sec | Pre-test System Sensitivity $S_2 = STDV_2 / (CL_2 - BG)$= 434%

Acceptance Criteria:	Rev.:	Appendix:	Code:	
Procedure: Spent Fuel Project Office Interim Staff Guidance 18 signed E. William Brach	May 2, 2003	N/A	ANSI N14.5097	Q = leak tight 1.0e-07 ref cc/sec

TEST	HLD Reading	Test BG atm cc/sec	LR Reading atm cc/sec	S_1	S_2	Actual LR std cc/sec	LR ≤ Q ACC	LR ≤ Q REJ	Observation Description and Location*
1	6.75e-08	6.42e-08	0.33e-08	1.70	4.34	1.43e-08	**XX**		Leakage not greater than 1.43×10^{-08} std cc/sec.

*Sketches, if necessary, may be made on additional sheets, (refer to a NCRs). (If additional sheets are used ensure identity and pagination are traceable to this filled out report)

HELIUM MASS SPECTROMETER
LEAK TESTING EXAMINATION REPORT

eFile Name: SNF Canister MCO-60-2 Post Drop Leak Test

Examination Date:	System Component:	Page	Pages
11/17/2004 SNF Canister Drop Test	Canister **MCO-60-2**	**2** of	**2**

*Auxiliary roughing pump (11 cfm) used to achieve crossover pressure to allow HLD to enter test mode and evacuate excess He at external leak standard. Aux pump isolated from test volume during leak detection phase of testing.

** Backfill helium concentration determined by estimated exchange of enclosure volume. Enclosure volume 15.7 ft^3 (see estimation) helium backfill flow rate 20 ft^3 min. back fill min 3-min. equal at leas 3 volume exchanges in enclosure. Estimate 90% concentration He.

Estimate of enclosure volume all units feet

Dia = 2	Dia = 2.2
Area x-sec $(dia / 2)^2 * pi$	Area x-sec $(dia / 2)^2 * pi$
3.141593	3.801327
Length = 18	Length = 19
Volume = Length X Area x-section	Volume = Length X Area x-section
56.54867 cubic ft.	72.22522 cubic ft.

Enclosure volume to backfill with I 15.67655 cubic ft.

Calibration	HLD Pretest	System LR factor S1	S2	Canister MCO-60-2
S	169.0%	161.4%	433.7%	S1 and S2 used to adjust instrument
CL	2.13E-08	8.63E-08	7.53E-08	measured leakage rate to actual system
BG	1.00E-12	6.40E-08	6.70E-08	standard leakage rate.
STDV	3.60E-08	3.60E-08	3.60E-08	

Examiner: James A. Dowalo III/ ASNT cert@ 33403 — NDE Level	1/5/2005 — Date	N/A

Shaded areas represent essential variables (ref. MCP-195)

414.73
02/20/2003
Rev. 04
Use with MCP-535

BBWI PERSONNEL CERTIFICATION DATA FORM

03Dowalo JA QLLT0002

SECTION I – Request (To be filled out by Applicant's Supervisor)

Applicant: **Dowalo, J. A.** S#: **45866** Current certification expires: 11/2003 Date: 10/17/03

Inspection activity candidate will be performing: Perform and document training, qualification and certification activities when requested by the Certification Administrator or PLTE. Evaluate or provide technical interpretations within the specified method of existing implementing procedures and advise PLTE of actions that are beyond the scope of or change existing procedures and techniques. *(MCP535 para. 4.1.5)*

SECTION II – Processing Documentation and Evaluations: (To be filled out by Level II and others as requested.)

1. Discipline: **NDE** Method: **Leak Testing** Level: **III** **Inspector**
Limits: **None**

2. **Physical/Vision Examination** Ref. MCP-535 Appendix I — **Applicant's Education Level**

Due Date 9/4/2002	A. Near Vision	B. Far Vision	C. Color Discrimination	☐ 4 Yr. Degree	☒ 2 Yr. Degree
Requirement	20/25 Snellen	N/A	OMP Color exam	☐ H.S./Equal	☐ Other
Corrected/Uncorrected	Uncorrected	Corrected	No restrictions noted	Note: 1981 Uofl Cert. of Proficiency QA	

3. **Training:** * Sub Exp. = additional experience permitted to substitute for formal training as specified in Appendix F or G

