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- Engineering Report 7953-R-027, *30-foot Free Drop Post-Test Summary Report for the NS30 Neutron Shielded Canister*, Revision 0, Petersen Incorporated, November 2009.

- G. J. Banken, *Thermal Analysis of RH Shielded Canisters in RH-TRU 72B Cask*, 01937.01.M0005.01-04, Rev. 0, AREVA Federal Services LLC, Tacoma, WA, January 2010.

- R. J. Migliore and B. A. Day, *72-B with NS15 and NS30 Shielded Canister Shielding Analysis*, 01937.01.M005-03, Rev. 0, AREVA Federal Services LLC, Tacoma, WA, January 2010.

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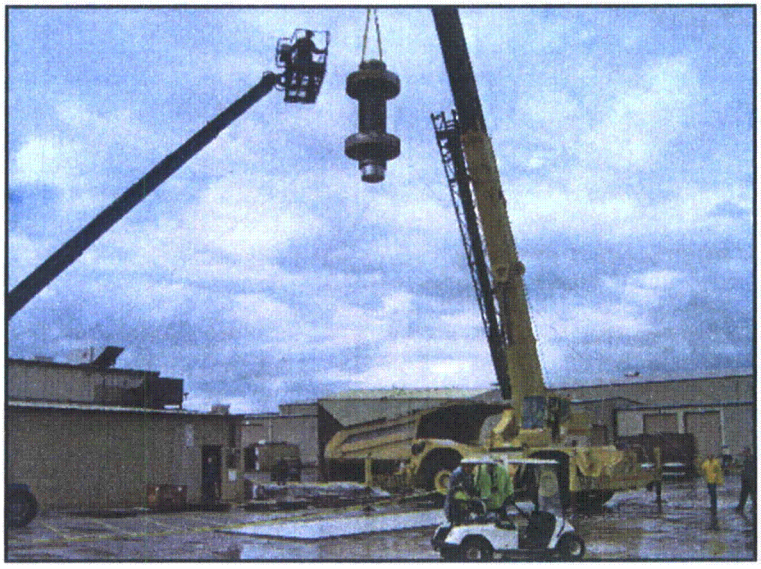
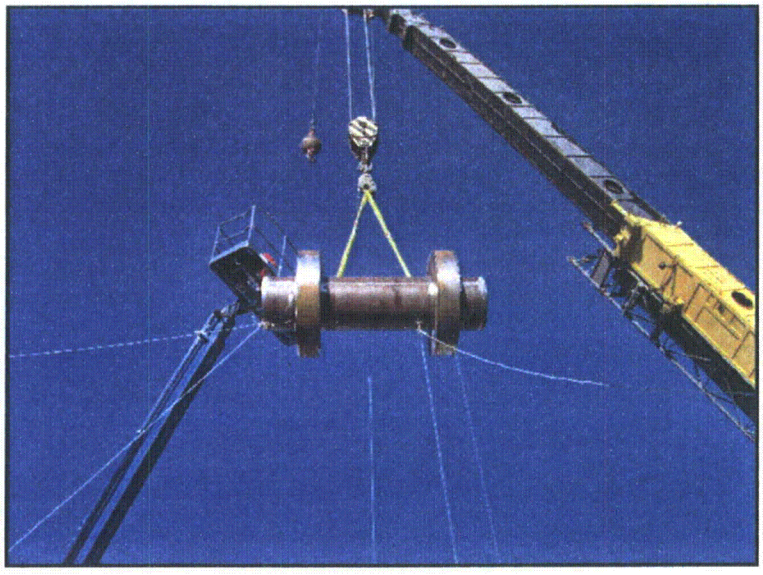
Engineering Report: 7953-R-027
November 16, 2009
Rev. 0

30-foot Free Drop Post-Test Summary Report For the NS30 Neutron Shielded Canister

PO 411566





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I. Introduction

This document summarizes the results of the 30-foot free drop tests performed from September 28, 2009 through October 8, 2009 at Petersen Incorporated in Ogden, UT per procedure No. JSP-7953-01.[1] The tests support the licensing activities for the NS30 and NS15 neutron shielded canisters.

An NS30 neutron shielded canister was assembled into a neutron shielded canister test fixture, configured to simulate the RH-TRU 72-B packaging and a bounding deceleration environment, to facilitate hot and cold drops of the canister while the test fixture is at ambient conditions. The reusable test fixture and two NS30 neutron shielded canisters were each to subject to two 30-foot free drops, one canister under hot and one canister under cold temperature conditions, onto a flat, essentially unyielding, horizontal surface. The test fixture was dropped such that it struck the target surface in a position to maximize damage of the NS30 neutron shielded canisters. At the conclusion of the second 30-foot free fall drop, each NS30 neutron shielded canister was removed from the test fixture and subjected to a visual and dimensional inspection to verify structural and shielding integrity. Additionally, any release of fine particulate sand used as simulated payload outside of the shield was quantified.

Only the NS30 neutron shielded canister design was physically tested as the NS15 neutron shielded canister design is less limiting from a drop test perspective.

II. Equipment and Test Preparations

Per Section 3.0 of JSP-7953-01[1], all test equipment and the drop test pad were prepared for the test. The Petersen Inc. drop test pad is constructed using a 1 inch thick x 10 foot wide x 30 foot long steel plate as the target face. This steel plate is leveled with and secured to a supporting concrete pad by 15 each – 1/2 inch concrete anchors. The supporting concrete pad is a 10 inch thick steel reinforced pad with an additional 2" of non-shrink grout up to the target surface. The total mass of the pad is 68,561 lbs (Figure 14).

In accordance with Section 4.1 of JSP-7953-01[1], the NS30 Neutron Shielded Canister test articles, Neutron Shielded Canister Test Fixture, Simulated Payload Drums, and Temperature Conditioning Chamber were fabricated, assembled, and accepted per their respective fabrication drawings, material test reports, manufacturing travelers, and inspection plans as documented in the purchase order data package.[2] Note that two production Removable Lid Canisters (S/N 090171 and S/N 090172) were utilized to produce the two NS30 Neutron Shielded Canister test articles, where the shield insert components (i.e., body pipe, end caps, and spacer) were added to complete the test articles.

In accordance with Section 4.2 of JSP-7953-01[1], the test component weights of the NS30 Neutron Shielded Canister test articles, Neutron Shielded Canister Test Fixture, and Simulated Payload Drums were obtained and all components marked. The component weight information

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[1] JSP-7953-01, *Neutron Shielded Canister Drop Test Procedure – 30' Height*, Revision 1, Petersen Incorporated, August 2009.

[2] WTS PO 411566, *Fabrication Data Package*, Petersen Incorporated, November 2009.

was recorded on DATA SHEET 1.1, provided in Appendix A. The Simulated Payload Drum weights each include the added 5 lbs. of fine particulate sand.

The test articles and test fixture were instrumented with thermocouples and accelerometer instrument mounts, respectively, as delineated in Section 4.3 of JSP-7953-01[1]. The thermocouple wires were installed on each of shield insert Body Pipes and necessary strain relief was applied (Figure 1). The Bottom End Cap Assembly and the Body Pipe were installed at the same time using the Bottom End Cap to align and lift into place inside the canister. During installation, the thermocouple wires were aligned with the collocated holes of the canister and carefully fed through (Figure 2).

Next the Payload Drums were placed into drum handling bags and then loaded into their respective test articles (Figure 3). Payload drums 1, 2, and 3 were installed into the NS30 #1 (Cold) test article and payload drums 4, 5, and 6 were installed into the NS30 #2 (Hot) test article (Figure 4, Figure 5). The Top End Cap Assembly was then installed and the maximum allowed 1" thick plywood spacer disc was installed to achieve an axial gap that was slightly in excess of the maximum gap allowed per the production drawings; the gap was verified to be between .50" and .55" (Figure 6, Figure 7). The canister lid was then installed and rotated to the locked position (Figure 8).

Finally the loaded NS30 test article was placed into the Temperature Conditioning Chamber in preparation for the "X" Hour test per Section 4.4 of JSP-7953-01[1] (Figure 9). This process developed the time duration required to remove the NS30 test article from the temperature conditioning chamber, install the test article into and assemble the test fixture, transport the test fixture to the drop test pad, rig and hoist the test fixture, and execute the drop test. This time was utilized to establish the temperature set-point for the Temperature Conditioning Tests (see Section 4.5 and 4.6 of JSP-7953-01[1]) and as a go/no-go decision point for each drop to ensure that the high-density polyethylene shield components in the NS30 test articles were at or conservatively above/below (as required) the respective hot/cold temperature requirements at the time of the drop. The "X" Hour Determination Test was run and the "X" Hour set at 60 minutes.

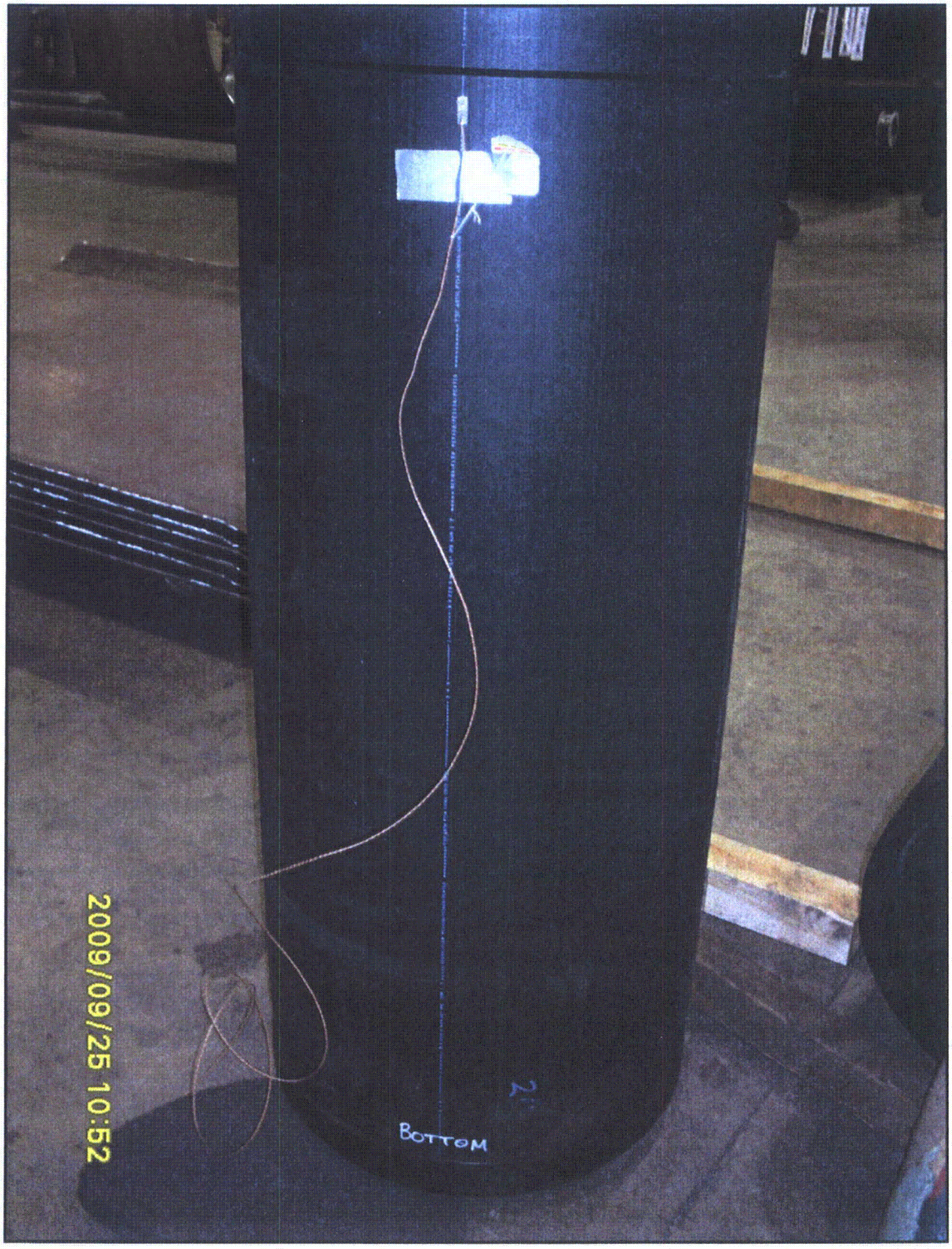

Figure 1 – Shield Insert Body and Bottom End Cap Prior to Installation in the Canister (with thermocouple installed near midline)

