INEL/EXT-97-00557

CLWR/T-97-011

Nondestructive Post-Irradiation Examination of Loop-1, S1, and B1 Rods

R. L. Bratton

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Published May 1997

MASTER

**Idaho National Engineering Laboratory
Specialty Engineering and Science Department
Lockheed Martin Idaho Technologies Company
Idaho Falls, Idaho 83415**

**Prepared for the
U.S. Department of Energy
Assistant Secretary for the
Office of Defense Programs
Under DOE Idaho Operations Office
Contract DE-AC07-94ID13223**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.

ABSTRACT

As a part of the Pacific Northwest National Laboratory's Tritium Target Development Program, eleven tritium target rods were irradiated in the Advanced Test Reactor located at the Idaho National Engineering and Environmental Laboratory during 1991. Both nondestructive and destructive post-irradiation examination on all eleven rods was planned under the Tritium Target Development Program. Funding for the program was reduced in 1991 resulting in the early removal of the program experiments before reaching their irradiation goals. Post-irradiation examination was only performed on one of the irradiated rods at the Pacific Northwest National Laboratory before the program was terminated in 1992.

On December 6, 1995, the Secretary of Energy announced the pursuit of the Commercial Light-Water Reactor option for producing tritium establishing the Tritium Target Qualification Program at the Pacific Northwest National Laboratory. This program decided to pursue nondestructive and destructive post-irradiation examination of the ten remaining rods from the previous program. The Idaho National Engineering and Environmental Laboratory, who was assigned the project lead for this examination, contracted the services of the Hot Fuels Examination Facility at Argonne-West National Laboratory, located on their site, to perform the nondestructive examinations.

The ten rods comprise three experiments. The Loop-1 experiment irradiated eight target rods in a loop configuration for 217 irradiation days. The other two rods were irradiated in two separate irradiation experiments, designated as S1 and B1 for 143 effective full-power days, but at different power levels.

After the ten rods were transferred from the ATR Canal to the Hot Fuels Examination Facility, the following examinations were performed:

- Visual Examination and Photography
- Neutron Radiography
- Axial Gamma Scanning
- Contact Profilometry Measurement
- Bow and Length Measurements
- Rod Puncture and Plenum Gas Analysis/Measurement of Plenum Gas Quantity
- Void Volume Determination
- Internal Pressure Determination.

This report presents the data collected during these examinations.

CONTENTS

ABSTRACT	iii
CONTENTS	v
ACRONYMS.....	vii
1. INTRODUCTION	1
1.1 Loop-1, S1, and B1 History	2
1.1.1 Loop-1 History.....	2
1.1.2 Loop-1 Discussion.....	2
1.1.3 S1 and B1 History.....	3
1.1.4 S1 and B1 Discussion.....	3
2. NONDESTRUCTIVE EXAMINATIONS.....	4
2.1 Visual Examination and Photography.....	4
2.2 Neutron Radiography	4
2.2.1 Operational Notes for Radiography.....	4
2.3 Axial Gamma Scanning	5
2.3.1 Operational Notes on Gamma Scanning.....	5
2.4 Contact Profilometry Measurement	6
2.4.1 Operational Notes on ECP.....	7
2.5 Bow and Length Measurement	8
2.6 Gas, Analysis, Sample, and Recharged System.....	10
2.6.1 GASR Overview	10
2.6.2 Dummy Rod.....	10
2.6.3 GASR Operations	10
2.6.4 Rod Void Volume And Pressure Calculations	11
Appendix A—Letter Report on Loop 1 Cutting Problems	
Appendix B—Photographs	

Appendix C—Neutron Radiography	
Appendix D—Gamma Scan	
Appendix E—Profilometry Plots	
Appendix F—Bow and Length	
Appendix G—Dummy Rod Data	
Appendix H—Calibration Sheets and Puncture Data	
Appendix I—Plenum Gas Analysis	

FIGURES

Figure 1. Sample of a neutron radiograph.	5
Figure 2. Profilometry gauge for measuring axial diameter profiles of elements and capsules.	6
Figure 3. View looking down on top of element/capsule.	7
Figure 4. Measurement system.	8
Figure 5. Elevation view of element as measured.	9

TABLES

Table 1. Examinations performed for nondestructive PIE at the HFEF.	1
Table 2. Loop-1 chronology.	2
Table 3. S1 and B1 history.	3

ACRONYMS

ANL	Argonne-West National Laboratory
ASCII	American Standard Code for Information Interchange
ATR	Advanced Test Reactor
CCW	counterclockwise
CLWR	Commercial Light-Water Reactor
dc	direct current
DOS	disk operating system
ECP	element contact profilometry
GASR	gas, analysis, sample, and recharge system
HFEF	Hot Fuels Examination Facility
ID	identification
INEEL	Idaho National Engineering and Environmental Laboratory
LMITCO	Lockheed Martin Idaho Technologies Company
PGS	precision gamma scanner
PIE	post-irradiation examination
PNNL	Pacific Northwest National Laboratory
TTDP	Tritium Target Development Program
UPG	ultra-pure germanium

Nondestructive Post-Irradiation Examination of Loop-1, S1, and B1 Rods

1. INTRODUCTION

Loop-1, S1, and B1 were removed from the Advanced Test Reactor (ATR) core in 1991 and stored in the ATR canal until 1996 when the Commercial Light-Water Reactor (CLWR) Project was funded to pursue the qualification of the CLWR target. Part of this project was assigned to the Idaho National Engineering and Environmental Laboratory (INEEL), which is operated by Lockheed Martin Idaho Technologies (LMITCO), to pursue the nondestructive post-irradiation examination (PIE) of the Loop-1, S1, and B1 rods at the Argonne-West National Laboratory (ANL) Hot Fuel Examination Facility (HFEF). ANL was a subcontractor to LMITCO for this work.

Requirements for nondestructive PIE were transmitted to LMITCO on December 19, 1995 by letter from J. L. Ethridge of Pacific Northwest National Laboratory (PNNL) to Dr. D. C. Mecham of LMITCO.

Table 1. Examinations performed for nondestructive PIE at the HFEF.

Type	Explanation
Visual Examination and Photography	Visually inspect and photograph the 10 rods through the periscope in the HFEF Cell. Construct a full length photographic mosaic of rods WL-10 and WL-26.
Neutron Radiography	A procedure similar to x-ray radiography, except neutrons are used as the penetrating radiation.
Axial Gamma Scanning	Scan the entire length of the rod for isotopes. The two isotopes present in detectable quantities are Mn ⁵⁴ and Co ⁶⁰ .
Contact Profilometry Measurement	Measure the diameter of each rod.
Bow and Length Measurement	Measure the bow and free-hanging length of each rod.
Rod Puncture and Plenum Gas Analysis/ Measurement of Plenum Gas Quantity	Laser puncture each rod and sample the plenum gas for tritium and other gas species. Measure the rod's void volume and pressure prior to puncture.
Recovery of Flux Wires and Counting of Flux Wires	Work started on this effort, but was suspended because a different method was identified that would provide a flux measurement with less uncertainty. The measurement will be performed during destructive PIE at PNNL.
Recovery of End-Plug Piece From Two Rods	This operation was canceled before it was started.