MCP-535 Appendix B, F, or G	Class Hr. by Education Level			Training Acquired (Ref. MCP-535 Appendix D)	
Subject/Topic/Description	H.S.	+ 2 Yr.	Sub Exp.*	Hr.	Description
[Leak Testing] Examination Technologies as described in ASNT Level III recommended training outline	N/A	N/A	N/A	10 40	1978 Advex Corp. Leak Testing Basic 78Dowalo JA NDE CERT Advex 1999 Varian Basic Vacuum and Application ref: 99Dowalo JA LT-TRAIN Varian

3a. **OJT/Self Study:**

Type & Activity/Objective Required	Req. Hr.	Date	Hr.	Reference Documentation and Comments:
Helium Leak Testing LaSalle County Nuclear Sta. Job site performance Hood Leak Test Emer. Cooling Piping	N/A	1976	80	Perform Hood leak testing of 18 Ft Diameter pipe component weld seams for Conam Inspection
Nuclear inspection experience or training specific to Nuclear QA program aspects.	4000 or sufficient training		N/A 48000	2001 INEEL Qualified QE DOE/RW-0333P QARD for SNF Ref: Train Qualification code QL-0333P 1972 to 1996 Nuclear Industry QA Experience.

4. **Experience:** Ref. MCP-535 Appendix A, B, F or G

	Hr. Required			Required Experience	Experience Obtained	
	H.S.	+ 2 Yr.	Other	Description	Hr.	Reference/Documentation
	Base LTE requirement: Experience from both row B1 and B2. (Experience listed in B1 and B2 plus experience in the Applicable discipline equal a minimum of 10 years.					
B1	-	-	-	Organization and administration of certification and qualification programs.	YES	1974 Commonwealth Assoc. Level III Examiner Ref: 74Dowalo JA NDE CERT CAI 1978 Conam Inspection Level III Ref: 78Dowalo JA NDE CERT pg1 1994 INEEL WINCO Level III Examiner 1996 INEEL LMITCO Level III Examiner Ref: Previous Cert 1999 to 11/2003 ASNT & INEEL BBWI Level III Examiner Ref 99Dowalo JA LT-LTE CERT
B2	8000	8000	10000	Experience in respective engineering discipline or QA/QC functions Plus requirements from qualifying disciplinebelow	48000	1972 to 1996 qualified NDE Level II in RT, MT, PT, VT, LT, UT Reference previous certification record.
	NDE Discipline: Complete both row N1 and N2					
N1	8000	10000	8000	(NDE LTE only) Of related NDE Level II Inspector experience in any NDE methods.	48000	1972 to 1996 qualified NDE Level II in RT, MT, PT, VT, LT, UT Reference previous certification record.
N2	8000	4000	2000	(NDE LTE only) Of NDE Level II or equivalent in [Leak Testing]	48000 14000	1975 to 1996 qualified minimum Level II each employment location 1996 to 2003 INEEL Level III LT

5. **Examination Results:**

TEST TYPE	INDIVIDUAL TEST SCORES						COMPOSITE SCORE
	Written Examinations & Min Number Questions*			Practical Examinations			
	ASNT Level III	Gen.10/(20)	Spec.10/( )	Demo	Oral	Other	
Description	Re-Cert # 33403	00Dowalo JA LTE SPEC	Appendix E Table	Appendix E Table			80
Scores	Pass	100	N/A	N/A			
Date	11/2004	11/2000	N/A	N/A			

* The Minimum number of examination questions is reduced when the scope of qualification is LIMITED MCP-535 Appendix A & D. Min # questions/(actual # questions)

6.

Additional Training Required Prior to Re-examination:	Minimum up-date or re-certification training:			
None	Hours	Subject Required	Hours	Ref. Documentation

7. **The "Applicant" is Certified in accordance with MCP-535 to perform the above Discipline – Method.**

Effective Date of Certification:	Certification Expiration Date:	TRAIN Qualification Code:
11/2003	**10/2008**	QLLT0002

J. S. Stone
Principle Level III Examiner
Print/Type Name

[signature]
Principle Level III Examiner
Signature

11/26/03
Date

The American Society for Nondestructive Testing, Inc.