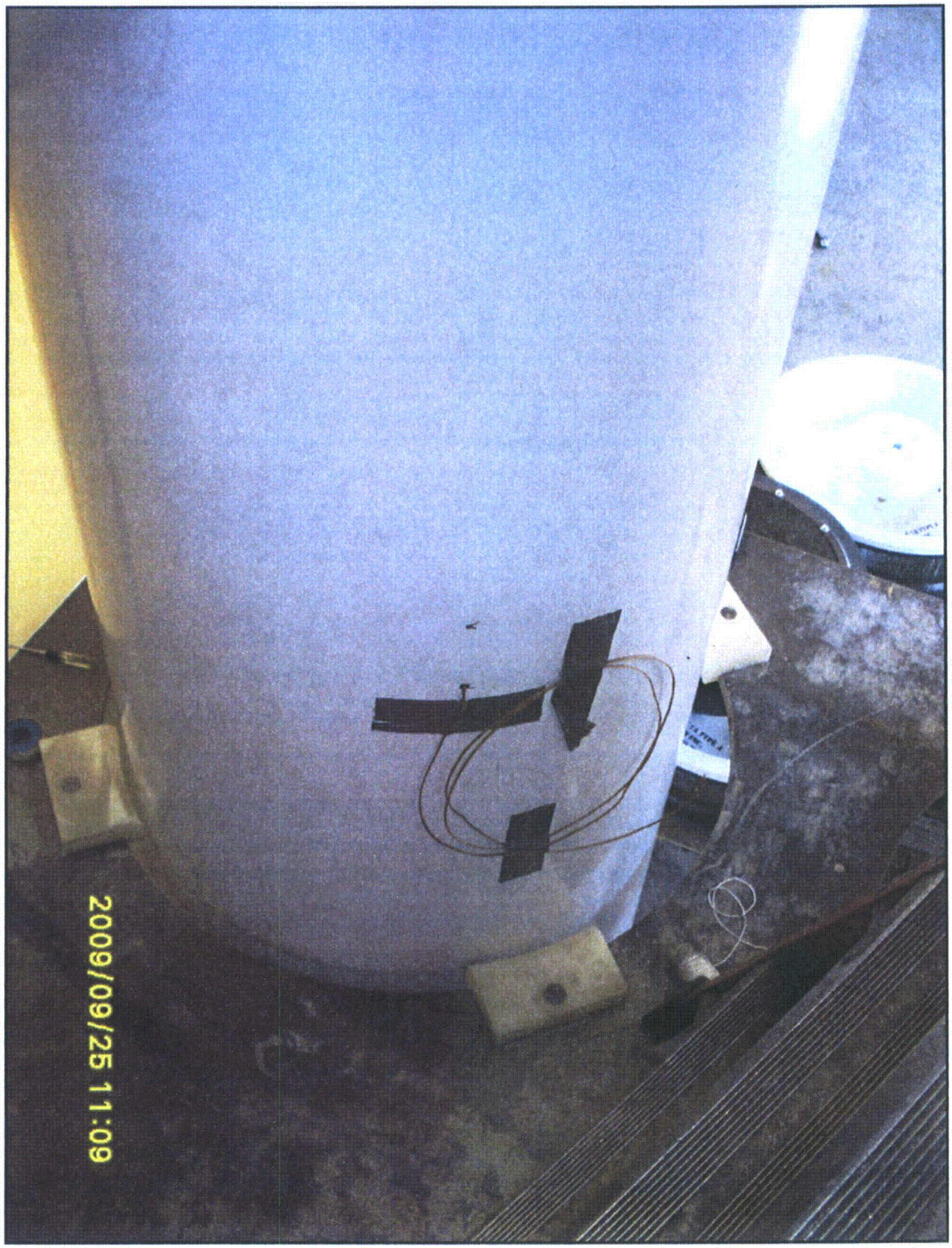

Figure 2 – Internal Thermocouple Wire Secured to the Outside of the NS30 Canister Body