The objective of this report is to only present data taken during the nondestructive PIE at ANL. No data analyses or interpretations will be presented in this report. The data analyses will be presented under a separate cover at a later time.

1.1 Loop-1, S1, and B1 History

1.1.1 Loop-1 History

Table 2. Loop-1 chronology.

Date	Event
10/05/91	Loop-1 experiment removed from the ATR Core after 217 irradiation days and stored in the ATR Canal.
02/22/94	Unanticipated occurrence in the ATR Canal during cutting of the Loop-1 shroud.
02/05/96	Loop-1 experiment shroud cut in the ATR Canal and Loop-1 assembly retrieved.
07/17/96	Loop-1 loaded in T2 Cask and transferred to the ANL HFEF.
10/07/96	T2 Cask unloaded. Loop-1 assembly placed in the HFEF Cells.
10/11/96	Disassembly of the individual Loop-1 rods in the HFEF Cells.

1.1.2 Loop-1 Discussion

Prior to current CLWR activities, the New Production Reactor Light Water Reactor experiments were scheduled to be disposed of at the burial grounds. This required the experiment lengths to be reduced to a size amenable for disposal. During the cutting of Loop-1, an "Occurrence" was declared. The use of an underwater dc arc saw resulted in the formation of a hydrogen bubble that ignited while cutting the zircaloy contained in the Loop-1 capsule. The operation was suspended and the Loop-1 experiment returned to storage in the ATR Canal. All disposal efforts were suspended pending review of the conditions leading to the hydrogen bubble ignition. The root cause report is enclosed in Appendix A.

The Loop-1 experiment was laid horizontal in the ATR Canal and secured to a table to facilitate the cutting of the experiment's shroud by pneumatic band saw. After cutting, the experiment was righted vertically and the Loop-1 assembly removed by a special tool. The Loop-1 assembly was loaded into a shipping container in the ATR Canal. The shipping container was lifted out of the ATR Canal and temporally left suspended above the ATR Canal to drain. The shipping container was then placed into a 2R basket inside the T2 Cask, in open air transfer. The 2T Cask was transferred to the ANL HFEF for nondestructive PIE

Due to a HFEF shutdown, the facility could not unload the T2 Cask immediately after receiving it from ATR. After a three month delay, the assembly was unloaded from the T2 Cask and placed in the HFEF Cells to begin disassembly procedures.

During disassembly, it was noticed that the rods were loose within the assembly, with some variation in the relative axial displacement of the bottom ends. The rods were easily pulled (by manipulator) horizontally from the assembly grid structure. The visual appearance of the rods showed isolated areas of high luster in comparison to the remaining surface area of the rods.

1.1.3 S1 and B1 History

Table 3. S1 and B1 history.

Date	Event
07/21/91	S1 and B1 experiments removed from the ATR Core after 143 effective full-power days.
08/29/96	Shroud length reduction of S1 in the ATR Canal.
09/03/96	Shroud length reduction of B1 in the ATR Canal.
09/24-25/96	Disassembly of the S1 and B1 capsule in the ATR Hot Cells.
10/05/96	S1 and B1 rods loaded into the T2 Cask for transfer to ANL HFEF.
10/28/96	S1 and B1 rods unloaded from T2 Cask and placed in the HFEF Cells.

1.1.4 S1 and B1 Discussion

The lengths of the shrouds for both experiments were approximately 15 feet. The transfer cask used to transport the experiments from the ATR to the ATR Hot Cells is limited to an internal height of five feet. This necessitated reducing the length of the shroud to five feet by using a pneumatic band saw in the ATR Canal and making cuts on both ends of the shroud. Once the two experiments were transferred to the ATR Hot Cells, additional cuts were made in the cell to expose the inner pressure capsule. A horizontal screw was used to push out the inner capsule from the shroud. Both rods were allowed to freely slide out of the inner pressure capsule onto a strongback. A catch basin was used during cutting to collect any internal water in the capsules. Little water was collected from the disassembly of S1, but water was collected in the basins during disassembly of B1. In addition, particulate matter came out of the inner pressure capsule as B1 was slid out onto the strongback. Both rods were smeared for tritium after disassembly.

Results of the analysis on the collected B1 water sample indicated a below background reading for tritium. The radio-isotopic analysis of the B1 particulate indicated the presence of the isotope Co^{60} . Chemical analysis of the B1 particulate appeared analogous to products of stainless steel corrosion.

Results of the smears from the ATR Hot Cells for S1 and B1 indicated a strong positive for the presence of tritium. Upon arrival from the ATR Hot Cells, the S1 and B1 rods were smeared again in the ANL HFEF Cell. The results indicated a high positive, but a second set of smears indicated below background readings. The difference between the readings could possibly be due to the method of taking the smears. ATR Hot Cells use a polystyrene "popcorn" bead as the smear medium. After smearing, the bead is directly immersed into the scintillation cocktail, where it completely dissolves, and the cocktail is then counted. HFEF uses a cotton material disk, which is immersed in distilled water (after swiping), as a leaching medium. The distilled water is transferred to the scintillation cocktail for counting.

2. NONDESTRUCTIVE EXAMINATIONS

2.1 Visual Examination and Photography

The Loop-1, S1, and B1 rods were visually inspected along the entire axial length through the ANL HFEF periscope at medium magnification ($\approx 10X$). Smaller features were visually examined with high magnification ($\approx 25X$). After all the rods were visually inspected, each rod was remounted in the periscope and photographs were taken of unique features, except for WL-10 and WL-26. These rods were selected for a full length photo composite taken at four angles of rotation 0, 90, 180, and 270 degrees. The photographs and their index are found in Appendix B.

2.2 Neutron Radiography

Neutron radiography is a procedure similar to x-ray radiography where neutrons are used instead of x-rays to expose metal foils instead of film. Four Loop-1 rods at a time or both S1 and B1 rods were inserted in stainless steel carrier tubes and positioned in front of the neutron shutter. Behind the stainless steel carrier tubes is a film pack consisting of dysprosium, cadmium, and indium foils. After a 30 minute neutron exposure the film pack is removed and disassembled. The dysprosium and indium foils have unexposed film placed in contact and held together in a light tight vacuum chamber overnight to expose the film. The exposed film is developed to normal background density. Due to the length of the film, several shots are required to exposed the entire length of the rods. The dysprosium exposed films represent the thermal radiographs and the indium exposed film represents the epithermal radiographs.

In addition to the films, "positives" of the films are made by exposing a high intensity light source through the films backed by black and white photographic film. This process provides photographs of the films. The photos, scanned and printed on 8×17 inch paper, are found in Appendix C.

2.2.1 Operational Notes for Radiography

When reading a neutron radiograph, orient the film so that the label is "right-reading," is located along the left side, and the ANL logo is in the bottom left corner. In this orientation, images appear as if the observer's eye were located at the source of neutrons.