Be it known that

James A Dowalo

has met the established and published Requirements for Certification by ASNT as

NDT Level III

in the following Nondestructive Testing Methods:

Method	Issue Date	Expiration Date
Leak Testing	10/03	10/08
Magnetic Particle	10/03	10/08
Liquid Penetrant	10/03	10/08
Radiographic Testing	10/03	10/08
Visual and Optical	10/03	10/08

33403
Certificate Number

ASNT President

Certification Management Council Chair

This certificate is the property of ASNT and is not official without ASNT's raised gold seal.

APPENDIX E. MEASURING AND TEST EQUIPMENT CALIBRATION DOCUMENTATION

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721516 Mfr: INTERFACE Model: 5000 LB Noun Name: LOAD CELL

		ACTION CODE		AS FOUND	
Calibration Date:	6/17/2004				
Next Cal Due Date:	3/17/2005	1 ☐	Acceptance Test	1 ○	In Tolerance
Charge Level:	64	2 ☐	Special Test	2 ●	Out of Tolerance >1x <2x
Repair Charge Level:	0	3 ☐	Calibration to MFG Specs	3 ○	Out of Tolerance >2x <3x
Material Amount:	0	4 ☐	Clean	4 ○	Out of Tolerance >3x <5x
Charge Number:	100664GSA	5 ☑	Limited Calibration	5 ○	Out of Tolerance >5x
Cal Work Inst ID:	5748C	6 ☐	Functional Check	6 ○	Out of Tolerance-Undetermined
Outside Vendor:		7 ☐	Performance Check	7 ☐	Inoperative
		8 ☐	Modify	8 ☐	Damaged
		9 ☐	Repair-needs Charge Level	9 ☐	Not Used
		10 ☐	Other	10 ☐	Not Determined
				11 ☐	Excessed
Calibrated By:	Stan Zohner	S#: 58146	Phone: 526-2761	12 ☐	Update

CALIBRATION STANDARDS USED

715606	714631	715559	714644	709226			

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY
4492.6238	LBS/TENS/DISP	4500	+/- 6
4692.369	LBS/TENS/DISP	4700	+/- 6
4493.3956	LBS/COMP/DISP	4500	+/- 6
4692.9214	LBS/COMP/DISP	4700	+/- 6

COMMENTS

UNIT WAS OUT OF TOLERANCE IN DISPLAY MODE. MADE ADJSUTMENTS AND RECALIBRATED.

INITIAL CALIBRATION USING mV OUT

LIMITED: MUST BE USED WITH DISPLAY P# 721514 CH 2. ECAL 4.041 ESCL 4770. IF NOT USED WITH ABOVE LISTED DISPLAY MAY BE USED IN mV OUTPUT MODE.

EXCITATION VOLTAGE: 10 VDC.

CALIBRATED AND THEN GENERATED NEW COEFFIECIENTS.

TENSION COEFFICIENTS A: -0.4066477956 B: 116.5617946 C: -0.001512210655

COMPRESSION COEFICIENTS A: -0.7305250315 B: -116.6423674 C: -0.002982122665

NSNFP Comments

All weighing activities performed with the 5000-lb load cell were tension measurements at weights below 3000 lbs. Since the out-of-tolerances occurred in the weight range above 4000 lbs, the weight measurements are still valid and within acceptable tolerances.

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721516 Mfr: INTERFACE Model: 5000 LB Noun Name: LOAD CELL

Calibration Date:	9/8/2003		ACTION CODE		AS FOUND
Next Cal Due Date:	6/8/2004	1 ☐	Acceptance Test	1 ◉	In Tolerance
Charge Level:	12	2 ☐	Special Test	2 ○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3 ☐	Calibration to MFG Specs	3 ○	Out of Tolerance >2x <3x
Material Amount:	0	4 ☐	Clean	4 ○	Out of Tolerance >3x <5x
Charge Number:	100348027	5 ☑	Limited Calibration	5 ○	Out of Tolerance >5x
Cal Work Inst ID:	5748C	6 ☐	Functional Check	6 ○	Out of Tolerance-Undetermined
Outside Vendor:		7 ☐	Performance Check	7 ☐	Inoperative
		8 ☐	Modify	8 ☐	Damaged
		9 ☐	Repair-needs Charge Level	9 ☐	Not Used
		10 ☐	Other	10 ☐	Not Determined
				11 ☐	Excessed
Calibrated By:	Stan Zohner	S#: 58146	Phone: 526-2761	12 ☐	Update