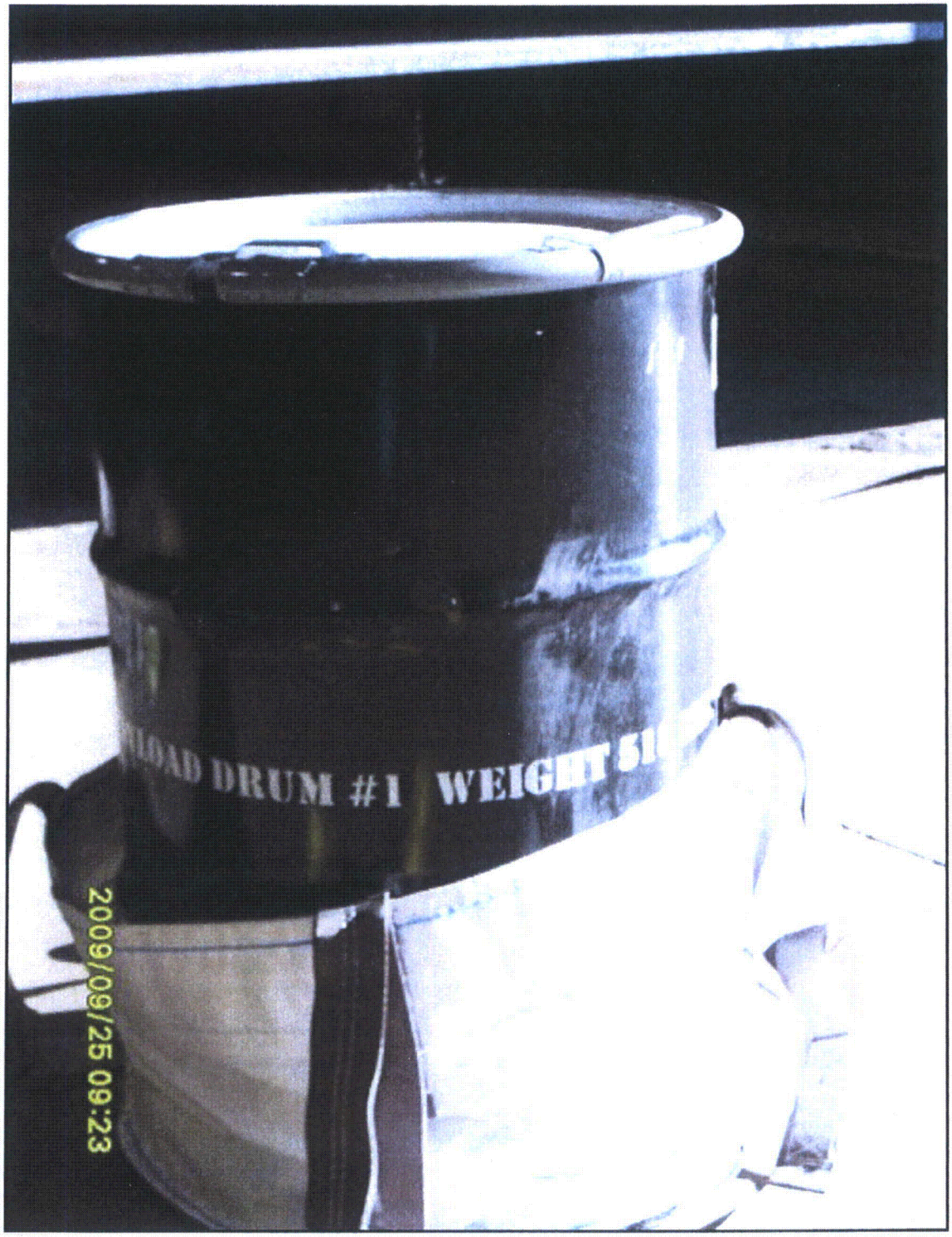

Figure 3 – Example of Payload and Drum Handling Bag

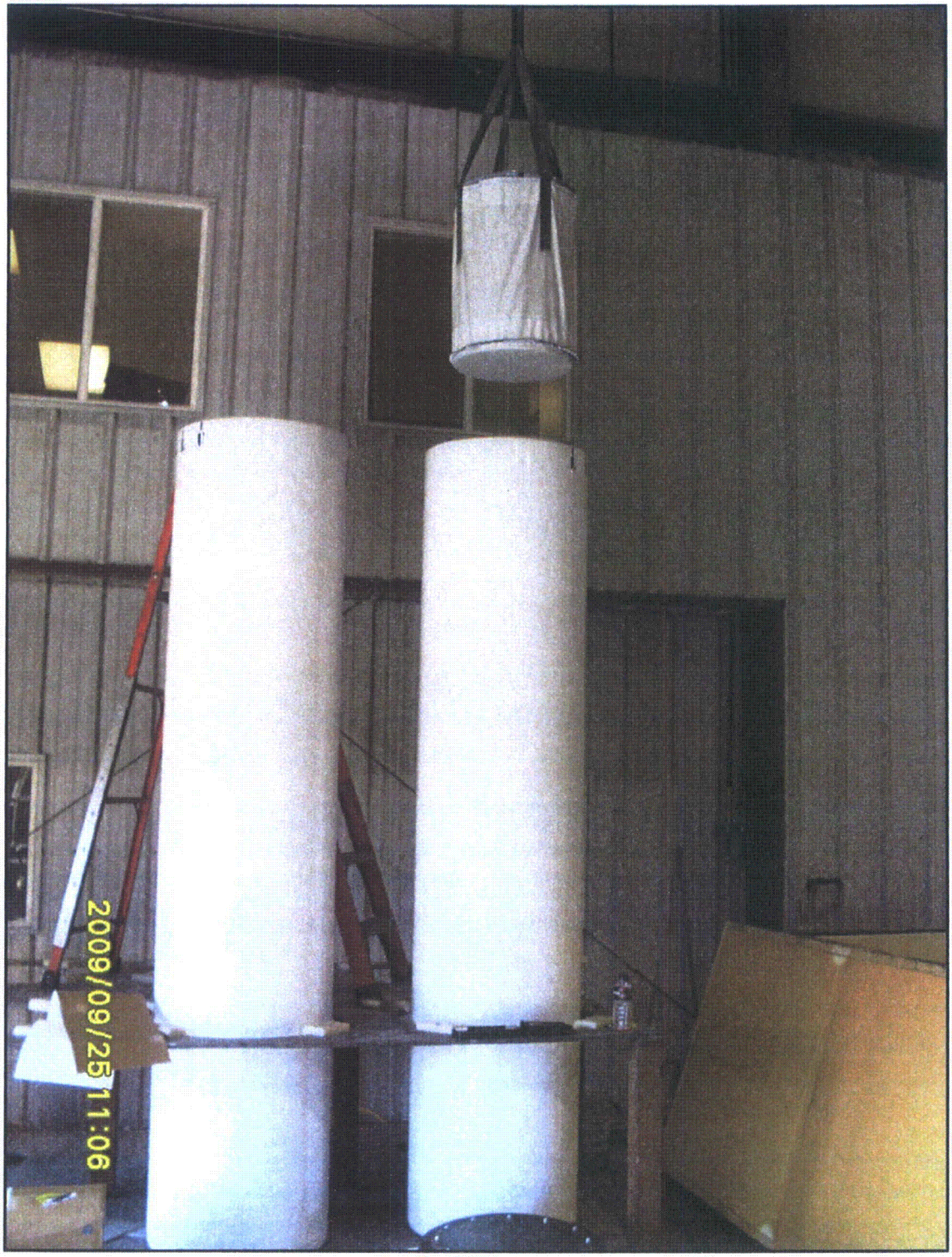

Figure 4 – Loading Payload into Test Article

Figure 5 – First Payload Drum Loaded Inside Shield Insert Body Pipe

Figure 6 – Top End Cap Installed

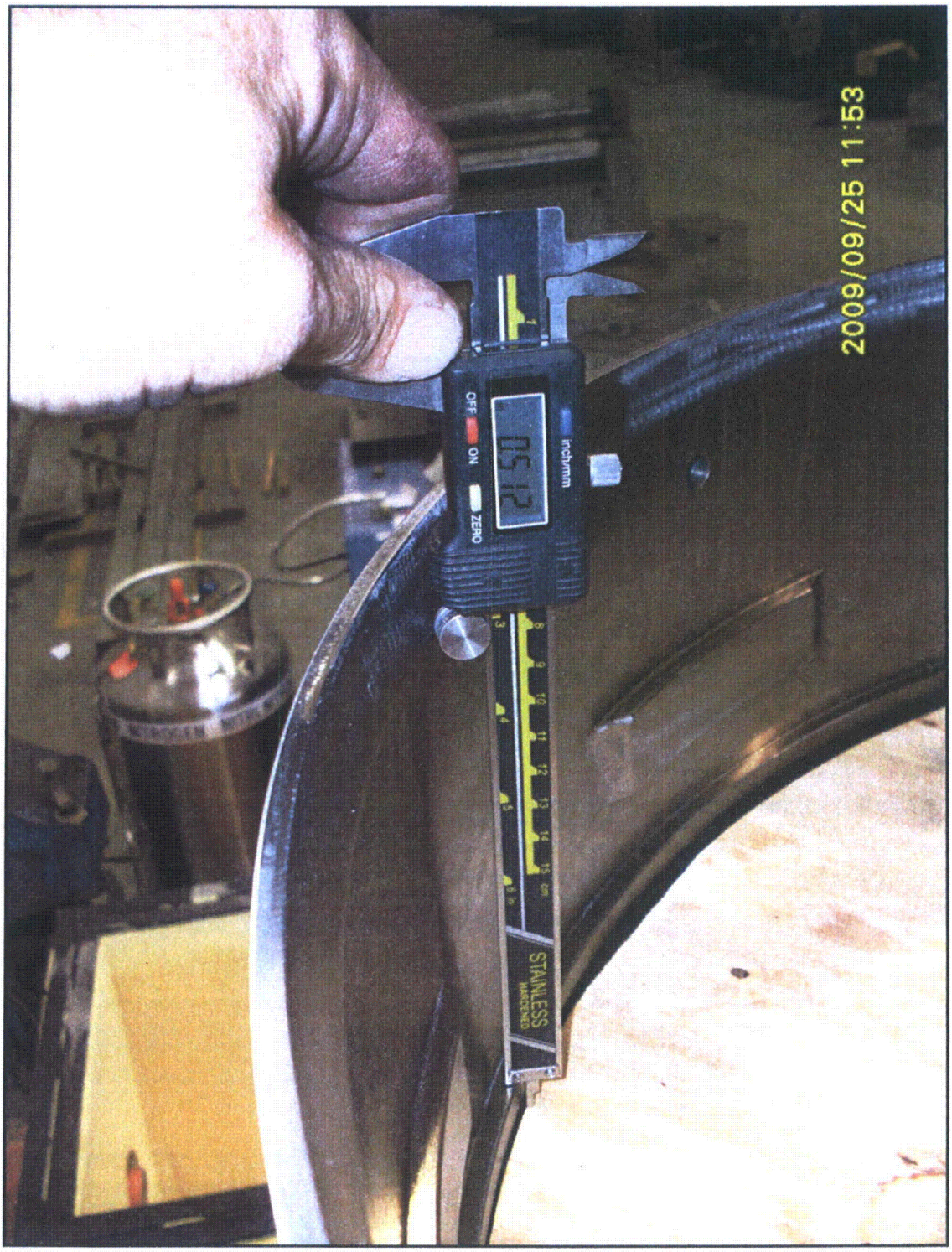

Figure 7 – Verification of Gap Between Plywood Spacer and RLC Lid

Figure 8 – NS30 Lid Installed and Locked

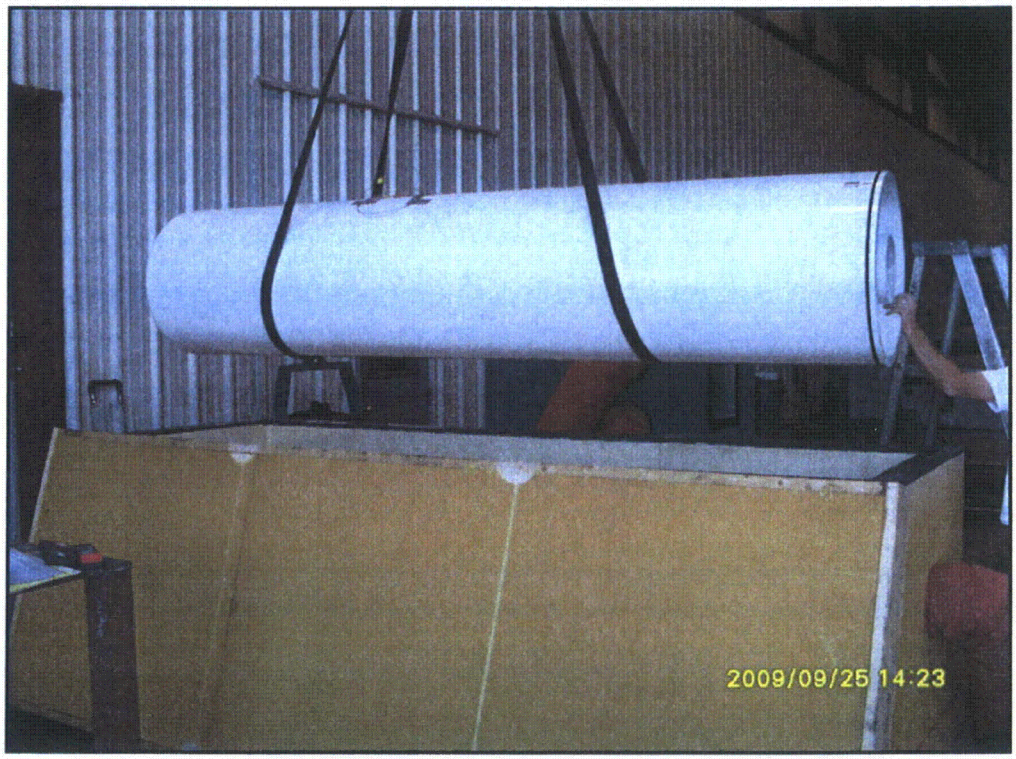

Figure 9 – NS30 Inserted into Temperature Conditioning Chamber

III. Cold End Drop

To establish the cold temperature conditioning unit set-point and confirm that the temperature of the shield components would be at or below the required test temperature of -20 °F at the time of the drop test, the cold cycle temperature conditioning was run with the set-point of -74.2 °F (-59 °C) per Section 4.5 of JSP-7953-01.[1] As detailed in Appendix C, the shield insert body pipe temperature at the start of the "X" hour dwell period was -31.1 °F and remained below -20 °F at the end of 1 hour at -24.4 °F.

The cold end drop sequence was performed in accordance with Section 5.1 and 5.2 of JSP-7953-01.[1] As soon as the cold cycle conditioning test requirement was met, the lid of the temperature conditioning chamber was placed back on the base and the conditioning unit was again turned on and the temperature was brought down to -31.7 °F on the internal (shield insert pipe body) thermocouple (see Appendix C).

Once the temperature set-point was achieved, the "X" hour clock was started, the temperature conditioning unit was turned off, and the NS30 #1 canister was removed from its horizontal orientation in the temperature conditioning chamber and lowered vertically into the test fixture (Figure 10 - Figure 12). The test fixture was rotated 90° and the test fixture end impact limiter #1 was installed. The assembled test fixture was then rotated an additional 90° (a total of 180° from the original installation orientation) such that the canister was in a top-down orientation. Simultaneously, data cables for the accelerometers were installed on the two accelerometer mounting bases located on the test fixture outer shell near the drop impact location and in-line with the drop orientation. The test fixture was then transported to the drop test pad, rigged, hoisted, and then dropped after data acquisition had been initiated (Figure 13 - Figure 21). The total elapsed time for the Cold End Drop Test was 46 minutes.

Deformation to the End Impact Limiter #1 was observed, measured, and recorded (see Appendix C). The end plate of the impact limiter experienced an out-of-plane bending plastic deformation of approximately 5/16" (Figure 22). The end impact limiter experienced axial crushing, as indicated by the residual deformation of the limiter shells at the weld location, of approximately 5/8" (Figure 23). Upon removal of the NS30 #1 Test Article from the Test Fixture, no visible damage to the exterior surfaces of the canister were observed (Figure 24).