The label (see the Figure 1) shows the Shot # (for internal ANL use), the Subassembly or Test ID, the elevation of the radiograph, and the Element or Specimen ID. The Element or Specimen ID reads from top to bottom (when oriented as above) and corresponds to the elements or specimens from left to right in the image.

All duplicate negatives of the radiographs have small holes punched in their bottom corners. Original radiograph films and positive prints do not have holes punched in them.

The two types of radiographs can be readily distinguished by the relative contrast of the images. Thermal radiographs have a high contrast, and the image of any fuel in the radiograph is generally white on the film. Labels on thermal radiographs are usually clear and easy to read. Epithermal radiographs have less contrast, but show more image detail in the pellet areas. Labels on these radiographs are difficult to read and often show on the film as dark blocks.

The background density of duplicate negatives is generally slightly darker than the originals because the duplicates are developed to match the density of the image areas of originals.

Figure 1. Sample of a neutron radiograph.

2.3 Axial Gamma Scanning

Gamma scans are presented in graphic form for each rod. Each rod has three scans associated with it, a gross scan, an Mn^{54} scan and a Co^{60} scan. These are found in Appendix D. Below are notes which describe the operation of the gamma scanning station.

2.3.1 Operational Notes on Gamma Scanning

The Precision Gamma Scanner-II (PGS-II) is designed to intermittently transverse rod-like objects in the form of a small, solid-angle collimator for collection of gamma spectra at a series of positions. Usually the increment of transverse is set equal to the collimator slit opening to provide complete object coverage.

The gamma-ray spectroscopy subsystem consists of an ultra-pure germanium (UPG) detector with a nominal efficiency of 10% (relative to a 2 x 2-in. NaI detector). Active Compton-suppression is accomplished by detecting the time-of-life delay between the UPG and the surrounding large-volume NaI guard detector. A background suppression factor of 6-10 (based on Co^{60} peaks) is normally achieved.

The PGS-II is designed and calibrated to position and report the location of the centroid of the collimator (with respect to the upper tip of the scanned object) to an accuracy of ± 0.005 inches for each positional measurement.

Data was acquired in spectral mode, which maps gamma energies (in the range of 50 to 1,600 keV) into 4,096 channels.

The collimator slit is rectangular with a width of 0.880 inches and an adjustable height of 0.0 to 0.100 inches. The slit opening was 0.100 inches for all measurements. Slit opening is reported in all data tables and charts. The distance between the rod and UPG is eight feet.

The live time of each positional count is infinitely adjustable, but is usually fixed for any given scan. The live time used for a scan is reported in all data and tables.

Because active isotopes Mn^{54} and Co^{60} have long decay times in comparison to the count times, there was no correction for decay during counting.

Gross, Mn^{54} , and Co^{60} axial data along the length the rod is provided in digital form on a CD-ROM. The data are stored as plain ASCII data in DOS file format (i.e., records are terminated by <CR><LF> pairs). The first 10 records contain self-explanatory header information. Following the header records, spectral data are stored in tab-delimited fields as follows:

<Position><tab><Gross><tab><Isotope-1><tab>...<Isotope-N><CR><LF>

2.4 Contact Profilometry Measurement

The element contact profilometry (ECP) is a high-throughput continuous-contact profilometry gauge for measuring axial-diameter profiles of elements and capsules. Horizontally-opposed linear transducers contact the element as it is pulled vertically through sapphire-tipped probes showing in Figure 2. Guide rollers are positioned three inches above and below the transducers to maintain the element vertical with respect to the horizontal transducers. Certified calibration standards are used for zero, mid-span, and full-span calibration. The data for ECP is found in Appendix E for angles, Φ_c , of 0, 45, 90, and 135. ECP was not performed on WL-10 or WL-26.

RED97 SG0082

Figure 2. Profilometry gauge for measuring axial diameter profiles of elements and capsules.

2.4.1 Operational Notes on ECP

When fuel elements (pins) or capsules are significantly bowed, a situation can arise when the lower tip of the element or capsule exits the bottom guide roller near the end of the measurement. Depending on the direction and magnitude of the bow, the portion of the element or capsule below the upper guide roller can assume an angle with respect to the measuring probes causing an erroneously high reading. This is an inherent feature of the system that cannot be corrected; therefore, the resultant data must be interpreted with caution.

Full-length scans usually start as high as possible on the element or capsule (but no higher than the upper cladding weld) and end at the lower cladding weld. Because of interference from the upper roller and the collet applied to the element or capsule, the topmost four inches cannot be measured.

The "Z-Position" reported on ANL-supplied plots is the raw position (Z_s , in inches) of the in-cell positioning stage and has no fixed or known offset from the top or bottom of the element or capsule. Note that the stage Z-Position is higher toward the bottom of an element or capsule.

The "Diameter" reported on ANL-supplied plots is the profile dimension (in inches) perpendicular to the azimuthal position, ϕ_e (in degrees), as shown in the diagram below.

By convention, azimuthal positions increase counterclockwise (CCW) from the azimuthal reference feature when viewed from the top of the element or capsule as shown in Figure 3.

Figure 3. View looking down on top of element/capsule.

During measurement of the profile, recorded data are sometimes corrupted by electronic noise. Until the source of this noise can be discovered and corrected, obvious data errors may have been removed from the attached data reports.

Copies of the profilometry data are provided on CD-ROMs. By convention, the data from each azimuthal angle is contained in a separate file with the name:

filename.ext

where:

filename = Element/Capsule ID

ext = Azimuthal Angle (e.g., 045)

Within each file, the data are recorded as plain ASCII text with each line terminated by a <CR><LF>. The first three lines of data contain descriptive text information (such as S/A ID and PIN ID) that is self explanatory. Below this are three columns of tab-delimited numeric data corresponding (left-to-right) to: "Z-Position (in.)", " ϕ_s ($^\circ$)" and "Diameter (in.)". The end of data are sometimes flagged by large contrasting numbers, usually a string of nines (e.g., "999.999").

2.5 Bow and Length Measurement

The rod bow and length measurement system is mounted in conjunction with the rod contact profilometer on a standard examination stage. The rod hangs freely from a collet-style end fitting applied to its end plug. The end fitting is held rigidly in the gripper attached to the vertical carriage of the examination stage. The measurement system (see Figure 4) consists of two horizontal screw-driven flat bars, oriented at right angles to each other, on which an edge following light-beam device is mounted. When the light beam is interrupted, the screw drive stops the motion of the bar.

RED97 SG0083

Figure 4. Measurement system.

For each element, a series of x-y coordinates is obtained at increments along the element (Z) by running the bars toward the element until each light beam is interrupted by the edge of the element and

converting the position into an x-y coordinate pair. This sequence is repeated until a full set of x, y, z coordinates is obtained.