CALIBRATION STANDARDS USED

708595	711804	714631					

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

INITIAL CALIBRATION
LIMITED: MUST BE USED WITH READOUT P# 721514 CH 2
ECAL 4.005 ESCL 4665

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721517 Mfr: INTERFACE Model: 25,000 LB Noun Name: LOAD CELL

			ACTION CODE		**AS FOUND**
Calibration Date:	6/10/2004				
Next Cal Due Date:	3/10/2005	1 ☐	Acceptance Test	1 ○	In Tolerance
Charge Level:	64	2 ☐	Special Test	2 ○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3 ☐	Calibration to MFG Specs	3 ◉	Out of Tolerance >2x <3x
Material Amount:	0	4 ☐	Clean	4 ○	Out of Tolerance >3x <5x
Charge Number:	100664GSA	5 ☑	Limited Calibration	5 ○	Out of Tolerance >5x
Cal Work Inst ID:	5748C	6 ☐	Functional Check	6 ○	Out of Tolerance-Undetermined
Outside Vendor:		7 ☐	Performance Check	7 ☐	Inoperative
		8 ☐	Modify	8 ☐	Damaged
		9 ☐	Repair-needs Charge Level	9 ☐	Not Used
		10 ☐	Other	10 ☐	Not Determined
				11 ☐	Excessed
Calibrated By:	Stan Zohner	S#: 58146	Phone: 526-2761	12 ☐	Update

CALIBRATION STANDARDS USED

714644	709226	715606	715558	321765			

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY
14030.175	LBS/TENS/DISP	14000	+/- 30
16032.7414		16000	
18035.1567		18000	
20003.5019		19970	

COMMENTS

NOMINAL (STD)	UNIT	AS FOUND (UUT)	MFG. ACCURACY
11957.2509	lbs/comp/display	12000	"+/-" 30
13950.4267	lbs/comp/display	14000	"+/-" 30
15950.7271	lbs/comp/display	16000	"+/-" 30
17943.5742	lbs/comp/display	18000	"+/-" 30
19904.8449	lbs/comp/display	19970	"+/-" 30

NOMINAL (STD)	UNIT	AS FOUND (UUT)	MFG. ACCURACY
7499.781	lbs/comp/mV out	75731.3107	"+/-" 30
9700.265	lbs/comp/mV out	9736.3327	"+/-" 30
12499.2056	lbs/comp/mV out	12538.7598	"+/-" 30
1500.9565	lbs/comp/mV out	15049.1124	"+/-" 30
17498.734	lbs/comp/mV out	17551.5968	"+/-" 30
20002.2287	lbs/comp/mV out	20062.3942	"+/-" 30
22501.7533	lbs/comp/mV out	22565.9076	"+/-" 30
25002.106	lbs/comp/mV out	25070.7826	"+/-" 30

UNIT WAS OUT OF TOLERANCE USING DISPLAY IN BOTH TENSION AND COMPRESSION. UNIT WAS ALSO OUT OF TOLERANCE USING mV/V OUTPUT IN COMPRESSION

MADE ADJUSTMENTS TO CH3 DISPLAY. UNIT IS CALIBRATED WITHOUT DISPLAY AS PER TOM RAHL REQUEST.

LIMITED: MUST BE USED WITH DISPLAY P# 721514 CH 3. ECAL 3.420 ESCL 19970 DISPLAY NOT CALIBRATED IN COMPRESSION AS PER TOM RAHL.

IF NOT USED WITH ABOVE LISTED DISPLAY MAY BE USED IN mV OUTPUT MODE IN BOTH TENSION AND COMPRESSION.

EXCITATION VOLTAGE: 10 VDC. TENSION COEFFICIENTS A: -7.738556206 B: 586.6181591 C: -.0339316991 COMPRESSION COEFICIENTS A: -8.901063581 B: -582.7266538 C: .002346861845

NSNFP Comments

This load cell was only used after this recalibration.