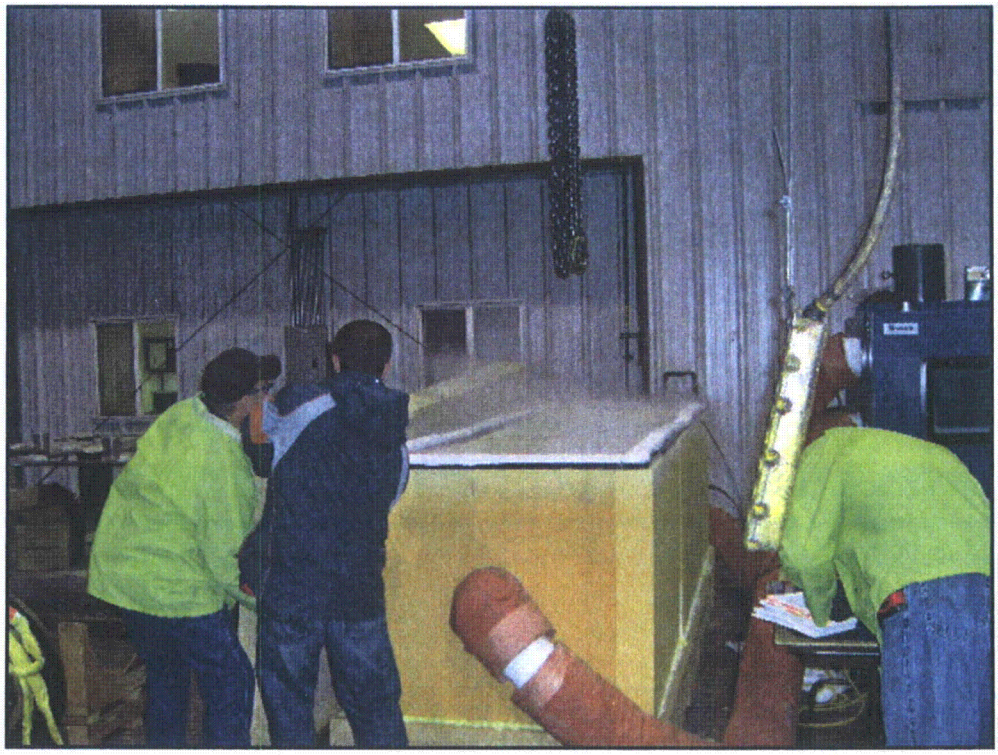

Figure 10 – Conditioning Chamber Lid Being Removed After Achieving Temperature

Figure 11 – Secure the Internal Thermocouple Lead Wires

Figure 12 – Insert Test Article Into Test Fixture

Figure 13 – Transport Test Fixture To the Drop Pad

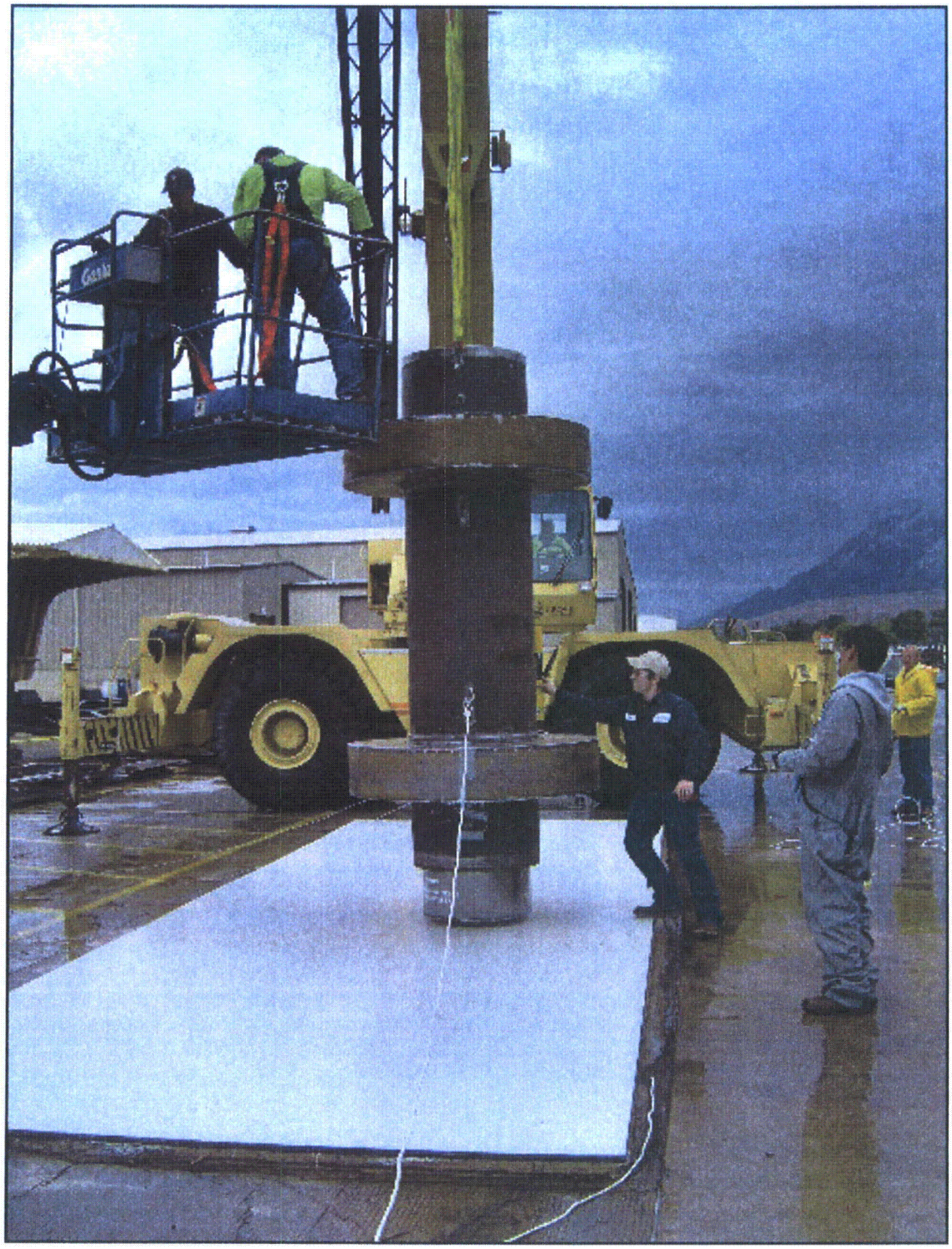

Figure 14 – Rig the Test Fixture for Cold End Drop

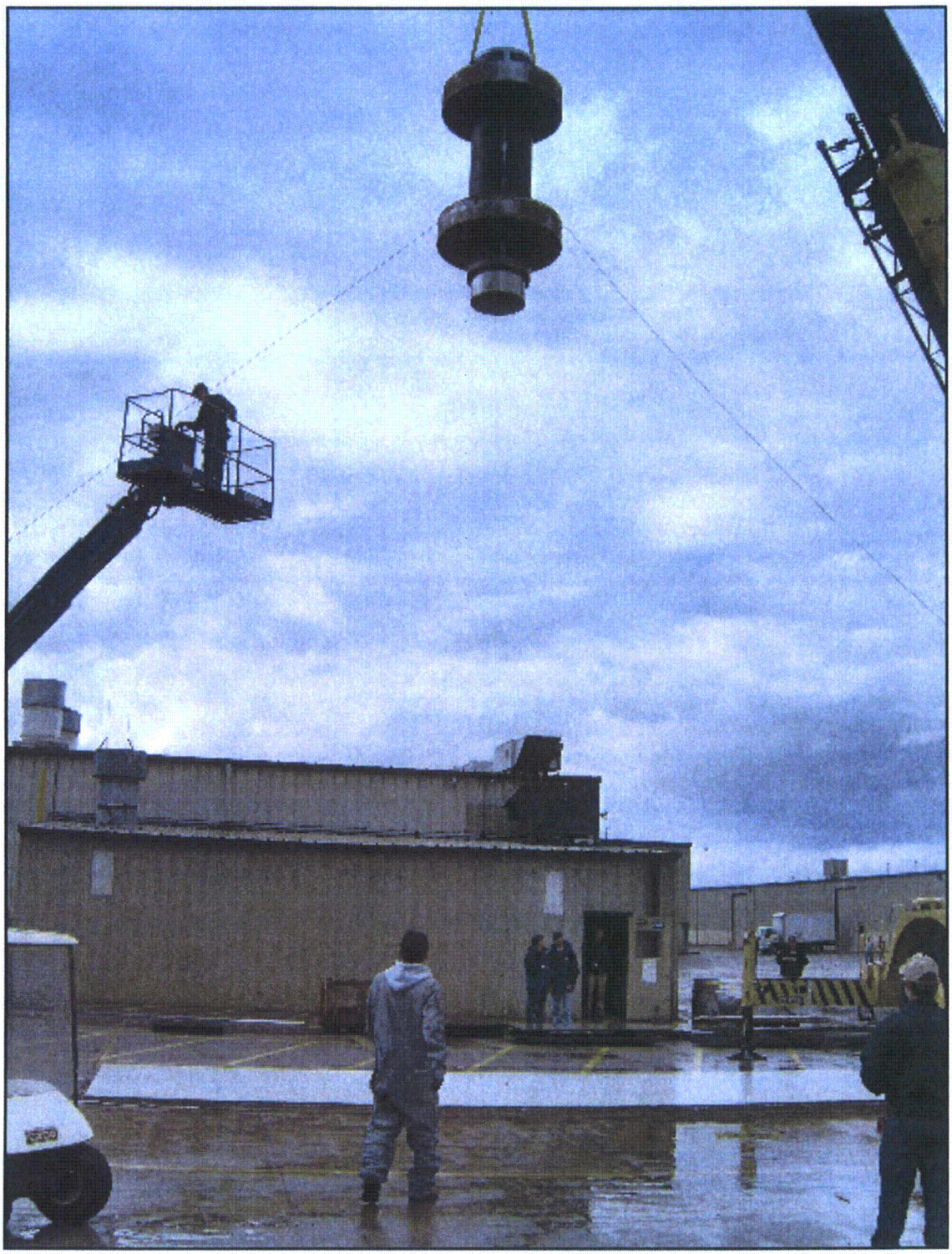

Figure 15 – Hoist to Height and Connect Release Mechanism

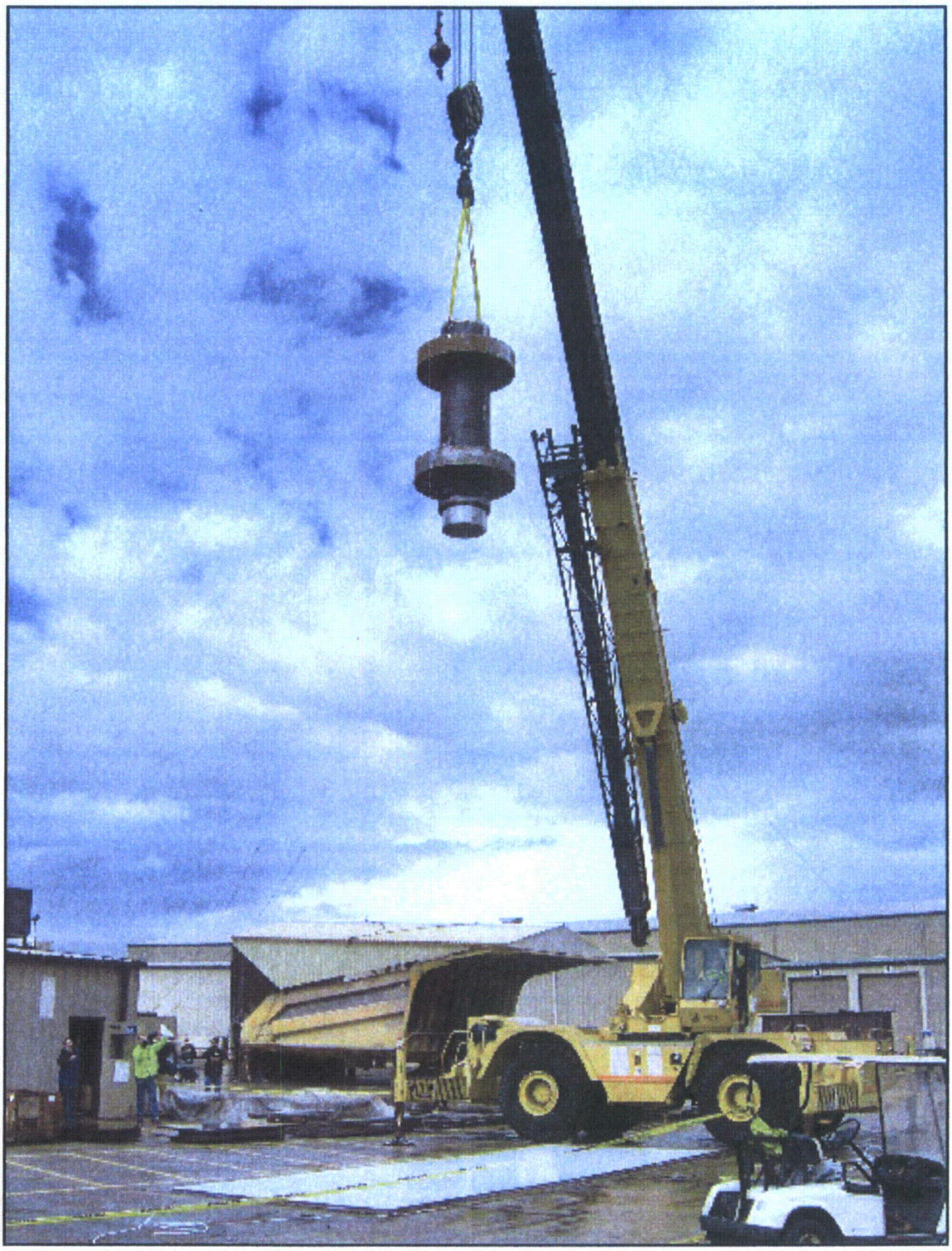

Figure 16 – Initiate Video Taping and Accelerometer Data Collection for Cold End Drop