The length of the element is determined and the positions of the element end points are extrapolated from the measured data. The reference, from which bow is measured, is an imaginary tip to tip centerline connecting the element position (Z_i); the horizontal distance (D_i) is calculated from this centerline (X_{ci} , Y_{ci}) to the element (X_i , Y_i). However, bow (B_i) is defined as the perpendicular distance and, as shown in Figure 5, the tip-to-tip centerline is offset from vertical by the angle θ ; therefore, the actual bow (B_i) is calculated from the horizontal distance by correcting for the angle θ . The hanging length of the element is measured by touching the bottom tip of the rod to a conductive plate on the bow and length gage assembly, and comparing that Z-position to the Z-position of a length standard similarly positioned.

All of the calculations of bow are performed by an online, data-reduction computer. The data recorded consists of a table of bow data for each rod, a table of maximum bow (and bow direction) for each rod, and a table of the corrected length of each rod. The bow measurements were made at 2-in. increments along the length of the rod. The corrected length of the rod is calculated by summing the 2-in. segment lengths (from tip to tip) between the calculated 3D positions of the element centerline (i.e., along the length of the bowed shape of the element). The data for the bow and length measurements are found in Appendix F.

RED97 SG0083

Figure 5. Elevation view of element as measured.

2.6 Gas, Analysis, Sample, and Recharged System

2.6.1 GASR Overview

The Gas, Analysis, Sample and Recharge System (GASR) located in the ANL HFEF was used to obtain the rod internal pressure and void volume and plenum gas samples for analysis. The laser punctures the capsule in the plenum region and releases the rod gas into calibrated volumes. After the gas has reached equilibrium, it is further expanded into evacuated sample bottles out-of-cell for mass spectrometric and tritium concentration analysis. Then the capsule and seal-head chamber are repeatedly refilled with helium gas and reopened into known evacuated calibrated system volumes in order to calculate the capsule's volume. After calculating the volume of the capsule, the pressure of the capsule (prior to puncture) is calculated using the equilibrium pressure values measured after expansion into the calibrated volumes.

2.6.2 Dummy Rod

To provide assurances that the GASR system was measuring accurate rod void volumes and pressures, a rod was taken from the Critical Test-2 assembly and modified by drilling through the upper end cap into the plenum and welding a valve on the upper end cap of the rod. The rod was pressurized with helium to a known pressure and temperature. The ANL was not told what the pressure was until the puncture and calculations were complete. The calculated pressure obtained from GASR data was within experimental accuracy of the measured pressure of the rod. Information on the dummy rod preparation and GASR puncture data is found Appendix G.

2.6.3 GASR Operations

Based on estimated ranges supplied by PNNL for Loop-1, S1, and B1 internal rod pressures, an auxiliary volume was needed to maintain the seal-head pressure, including the auxiliary volume, below 50 psia. This restriction prevents the resultant pressure from expansion into the manifold of being greater than atmospheric pressure. An interlock is in place which prohibits taking samples of gas outside the cell at pressures greater than atmospheric.

The rod is clamped against the saddle-shaped gasket in the seal head. The entire system, including the sample chambers, is evacuated to <30 mtorr.

The seal head, including the auxiliary volume, is isolated from the manifold and the sampling chambers.

The laser drills a small hole 5 to 10 mm in diameter in the capsule wall of the plenum region. The gas expands into the seal-head and auxiliary volume where the pressure is measured on a high-range meter (P1).

When the pressure has equilibrated in the seal-head and auxiliary volume, a valve is opened to the manifold and the gas expands into the manifold, where the pressure is monitored on an accurate low-range meter (P2) and the capsule temperature is measured by an in-cell thermocouple. The assumption is made that all expansions are adiabatic, since no temperature increase is seen in the rod.

Valves to the sample lines are opened to allow the gas to expand into the sample bottles. Isolation valves on the sample bottles are closed to capture the gas samples and the bottles are carried to the Analytical Laboratories. The pressure reading from P2 and a temperature reading from a thermometer inside the sampling box are recorded on the traveler accompanying the bottles to the analytical laboratory.

A series of backfill and expansion operations are performed to accurately determine the capsule void volume. The auxiliary volume is isolated from the system during all backfill and expansion operations. Helium is used to backfill the capsule to selected target pressure ranging from atmospheric to 45 psia, as monitored by P2. The capsule/seal head is isolated and the manifold is re-evacuated to <30 mtorr. The helium in the capsule/seal head is then expanded into the manifold where the pressure is monitored on P2.

The rod is backfilled with helium gas before rewelding. The laser beam is defocused and fired to create a puddle weld. Attempts to reweld all rods were not successful. On the first rod, WL-18, silicone was used to plug the hole, but this procedure was discontinued on the remaining rods.

2.6.4 Rod Void Volume And Pressure Calculations

Variables used to describe the GASR system are the seal-head volume, V_{seal} , the manifold volume, V_{man} , and the auxiliary volume, V_{aux} . The pressures are measured by two pressure gauges. The pressure gauge, P1, which measures the pressure in the seal-head and auxiliary volume, is denoted by P_{seal} . The gauge has a range of 0 to 200 psia with an accuracy of ± 0.1 psia. The pressure gauge in the manifold, P2, measures the pressure, P_{man} . P2 has a range of 0 to 50 psia with an accuracy of ± 0.01 psia. P_{cap} and V_{cap} are the rod's void volume and internal pressure prior to puncture. P_{seal} is only measured once, upon initial puncture. This is the only measurement that P1 is used for due to its inherent inaccuracies. All other pressure measurements are made with the more accurate P2 pressure gauge.

Below is the mass balance equation describing the expansion from the capsule into the seal-head and auxiliary volume (denoted as the primary side) after puncture.

$$P_{cap} V_{cap} = P_{seal} (V_{cap} + V_{seal} + V_{aux})$$

The expansion from the primary side into the manifold of the GASR system (denoted as the secondary side) is the second expansion. This expansion can be performed with the auxiliary volume open or isolated from the system. Except for one rod out of the ten, the auxiliary volume was open to the secondary side during expansion. Below is the mass balance equation for the expansion into the manifold with the auxiliary volume open.

$$P_{seal} (V_{cap} + V_{seal} + V_{aux}) = P_{man} (V_{cap} + V_{seal} + V_{aux} + V_{man})$$

P_{cap} can be obtained by substituting the above expression for V_{cap} into the prior expression for P_{cap} .

$$P_{cap} = P_{man} (V_{cap} + V_{seal} + V_{aux} + V_{man}) / V_{cap}$$

There was one rod where the auxiliary volume was isolated from the seal-head volume during expansion into the secondary side. In this case, the mass balance equation governing the expansion into the manifold is modified by eliminating the auxiliary volume on both sides of the equation:

$$P_{\text{seal_mod}} (V_{\text{cap}} + V_{\text{seal}}) = P_{\text{man}} (V_{\text{cap}} + V_{\text{seal}} + V_{\text{man}})$$

$$P_{\text{seal_mod}} = P_{\text{man}} (V_{\text{cap}} + V_{\text{seal}} + V_{\text{man}}) / (V_{\text{cap}} + V_{\text{seal}})$$