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721436 Mfr: STARRETT Model: 20-24 INCH Noun Name: DIGITAL OD MICROMETER

				ACTION CODE			AS FOUND
Calibration Date:	7/22/2004						
Next Cal Due Date:	7/22/2005	1	[ ]	Acceptance Test	1	[x]	In Tolerance
Charge Level:	4	2	[ ]	Special Test	2	[ ]	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	[x]	Calibration to MFG Specs	3	[ ]	Out of Tolerance >2x <3x
Material Amount:	0	4	[ ]	Clean	4	[ ]	Out of Tolerance >3x <5x
Charge Number:	100664GSA	5	[ ]	Limited Calibration	5	[ ]	Out of Tolerance >5x
Cal Work Inst ID:	3078G	6	[ ]	Functional Check	6	[ ]	Out of Tolerance-Undetermined
Outside Vendor:		7	[ ]	Performance Check	7	[ ]	Inoperative
		8	[ ]	Modify	8	[ ]	Damaged
		9	[ ]	Repair-needs Charge Level	9	[ ]	Not Used
		10	[ ]	Other	10	[ ]	Not Determined
					11	[ ]	Excessed
Calibrated By:	Larry Deming	S#:	39571	Phone: 526-2761	12	[ ]	Update

CALIBRATION STANDARDS USED

705471	718306						

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721436 Mfr: STARRETT Model: 20-24 INCH Noun Name: DIGITAL OD MICROMETER

				ACTION CODE			AS FOUND
Calibration Date:	7/25/2003 6:16:23 AM						
Next Cal Due Date:	7/25/2004	1	☐	Acceptance Test	1	◉	In Tolerance
Charge Level:	4	2	☐	Special Test	2	○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	○	Out of Tolerance >2x <3x
Material Amount:	0	4	☐	Clean	4	○	Out of Tolerance >3x <5x
Charge Number:	100348027	5	☐	Limited Calibration	5	○	Out of Tolerance >5x
Cal Work Inst ID:	3078G	6	☐	Functional Check	6	○	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Terry Wilde	S#:	57438	Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

718307	707769	703081	705471				

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

INITIAL CALIBRATION

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721438 Mfr: STARRETT Model: 24-30 INCH Noun Name: DIGITAL OD MICROMETER

				ACTION CODE			AS FOUND
Calibration Date:	7/22/2004						
Next Cal Due Date:	7/22/2005	1	☐	Acceptance Test	1	◉	In Tolerance
Charge Level:	4	2	☐	Special Test	2	○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	○	Out of Tolerance >2x <3x
Material Amount:	0	4	☐	Clean	4	○	Out of Tolerance >3x <5x
Charge Number:	100664GSA	5	☐	Limited Calibration	5	○	Out of Tolerance >5x
Cal Work Inst ID:	3078G	6	☐	Functional Check	6	○	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Larry Deming	S#:	39571	Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

705471	718306						

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

MINOR ADJUSTMENT WAS NECESSARY

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL **BADGE: 35231** **PH: 526-0372** **AREA: IF** **BLDG: EROB** **RM: W2/C1**

ID Number: 721438 Mfr: STARRETT Model: 24-30 INCH Noun Name: DIGITAL OD MICROMETER

Calibration Date:	7/25/2003 6:19:09 AM			**ACTION CODE**			**AS FOUND**	
Next Cal Due Date:	7/25/2004	1	☐	Acceptance Test	1	◉	In Tolerance
Charge Level:	4	2	☐	Special Test	2	○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	○	Out of Tolerance >2x <3x
Material Amount:	0	4	☐	Clean	4	○	Out of Tolerance >3x <5x
Charge Number:	100348027	5	☐	Limited Calibration	5	○	Out of Tolerance >5x
Cal Work Inst ID:	3078G	6	☐	Functional Check	6	○	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Terry Wilde	S#:		57438 Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

718307	707769	703081	705471				

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

INITIAL CALIBRATION

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721714 Mfr: STARRETT Model: 6 INCH Noun Name: DIGITAL CALIPER

				ACTION CODE			**AS FOUND**
Calibration Date:	11/2/2004						
Next Cal Due Date:	11/2/2005	1	☐	Acceptance Test	1	☒	In Tolerance
Charge Level:	2	2	☐	Special Test	2	☐	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	☐	Out of Tolerance >2x <3x
Material Amount:	0	4	☐	Clean	4	☐	Out of Tolerance >3x <5x
Charge Number:	100664GSB	5	☐	Limited Calibration	5	☐	Out of Tolerance >5x
Cal Work Inst ID:	3053K	6	☐	Functional Check	6	☐	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Terry Wilde	S#:	57438	Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