Figure 17 – Freefall During 30' Cold End Drop of NS30 #1

Figure 18 – NS30 #1 Cold End Drop After Impact

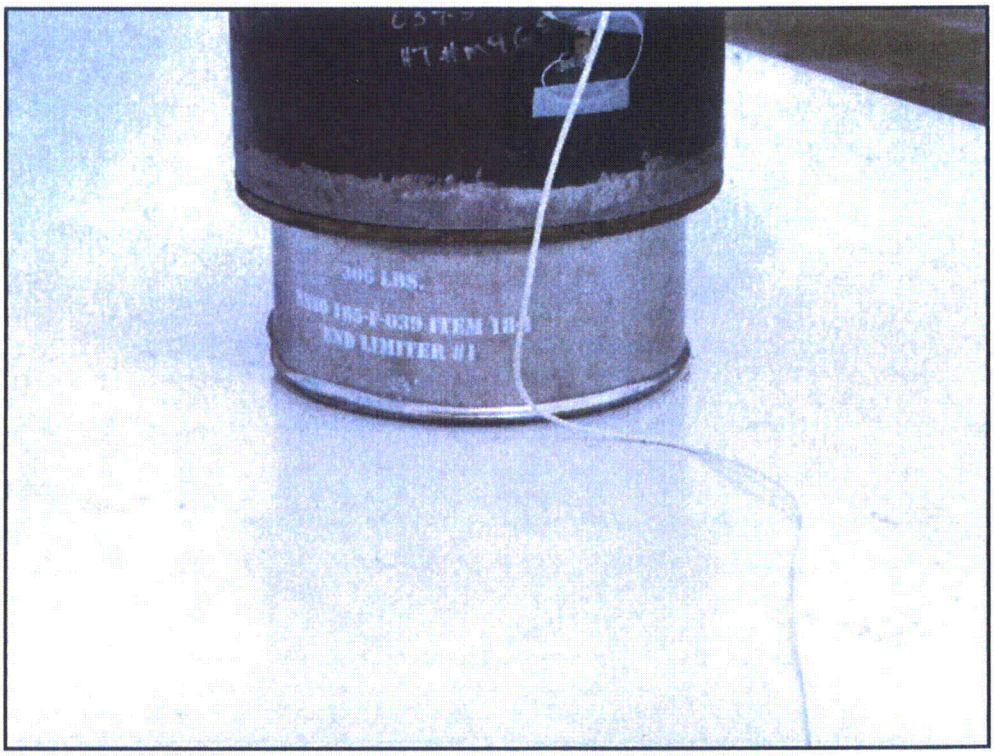

Figure 19 – NS30 #1 Cold End Drop After Impact (close-up of end impact limiter)

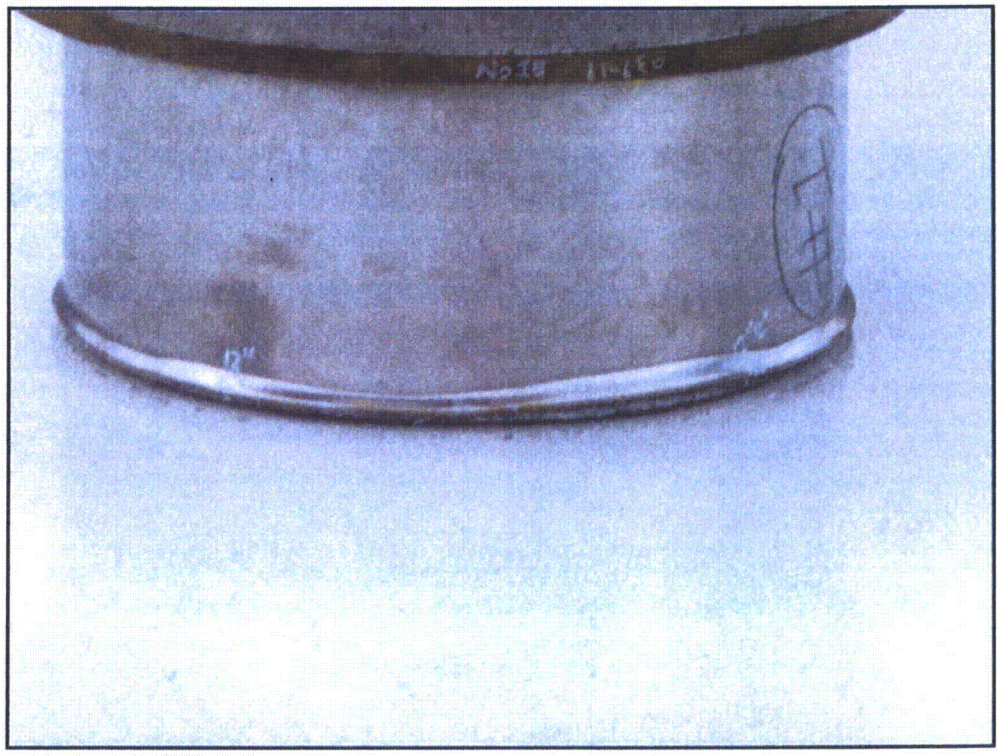

Figure 20 – NS30 #1 Cold End Drop After Impact (close-up #2 of end impact limiter)

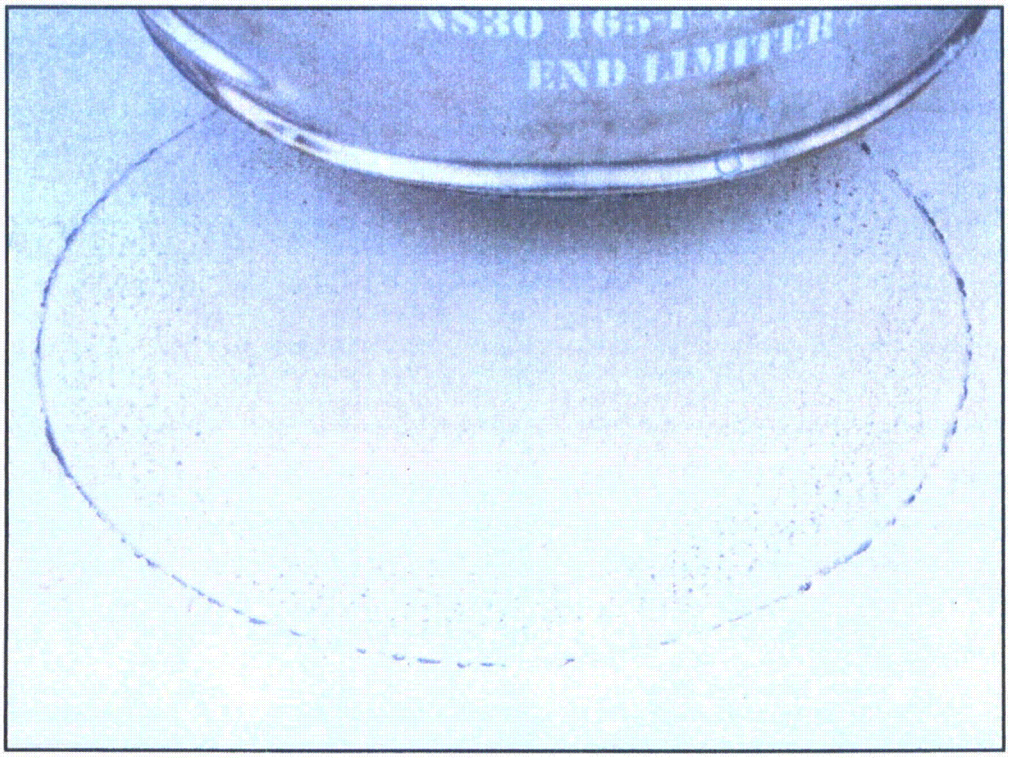

Figure 21 – Paint Removal and Impact Marks on Drop Test Pad Steel Cap Plate

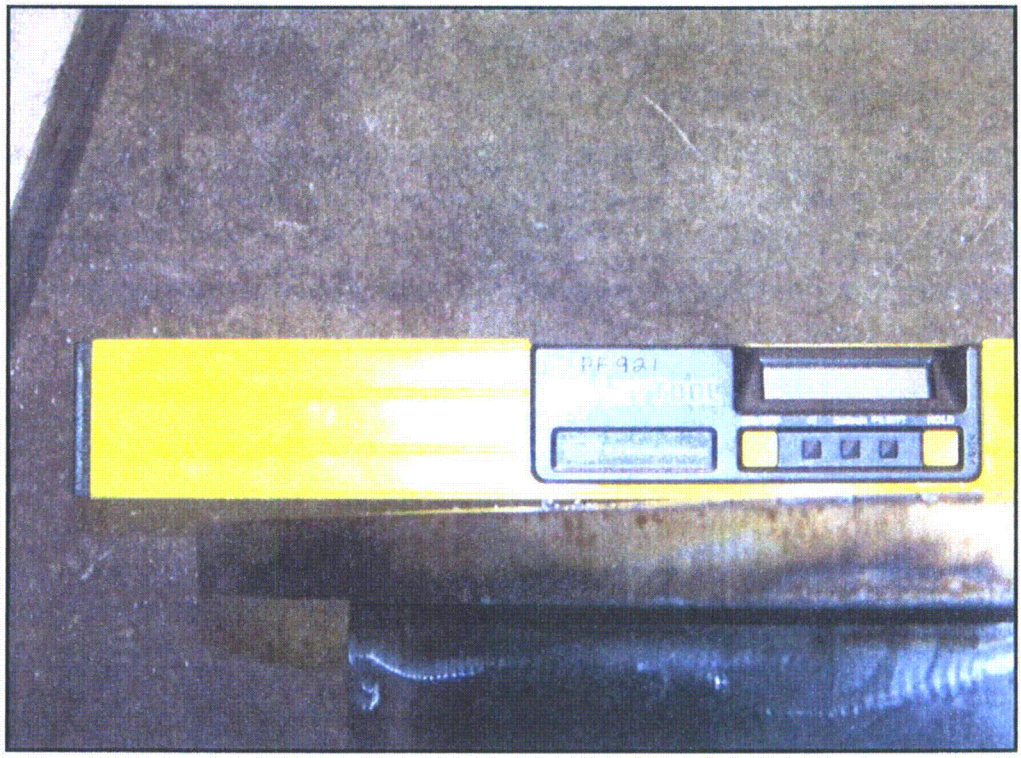

Figure 22 – Measurement of Plastic Deformation of Base Plate on End Impact Limiter #1