Where $P_{\text{seal_mod}}$ represents the pressure of only the gas in the seal-head volume and does not include the moles of gas in the auxiliary volume. $P_{\text{seal_mod}}$ is used in the expression for V_{cap} replacing P_{seal} . This results in an expression to calculate the P_{cap} when the auxiliary volume is isolated during expansion:

$$P_{\text{cap}} = P_{\text{man}} (V_{\text{cap}} + V_{\text{seal}} + V_{\text{aux}}) (V_{\text{cap}} + V_{\text{seal}} + V_{\text{man}}) / (V_{\text{cap}} (V_{\text{cap}} + V_{\text{seal}}))$$

During backfills, the auxiliary volume was isolated from the seal-head volume, so the expansion of the seal head and capsule expands directly into the manifold volume. The mass balance for this operation becomes:

$$P_{\text{seal}} (V_{\text{cap}} + V_{\text{seal}}) = P_{\text{man}} (V_{\text{cap}} + V_{\text{seal}} + V_{\text{man}})$$

Solving for V_{cap} :
$$V_{\text{cap}} = ((P_{\text{man}} - P_{\text{seal}}) V_{\text{seal}} + P_{\text{man}} V_{\text{man}}) / (P_{\text{seal}} - P_{\text{man}})$$

From each backfill a value for V_{cap} can be obtained along with a value for P_{cap} . Data from the punctures is located in Appendix H, including the calibration sheets, the data sheets, sample bottle table and volumes ANL's spread sheet for void volume and rod pressure, and MATHCAD work sheets used to verify the calculations.

Appendix I contains the results for the analysis of the plenum gas.

Appendix A

Letter Report on Loop 1 Cutting Problems

INTEROFFICE CORRESPONDENCE

Date: March 7, 1994

To: L. R. Davison, MS 7101

From: L. B. Lundberg, MS 3890 *LB-L*

Subject: ANALYSIS OF LIGHT WATER NEW PRODUCTION REACTOR LOOP-1
EXPERIMENTAL ASSEMBLY CUTTING PROBLEMS - LBL-06-94

On February 22, 1994, while attempting to cut off the end of the New Production Reactor (NPR) Light Water Reactor (LWR) Loop-1 Experiment Assembly under the water of the ATR can, an unusual "noise and vibration" were noted. The cutting operation was stopped, and an 'Occurrence' was declared. An Occurrence Report was written, entitled, "Noise and Vibration Observed During Underwater Cutting Operations in the Advanced Test Reactor Canal" (ID-EGG-ATR-1994-0004). The report states that the assembly was being cut with an underwater DC-arc saw which cuts metal by producing a plasma arc between the circumference of the rotating blade of the saw and the work piece. The arc saw cuts by melting through the work piece under the blade. The saw was cutting through a region of the assembly that contained zircaloy captured inside a stainless steel collar. The cutting line is indicated in Figure 1 below.

Figure 1. Cross-section of experimental assembly being cut with the arc saw in the ATR canal.

In subsequent conversations with Lee Davison and Robert O'Connor, it was determined that the "vibrations" were actually "muffled thumps" which can be interpreted to have been caused by water hammers or small explosions. These small explosions were felt through the feet of individuals standing on the concrete floor near the canal. A reddish flash and a cloud of bubbles was also observed to emanate from the cutting area. The resultant bubble cloud obscured the view of the cutoff saw. It was also stated that the cloud of bubbles was the size of a "pie plate" when it reached the surface of the water.

The bubbles probably contained hydrogen that was generated by the reaction between zirconium and water: $\text{Zr} + 2\text{H}_2\text{O} \Rightarrow \text{ZrO}_2 + 2\text{H}_2\uparrow$. This type of chemical reaction applies to arc cutting of most metals under water. This reaction is expected to proceed at a very high rate because the rotating arc saw ejects molten metal droplets from the kerf into the surrounding water.

It is important to realize that the hydrogen cannot ignite under water, and the primary source of chemical energy is the reaction between molten metal droplets and the water. Electrolysis of the water due to the voltage between the saw blade and the work piece will produce an additional small quantity of hydrogen, but this source is expected to be insignificant compared to that generated by metal-water reactions.

An estimate was made for the amount of hydrogen generated in the observed explosion. It was estimated that a sufficient quantity of hydrogen was generated to fill a cylinder 10" in diameter by 10" high just below the surface of the water. Assuming that this volume is at standard temperature and pressure (STP: 298 K and 1 atmosphere pressure), it was calculated that about 0.6 moles of hydrogen were contained in the bubbles. This indicates that about 26 grams (0.3 moles) of zirconium reacted with the water to cause the explosion.

The maximum rate of metal ejection from the kerf was calculated from the highest electrical power input to the arc saw. Using enthalpy data for zircaloy¹, it was calculated that, for an arc saw cutting only zircaloy and operating at 27 volts and 3000 amperes, an upper limit melting rate of about 91g/s could be achieved. Oxidizing this amount of zirconium in water would generate up to 600 kW of thermal energy. The metal droplets will have to be small to ignite explosively in water at the melting temperature because it has been reported that bulk molten zirconium will not explosively react with water when the liquid metal is below 2873 K². Explosive metal-water reactions are observed for metals that do not form a protective oxide at about 1.03 times the absolute melting temperature of the metal³. For small zirconium droplets, explosive reactions could be expected at metal temperatures as low as 2194 K, only 64°K above the melting point of

zirconium. The observed, chaotically occurring explosions probably resulted from the special conditions of ejected droplet size and number. For example, these explosions could have occurred as a result of bursts of metal droplets being ejected after a brief holdup in the kerf due to the high surface tension of molten zircaloy.

Steam bubbles generated from the chemically derived heat will also add to the problem. The steam bubbles will rapidly collapse after they are formed, and the force generated from the collapse will be significant and impulsive in nature. For example, we calculated that a 4-cm diameter steam bubble collapses with a force of 127 kN (28,500 lbf) under 138 kPa (20 psia), 300 K (80°F) water. (A description of the details of this calculation is attached.)

Hazards of cutting zircaloy with an arc saw are clearly indicated by this incident. Cutting zircaloy with an arc saw under water causes explosions, probably due to metal-water reactions. The potential severity of an explosion resulting from this procedure appears to be proportional to the power applied to the arc, i.e., the cutting rate. The ability of the work piece to hold up and eject, in bursts, large quantities of molten metal is chaotic, and therefore, the magnitude of an explosion resulting from contact with water cannot be predicted with any confidence.

The explosion hazard associated with cutting zircaloy under water would probably become negligible if the cutting method did not generate molten metal, especially if the cutting tool generated only large chips or turnings. A bandsaw or a circular saw with a toothed blade are likely candidates for cutting zircaloy with reasonably large chips and without generating molten metal.

References

¹ SCDAP/RELAP5/MOD2 Code Manual, Vol. 4: MATPRO - A Library of Materials Properties for Light-Water-Reactor Accident Analysis, J. K. Hohorst (Ed.), U.S. Nuclear Regulatory Commission Report No. NUREG/CR-5273, February 1990, p. 4.3-17.

² P. Kuan and B. J. Buescher, "Ignition Threshold of Molten Aluminum in Water," in Heat Transfer - Minneapolis 1991, S. B. Yilmaz and B. G. Volintine (Eds.), AIChE Symposium Series, Vol. 87, No. 283, AIChE, NY (1991) pp. 177-181.