718307	702056	703081	707769				

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 721714 Mfr: STARRETT Model: 6 INCH Noun Name: DIGITAL CALIPER

				ACTION CODE			AS FOUND
Calibration Date:	12/15/2003 3:57:03 PM						
Next Cal Due Date:	9/15/2004	1	☐	Acceptance Test	1	◉	In Tolerance
Charge Level:	2	2	☐	Special Test	2	○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	○	Out of Tolerance >2x <3x
Material Amount:	0	4	☐	Clean	4	○	Out of Tolerance >3x <5x
Charge Number:	100664GSB	5	☐	Limited Calibration	5	○	Out of Tolerance >5x
Cal Work Inst ID:	3053J	6	☐	Functional Check	6	○	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Terry Wilde	S#:		57438 Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

718307	707769	703081	702056				

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

INITIAL CALIBRATION
TEST REFERRAL QA# 104353

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 716309 Mfr: FOWLER Model: 6 INCH Noun Name: DIGITAL CALIPER

				ACTION CODE			AS FOUND
Calibration Date:	3/9/2004 8:46:37 AM						
Next Cal Due Date:	12/9/2004	1	☐	Acceptance Test	1	◉	In Tolerance
Charge Level:	2	2	☐	Special Test	2	○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	○	Out of Tolerance >2x <3x
Material Amount:	3	4	☑	Clean	4	○	Out of Tolerance >3x <5x
Charge Number:	530130226	5	☐	Limited Calibration	5	○	Out of Tolerance >5x
Cal Work Inst ID:	3053J	6	☐	Functional Check	6	○	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Terry Wilde	S#:	57438	Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

718307	702056	703081	707769				

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS

REPLACED 2 BATTERIES AT A COST OF $3.00

INEEL
CALIBRATION INPUT DATA

NAME: TOM RAHL	BADGE: 35231	PH: 526-0372	AREA: IF	BLDG: EROB	RM: W2/C1

ID Number: 716309 Mfr: FOWLER Model: 6 INCH Noun Name: DIGITAL CALIPER

				ACTION CODE			AS FOUND
Calibration Date:	6/4/2003 4:24:36 PM						
Next Cal Due Date:	3/4/2004	1	☐	Acceptance Test	1	◉	In Tolerance
Charge Level:	2	2	☐	Special Test	2	○	Out of Tolerance >1x <2x
Repair Charge Level:	0	3	☑	Calibration to MFG Specs	3	○	Out of Tolerance >2x <3x
Material Amount:	0	4	☐	Clean	4	○	Out of Tolerance >3x <5x
Charge Number:	100348027	5	☐	Limited Calibration	5	○	Out of Tolerance >5x
Cal Work Inst ID:	3053J	6	☐	Functional Check	6	○	Out of Tolerance-Undetermined
Outside Vendor:		7	☐	Performance Check	7	☐	Inoperative
		8	☐	Modify	8	☐	Damaged
		9	☐	Repair-needs Charge Level	9	☐	Not Used
		10	☐	Other	10	☐	Not Determined
					11	☐	Excessed
Calibrated By:	Terry Wilde	S#:	57438	Phone: 526-2761	12	☐	Update

CALIBRATION STANDARDS USED

718307	703081	702056	707769				

STANDARDS USED ARE TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY DERIVED FROM ACCEPTED VALUES FOR NATURAL PHYSICAL CONSTANTS, OR DERIVED FROM THE RATIO TYPE OF SELF CALIBRATION TECHNIQUES

LABORATORY TEMPERATURE AND HUMIDITY

Physical	STD. 23.0 ° +/-0.3 ° C (40-55% RH)	Electronic	STD. 23.0 ° +/-0.5 ° C (30-45% RH)
Dimensional	STD. 20.0 ° +/-0.25 ° C (30-45% RH)		STD. 23.0 ° +/-2.0 ° C (20-50% RH)
	CAL. 20.0 ° +/-1.0 ° C (20-50% RH)		

Manufacturer's environmental specifications are evaluated for conformance when calibrations are performed outside the above stated conditions.

OUT OF TOLERANCE CONDITIONS FOUND DURING CALIBRATION

NOMINAL (STD)	UNITS	AS FOUND (UUT)	MFG. ACCURACY

COMMENTS