Figure 23 – Foam Crush and Skin Deformation Inspection of End Impact Limiter #1

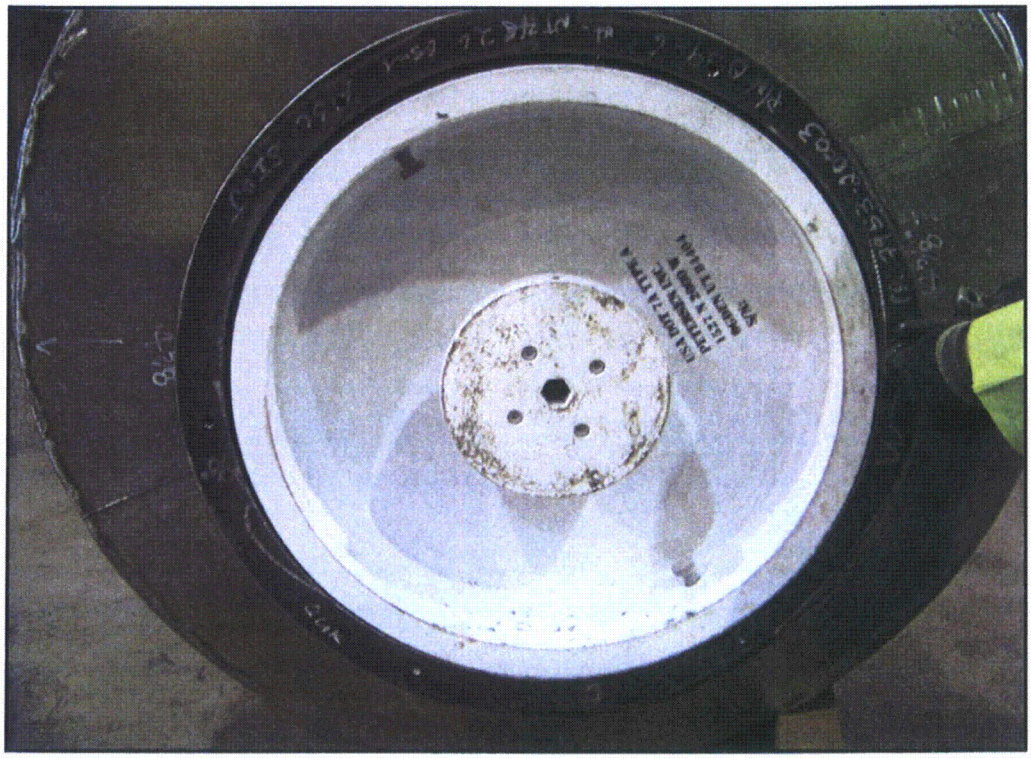

Figure 24 – Removal of Test Fixture End Impact Limiter #1 to Reveal NS30 #1 Canister Lid

IV. Cold Side Drop

The cold side drop sequence was performed in accordance with Section 5.3 and 5.4 of JSP-7953-01.[1] After completion of the cold end drop test, the NS30 #1 test article again placed in the temperature conditioning chamber and the conditioning unit was activated with the previously established temperature set-point and the temperature was brought down to -30.1 °F on the internal (shield insert pipe body) thermocouple (see Appendix D).

Once the temperature set-point was achieved, the "X" hour clock was started, the temperature conditioning unit was turned off, and the NS30 #1 canister was removed from its horizontal orientation in the temperature conditioning chamber and lowered vertically into the test fixture. The test fixture was rotated 90° such that the canister was in a horizontal orientation and the test fixture end plate was installed. Simultaneously, data cables for the accelerometers were installed on the two accelerometer mounting bases located on the test fixture outer shell near the drop impact location and in-line with the drop orientation. The test fixture was then transported to the drop test pad, rigged, hoisted, and then dropped after data acquisition had been initiated (Figure 25 - Figure 27). The total elapsed time for the Cold Side Drop Test was 38 minutes.

Deformation to the Side Impact Limiters was observed, measured, and recorded (see Appendix D). The side impact limiters experienced permanent plastic deformation of approximately 1-5/8" and chord-length contact, as indicated by paint transfer from the drop test pad, of 25-5/8" (Figure 28 - Figure 33). There was no other visible damage to the test fixture with the exception that one of the closure bolts attaching the end plate of the test fixture to its flange sheared upon removal (Figure 34).

Upon removal of the NS30 #1 Test Article from the Test Fixture, visible damage to the exterior surfaces of the canister was observed at interface locations with the text fixture upper and lower centering rings (Figure 35). The permanent deformation of approximately ½" was located along the lower 1/3 of the canister shell where it aligned to the bottom dead center impact location of the side drop (Figure 36). No other damage or deformation was seen on the exterior of the NS30 #1 Test Article.

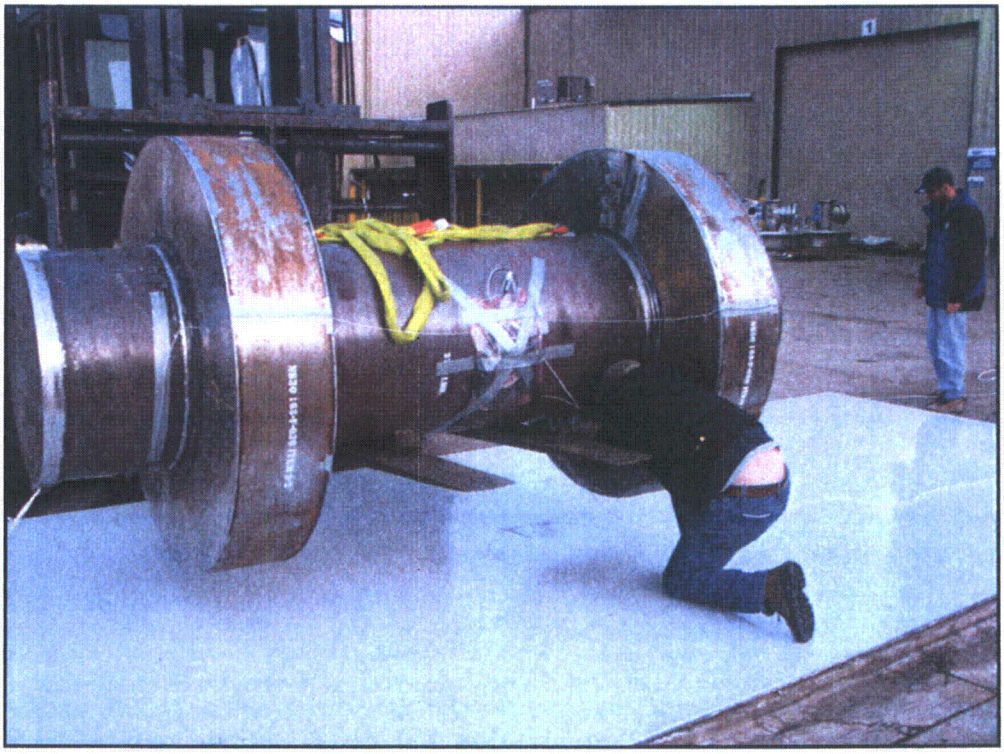

Figure 25 – Preparation for Cold Side Drop of NS30 #1

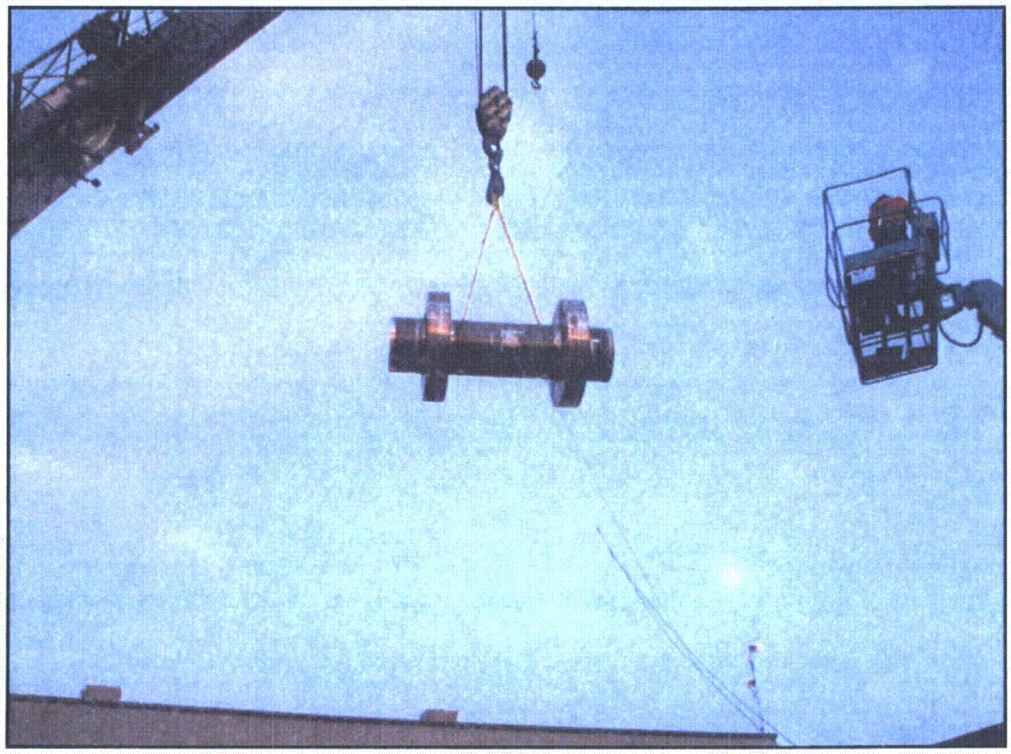

Figure 26 – Initiate Video Taping and Accelerometer Data Collection for Cold Side Drop