L. R. Davison
March 7, 1994
LBL-06-94
Page 4

³ L. F. Epstein, "Correlation and Prediction of Explosive Metal-Water-Reaction Temperatures," Nuclear Science and Engineering, 10 (1961) pp. 247-253

djm

Attachment:
As Stated

cc: R. C. Green, MS 4129
R. R. O'Connor, MS 7136
S. T. Polkinghorne, MS 3885
J. R. Wolf, MS 3890 *gr*
L. B. Lundberg Letter File

Bubble Collapse Height and Force Estimates

Nomenclature

C sound speed
 c_p specific heat
 d initial bubble diameter
 F force
 g acceleration of gravity
 H height at collapse
 h_{fg} latent heat of condensation
 Ja Jakob number (Equation 2)
 P_∞ liquid pressure
 Pr Prandtl number
 Ra Rayleigh number (Equation 3)
 T_{sat} saturation temperature
 T_∞ liquid temperature

Greek symbols

ν kinematic viscosity
 ρ density

Subscripts

l liquid property at T_∞
 f liquid property at $T_f = \frac{1}{2}(T_{sat} + T_\infty)$
 v vapor property at saturation

Collapse Height

The height saturated steam bubbles rise in subcooled water before collapsing (i.e., condensing) can be estimated as follows:¹

$$H/d = 768/Ja^{3/5} Ra^{1/4} \quad (1)$$

where

$$Ja = \rho_l c_{pf} (T_{sat} - T_\infty) / \rho_v h_{fg} \quad (2)$$

$$Ra = [g(\rho_l - \rho_v) d^3 / \rho_l \nu_f^2] Pr_f \quad (3)$$

Solutions to Equation 1 for initial bubble radii ranging from 0.1 to 4 cm are shown below. The water pressure and temperature were assumed to be 138 kPa (20 psia) and 300 K (80°F), respectively, and the bubbles were assumed to contain no noncondensable gas (air or H₂). In addition, Equation 1 was assumed to be valid at low pressure (see Note).

d (cm)	H (cm)
0.1	0.17
0.2	0.20
0.5	0.25
1.0	0.30
2.0	0.36
3.0	0.40
4.0	0.43

These results indicate that the steam bubbles would collapse almost immediately after being introduced into highly subcooled water. On the basis of these results, it appears unlikely that any steam reached the surface during underwater cutting operations in the ATR canal.

Note: The experiments reported in Reference 1 were performed for pressures ranging from 150 to 900 psia, for subcooling from 27 to 180°F, and for initial bubble diameters of about 3 mm. Collapse heights ranged from 2 to 15 times the initial bubble diameter, depending on operating conditions. The authors noted that collapse heights increase with increasing pressure because the latent heat per unit volume increases significantly with pressure, necessitating a longer bubble lifetime to transfer the heat liberated by condensation. The above results are consistent with this observation.

Collapse Force

The maximum force exerted on an "infinite" flat wall due to rapid bubble collapse can be estimated as follows:²

$$F = 4.5d^2(\rho_l C_l)(P_\infty/\rho_l)^{1/2} \quad (4)$$

Solutions to Equation 4 for bubble radii ranging from 0.1 to 4 cm are given below. The water pressure and temperature were again assumed to be 138 kPa (20 psia) and 300 K (80°F), respectively.

<u>d (cm)</u>	<u>F (kN)</u>	<u>F (lbf)</u>
0.1	0.0792	17.8
0.2	0.317	71.2
0.5	1.98	445
1.0	7.92	1780
2.0	31.7	7120
3.0	71.3	16000
4.0	127	28500

These results indicate that bubble collapse forces can be significant, which may explain the vibration and noise detected during underwater cutting operations in the ATR canal.

Property Values at 138 kPa and 300 K

$T_{sat} = 382 \text{ K (228}^\circ\text{F)}$
 $T_f = 341 \text{ K (154}^\circ\text{F)}$
 $\rho_f = 980 \text{ kg/m}^3$
 $\rho_l = 996 \text{ kg/m}^3$
 $\rho_v = 0.798 \text{ kg/m}^3$
 $\nu_f = 4.26 \times 10^{-7} \text{ m}^2/\text{s}$
 $c_{pf} = 4180 \text{ J/kg}\cdot\text{K}$
 $h_{fg} = 2.23 \times 10^6 \text{ J/kg}$
 $Pr_f = 2.64$
 $C = 1500 \text{ m/s}$

References

1. G. G. Brucker and E. M. Sparrow, "Direct Contact Condensation of Steam Bubbles in Water at High Pressure," Int. J. Heat Mass Transfer, 20, 1977, pp. 371-381.
2. F. J. Moody, Introduction to Unsteady Thermofluid Mechanics, New York: John Wiley & Sons, 1990, p. 570.

Appendix B

Photographs

Appendix B

Table of Contents

Loop-1

PHOTO-ID	PIN-ID	Caption
9G1	Loop Assembly	Top half of face #1 (Bundle 0° face)
9G2	Loop Assembly	Bottom half of face #1 (Bundle 0° face)
9G3	Loop Assembly	Top half of face #2 (Bundle 90° face)
9G4	Loop Assembly	Bottom half of face #2 (Bundle 90° face)
9G5	Loop Assembly	Top half of face #3 (Bundle 180° face)
9G6	Loop Assembly	Bottom half of face #3 (Bundle 180° face)
9G7	Loop Assembly	Top half of face #4 (Bundle 270° face)
9G8	Loop Assembly	Bottom half of face #4 (Bundle 270° face)
9G9	Loop Assembly	Through-mirror view of bottom of bundle (face #1 up)
11G1	WL-01	Shiny axial patch
11G2	WL-01	Low-luster surface (bottom of target)
11G3	WL-01	Light-to-dark transition
11G4	WL-01	Shiny surface (upper middle)
11G5	WL-01	Upper weld (shows end-fitting grip marks)
11G6	WL-27	General pitting (typical)
11G7	WL-27	Large pit (typical)
11G8	WL-27	Large pit (typical)
11G9	WL-27	Barrier transition (typical)
11G10	WL-27	Spacer grid marks (typical)
11G11	WL-26	General pitting
11G12	WL-26	Lower tip
11G13	WL-22	Typical barrier (bottom, front)
11G14	WL-22	Typical barrier (bottom, back)
11G15	WL-22	Typical barrier (center) - Rotational composite, 328°
11G16	WL-22	Typical barrier (center) - Rotational composite, 28°
11G17	WL-22	Typical barrier (center) - Rotational composite, 88°
11G18	WL-22	Typical barrier (center) - Rotational composite, 148°