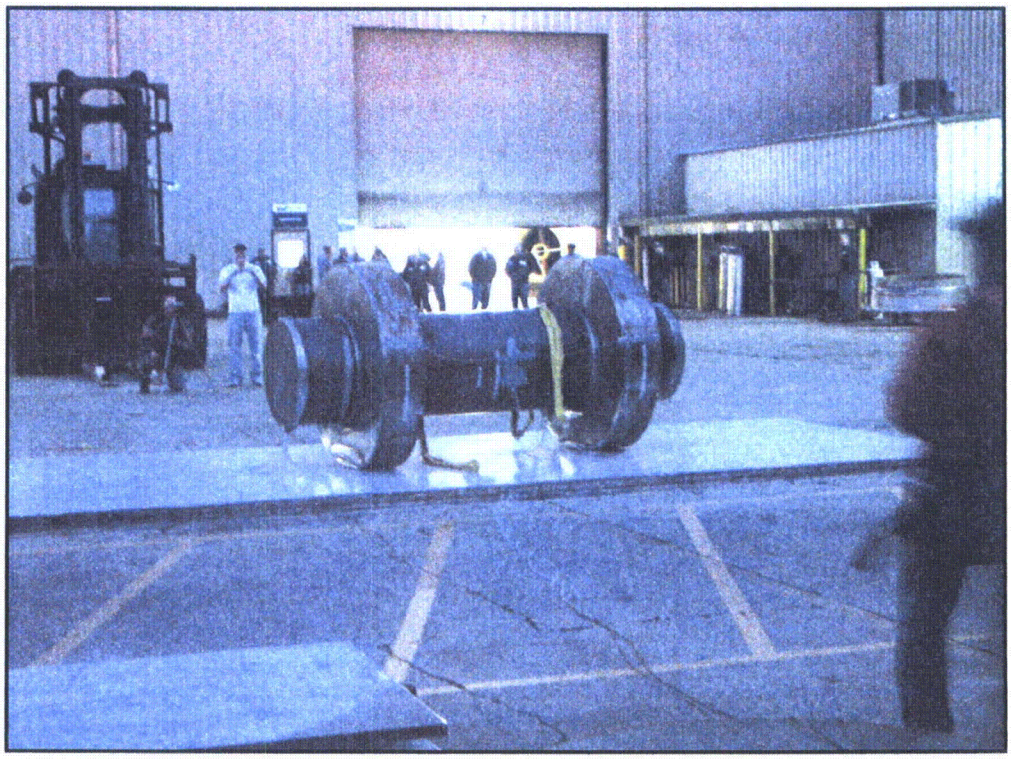

Figure 27 – NS30 #1 Cold Side Drop After Impact

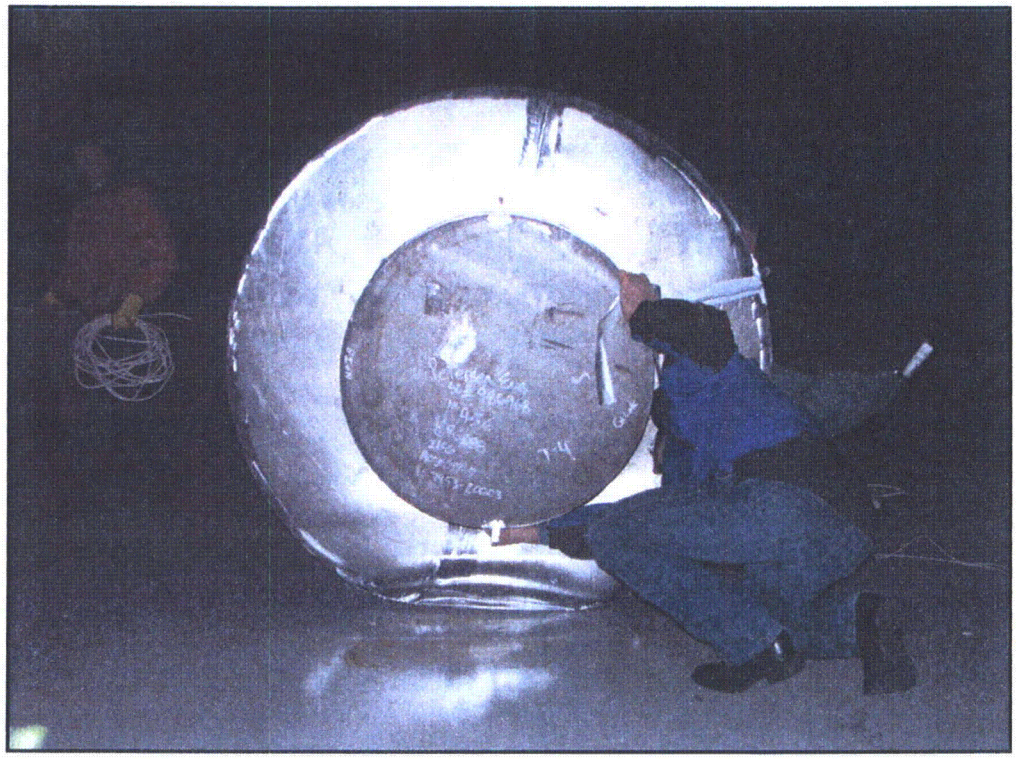

Figure 28 – Left Side (associated with bottom end of NS30 #1) Impact Limiter Deformation

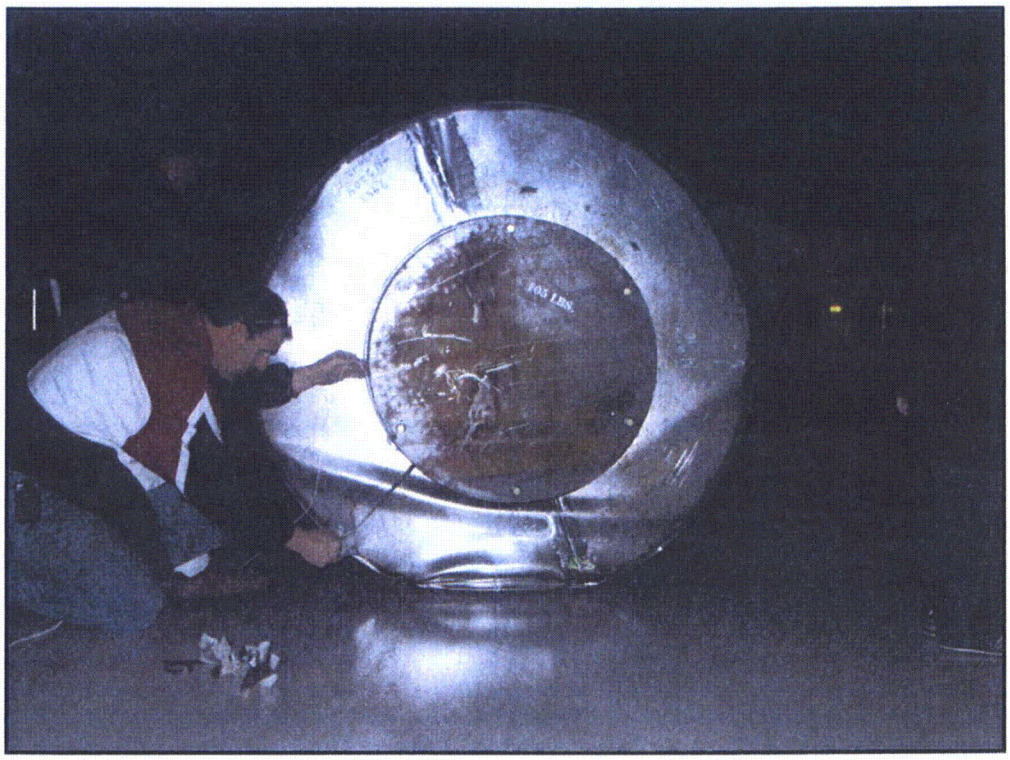

Figure 29 – Right Side (associated with top end of NS30 #1) Impact Limiter Deformation

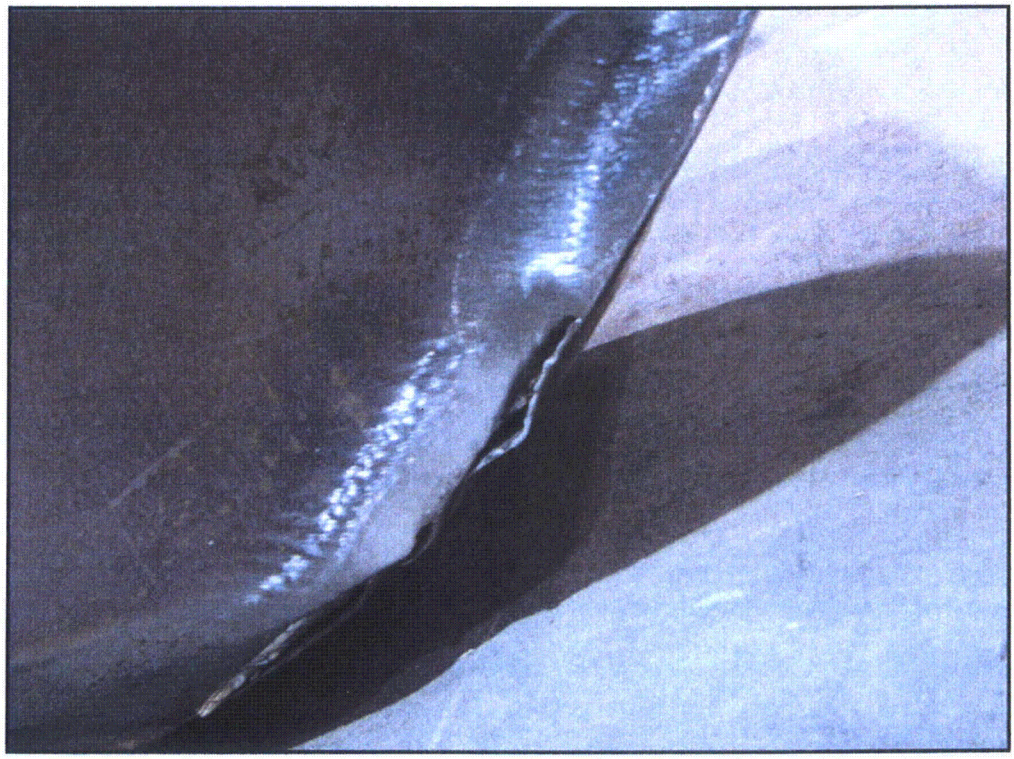

Figure 30 – Side Impact Limiter Skin Damage (weld unzip)