Loop-1

PHOTO-ID	PIN-ID	Caption
11G19	WL-22	Typical barrier (center) - Rotational composite, 207°
11G20	WL-22	Typical barrier (center) - Rotational composite, 268°
11G21	WL-22	Barrier islands
11G22	WL-22	Lower tip
11G23	WL-18	Footprints
11G24	WL-18	Bottom tip
11G25	WL-10	Dark pit
11G26	WL-09	Typical barrier (bottom) - Rotational composite, 119°
11G27	WL-09	Typical barrier (bottom) - Rotational composite, 179°
11G28	WL-09	Typical barrier (bottom) - Rotational composite, 239°
11G29	WL-09	Typical barrier (bottom) - Rotational composite, 299°
11G30	WL-09	Typical barrier (bottom) - Rotational composite, 359°
11G31	WL-09	Typical barrier (bottom) - Rotational composite, 60°
11G32	WL-03	Footprints
11G33	WL-03	Top End
11G34	WL-03	Bottom End
11G35	WL-03	Dark stain

WL-10 Photo Composite

15G1	WL-10	Angle of 270
15G2	WL-10	Angle of 270
15G3	WL-10	Angle of 270
15G4	WL-10	Angle of 270
15G5	WL-10	Angle of 0
15G6	WL-10	Angle of 0
15G7	WL-10	Angle of 0
15G8	WL-10	Angle of 0
15G9	WL-10	Angle of 90
15G10	WL-10	Angle of 90
15G11	WL-10	Angle of 90
15G12	WL-10	Angle of 90
15G13	WL-10	Angle of 180

Loop-1

PHOTO-ID	PIN-ID	Caption
15G14	WL-10	Angle of 180
15G15	WL-10	Angle of 180
15G16	WL-10	Angle of 180

WL-26 Photo Composite

15G17	WL-26	Angle of 270
15G18	WL-26	Angle of 270
15G19	WL-26	Angle of 270
15G20	WL-26	Angle of 270
15G21	WL-26	Angle of 0
15G22	WL-26	Angle of 0
15G23	WL-26	Angle of 0
15G24	WL-26	Angle of 0
15G25	WL-26	Angle of 90
15G26	WL-26	Angle of 90
15G27	WL-26	Angle of 90
15G28	WL-26	Angle of 90
15G29	WL-26	Angle of 180
15G30	WL-26	Angle of 180
15G31	WL-26	Angle of 180
15G32	WL-26	Angle of 180

S1 and B1 Photos

PHOTO-ID	PIN-ID	Caption
96-659-1-30	WT-11	ATR Hot Cell Disassembly
96-659-2-26	WT-12	ATR Hot Cell Disassembly
96-659-2-24	WT-12	ATR Hot Cell Disassembly
10G1	WT-11	Disassembly
10G2	WT-12	Disassembly
14G1	WT-11	Top end
14G2	WT-11	Bottom end
14G3	WT-11	Typical scratches (rotation composite), 29°
14G4	WT-11	Typical scratches (rotation composite), 89°
14G5	WT-11	Typical scratches (rotation composite), 150°
14G6	WT-11	Typical scratches (rotation composite), 210°
14G7	WT-11	Typical scratches (rotation composite), 269°
14G8	WT-11	Typical scratches (rotation composite), 329°
14G9	WT-12	Top end
14G10	WT-12	Top end
14G11	WT-12	Bottom end
14G12	WT-12	Typical scratches (rotation composite), 291°, elev. 46.3 in.
14G13	WT-12	Typical scratches (rotation composite), 351°, elev. 46.3 in.
14G14	WT-12	Typical scratches (rotation composite), 52°, elev. 46.3 in.
14G15	WT-12	Typical scratches (rotation composite), 112°, elev. 46.3 in.
14G16	WT-12	Typical scratches (rotation composite), 171°, elev. 46.3 in.
14G17	WT-12	Typical scratches (rotation composite), 232°, elev. 46.3 in.
14G18	WT-12	Typical scratches (rotation composite), 292°, elev. 16.8 in.
14G19	WT-12	Typical scratches (rotation composite), 352°, elev. 16.8 in.
14G20	WT-12	Typical scratches (rotation composite), 52°, elev. 16.8 in.
14G21	WT-12	Typical scratches (rotation composite), 112°, elev. 16.8 in.
14G22	WT-12	Typical scratches (rotation composite), 172°, elev. 16.8 in.
14G23	WT-12	Typical scratches (rotation composite), 232°, elev. 16.8 in.

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 6, 1997

MATERIAL EXAMINED:

Rods WL-10 and WL-26 from CLWR Loop-1 Bundle

TYPE OF EXAMINATION:

Composite Photography

FORM OF DATA:

Photo Index and Mosaics (5)

NOTES:

CC: w/Attachments

Loop-1 file (unassembled)

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data
transmittal should be directed to
the Cognizant Engineer at
extension (208) 533-7773.

Revised: 2/11/97

INDEX OF PHOTOGRAPHS

[illegible]

* Arbitrary angular reference

Revised 6/12/95

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies Co.
P. O. Box 1625
EROB MS-3760
Idaho Falls, ID 83415

DATE:

March 3, 1997

MATERIAL EXAMINED:

Two Rods from CLWR Test S1/B1

TYPE OF EXAMINATION:

Visual Examination

FORM OF DATA:

Data Sheets, Photo Index, Negatives (1) and Prints (5)

NOTES:

CC: w/Attachments

S1/B1 file (prints only)

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

INDEX OF PHOTOGRAPHS

FACILITY: ☐ FMF ☐ AL ☒ HFEF ☐ OTHER:				DATE: 3/3/97
ITEM:	S/A or Test CLWR S1/B1	Cap/Elem As noted	Subcap N/A	Other N/A
SUBJECT: Visual examination of CLWR Target Rods				

PHOTO ID	PIN ID	Z_e^1	ϕ_e^2	MAG.	DESCRIPTION
14G1	WT-11	48.6	287	Med	Top end
14G2	WT-11	0.7	189	Med	Bottom end
14G3	WT-11	28.0	29	Med	Typical scratches (Rotational composite)
14G4	WT-11	28.0	89	Med	Typical scratches (Rotational composite)
14G5	WT-11	28.0	150	Med	Typical scratches (Rotational composite)
14G6	WT-11	28.0	210	Med	Typical scratches (Rotational composite)
14G7	WT-11	28.0	269	Med	Typical scratches (Rotational composite)
14G8	WT-11	28.0	329	Med	Typical scratches (Rotational composite)
14G9	WT-12	48.7	201	Med	Top end
14G10	WT-12	48.7	317	Med	Top end
14G11	WT-12	0.5	354	Med	Bottom end
14G12	WT-12	46.3	291	Med	Typical (Rotational composite)
14G13	WT-12	46.3	351	Med	Typical (Rotational composite)
14G14	WT-12	46.3	52	Med	Typical (Rotational composite)
14G15	WT-12	46.3	112	Med	Typical (Rotational composite)
14G16	WT-12	46.3	171	Med	Typical (Rotational composite)
14G17	WT-12	46.3	232	Med	Typical (Rotational composite)
14G18	WT-12	16.8	292	Med	Typical (Rotational composite)
14G19	WT-12	16.8	352	Med	Typical (Rotational composite)
14G20	WT-12	16.8	52	Med	Typical (Rotational composite)
14G21	WT-12	16.8	112	Med	Typical (Rotational composite)
14G22	WT-12	16.8	172	Med	Typical (Rotational composite)
14G23	WT-12	16.8	232	Med	Typical (Rotational composite)

REMARKS:

1. Approximate axial position of photo center above bottom tip (in inches).
2. Azimuthal angle of photo (in degrees) measured CCW from visual reference (index notch toward eye).