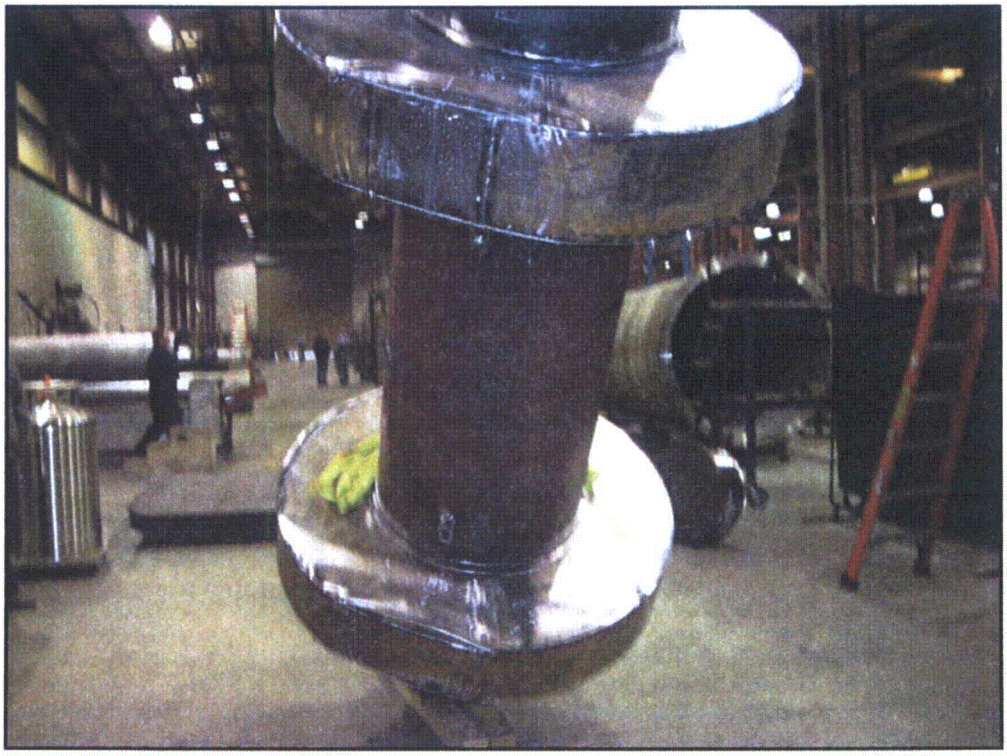

Figure 31 – Cold Side Drop Impact Limiter Deformation

Figure 32 – Measurement of Cold Side Drop Impact Limiter Deformation

Figure 33 – Measurement of Cold Side Drop Extent of Paint Transfer from Test Pad

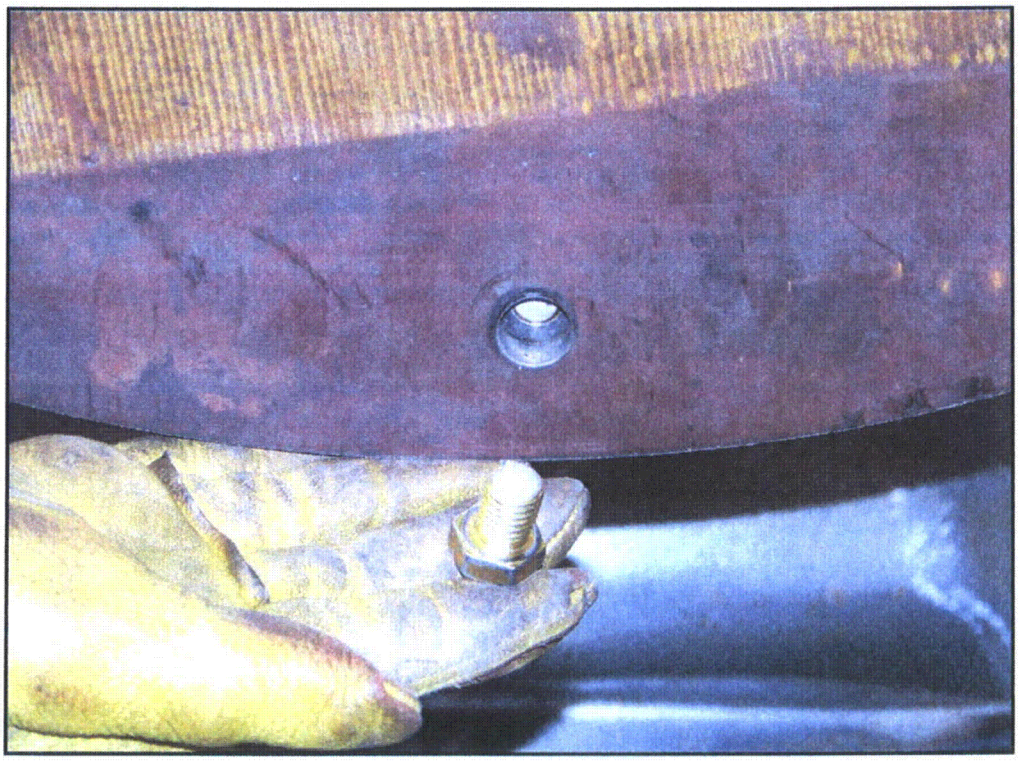

Figure 34 – Sheared Test Fixture Closure Plate Bolt (due to shear from side drop)

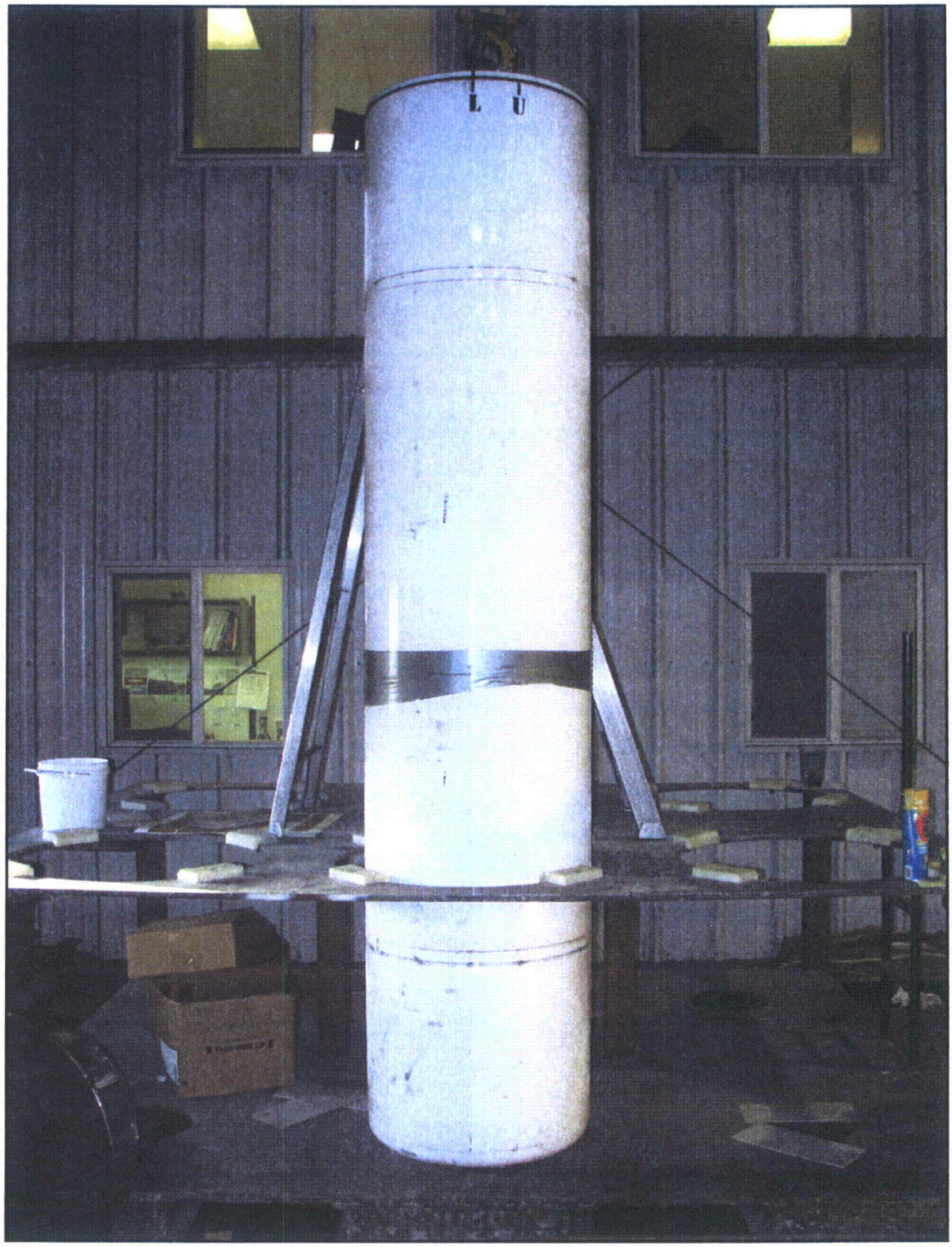

Figure 35 – Inspection of NS30 #1 Exterior Canister Shell for Permanent Plastic Deformation

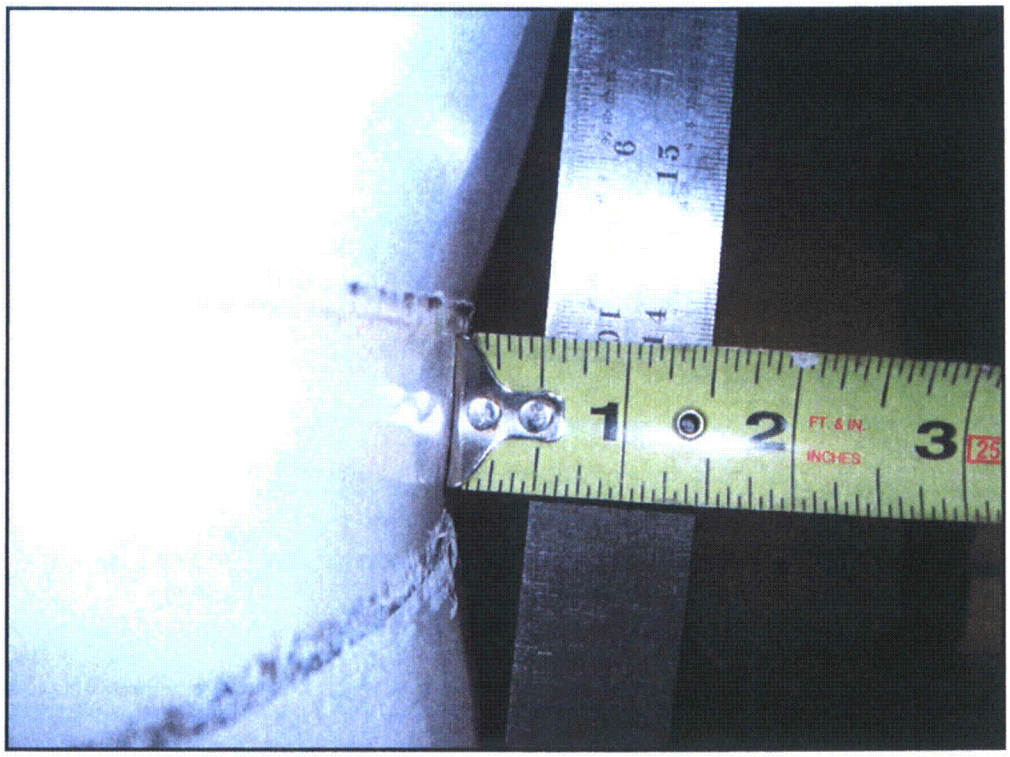

Figure 36 – Permanent Deformation of NS30 #1 Canister Shell due to Interaction with Lower Test Fixture Centering Ring during Cold Side Drop