Photograph is properly oriented when ID No. is in lower right-hand corner as shown.

NOTE: Original negatives are permanently archived at ANL-West.

Revised 6/12/95

VISUAL EXAMINATION DATA SHEET

Elem. No. <u>WT-12</u>		Grid Pos. _____		Date <u>11/15/96</u>		Examiner <u>BEATON</u> S/A <u>B-1</u>	
Top End-Plug Weld: 1. ☐ OK 2. ☐ Reject				Indicated Stage Position		Distance from Bottom of Element	
Wire Wrap Condition: 1. ☐ N/A 2. ☐ Tight, no gaps 3. ☐ Loose, gaps up to wire diam. 4. ☐ Very loose, gaps up to 1/8" 5. ☐ Extremely loose, gaps > 1/8" 6. ☐ Broken							
SURFACE CONDITION							
Axial Scratch.		Circum. Scratch				Random Scratches	
few--many		few--many				few--many	
Light		Light				Light	
Medium		Medium				Medium	
Heavy		Heavy				Heavy	
Spotty Stains		Discoloration				Contact Marks	
few--many		RdB/BGr				few--many	
Light		Light				Stains	
Medium		Medium		Burnish			
Dark		Dark		Wear			
Above Core				TOF			
Axial Scratch.		Circum. Scratch		Random Scratches			
few--many		few--many		few--many			
Light		Light		Light			
Medium		Medium		Medium			
Heavy		Heavy		Heavy			
Spotty Stains		Discoloration		Contact Marks			
few--many		RdB/BGr		few--many			
Light		Light		Stains			
Medium		Medium		Burnish			
Dark		Dark		Wear			
Core Region				BOF			
Axial Scratch.		Circum. Scratch		Random Scratches			
few--many		few--many		few--many			
Light		Light		Light			
Medium		Medium		Medium			
Heavy		Heavy		Heavy			
Spotty Stains		Discoloration		Contact Marks			
few--many		RdB/BGr		few--many			
Light		Light		Stains			
Medium		Medium		Burnish			
Dark		Dark		Wear			
Below Core							
Bottom End-Plug Weld: 1. ☐ OK 2. ☐ Reject				Z ₀ <u>58.361</u>		φ ₀ <u>331.3</u>	
T-Bar Slot: 1. ☐ N/A 2. ☐ Good 3. ☐ Closed 4. ☐ Spread 5. ☐ Reject				Note: Angular zero reference (φ ₀) measured at (ck. one)			
General Condition: 1. ☐ Excellent 2. ☐ Good 3. ☐ OK 4. ☐ Poor 5. ☐ Bad 6. ☐ Breach				☐ Spade slot, by wire			
Wash: 1. ☐ IBC 2. ☐ Hand 3. ☐ None				☐ ID flat ☒ Other (expl.)			
Photographs: 1. ☒ Yes 2. ☐ No Series <u>14G</u>				<u>SLOTTED THRU-HOLE</u>			
General Comments: _____				<u>(ARBITRARY DIRECTION)</u>			

Note: $\theta_e = \phi_1 - \phi_0$, if measured CCW; $\theta_e = \phi_0 - \phi_1$, if CW (looking down at top of element).

VISUAL EXAMINATION DATA SHEET

Elem. No. <u>WT-11</u>		Grid Pos. _____		Date <u>11/15/96</u>		Examiner <u>BRATTON S/A S-1</u>		
Top End-Plug Weld: 1. ☐ OK 2. ☐ Reject						Indicated Stage Position Distance from Bottom of Element <div style="border: 1px solid black; height: 150px; width: 100%; margin-top: 10px;"></div>		
Wire Wrap Condition: 1. ☐ N/A 2. ☐ Tight, no gaps 3. ☐ Loose, gaps up to wire diam. 4. ☐ Very loose, gaps up to 1/8" 5. ☐ Extremely loose, gaps > 1/8" 6. ☐ Broken								
SURFACE CONDITION								
Above Core	Axial Scratch.		Circum. Scratch		Random Scratches			
	few--many		few--many		few--many			
	Light		Light		Light			
	Medium		Medium		Medium			
	Heavy		Heavy		Heavy			
	Spotty Stains		Discoloration		Contact Marks			
few--many		RdB1BrGr		few--many				
Light		Light		Stains				
Medium		Medium		Burnish				
Dark		Dark		Wear				
Core Region	Axial Scratch.		Circum. Scratch		Random Scratches			
	few--many		few--many		few--many			
	Light		Light		Light			
	Medium		Medium		Medium			
	Heavy		Heavy		Heavy			
	Spotty Stains		Discoloration		Contact Marks			
few--many		RdB1BrGr		few--many				
Light		Light		Stains				
Medium		Medium		Burnish				
Dark		Dark		Wear				
Below Core	Axial Scratch.		Circum. Scratch		Random Scratches			
	few--many		few--many		few--many			
	Light		Light		Light			
	Medium		Medium		Medium			
	Heavy		Heavy		Heavy			
	Spotty Stains		Discoloration		Contact Marks			
few--many		RdB1BrGr		Few--many				
Light		Light		Stains				
Medium		Medium		Burnish				
Dark		Dark		Wear				
Bottom End-Plug Weld: 1. ☐ OK 2. ☐ Reject						Z ₀ <u>58.566</u> φ ₀ <u>68.7</u> Note: Angular zero reference (φ ₀) measured at (ck. one) ☐ Spade slot, by wire ☐ ID flat ☒ Other (expl.) <u>SLOTTED THRU-HOLE</u> <u>(ARBITRARY DIRECTION)</u>		
T-Bar Slot: 1. ☐ N/A 2. ☐ Good 3. ☐ Closed 4. ☐ Spread 5. ☐ Reject								
General Condition: 1. ☐ Excellent 2. ☐ Good 3. ☐ OK 4. ☐ Poor 5. ☐ Bad 6. ☐ Breach								
Wash: 1. ☐ IBC 2. ☐ Hand 3. ☐ None								
Photographs: 1. ☐ Yes 2. ☐ No Series <u>14G</u>								
General Comments: _____								

Note: $\theta_e = \phi_j - \phi_0$, if measured CCW; $\theta_e = \phi_0 - \phi_j$, if CW (looking down at top of element).

Loop 1: Photographs

9G1. Loop Assembly, Top half of face #1 (Bundle 0° face)

9G2. Loop Assembly, Bottom half of face #1 (Bundle 0° face)

9G3. Loop Assembly, Top half of face #2 (Bundle 90° face)

9G4. Loop Assembly, Bottom half of face #2 (Bundle 90° face)

9G5. Loop Assembly, Top half of face #3 (Bundle 180° face)

9G6. Loop Assembly, Bottom half of face #3 (Bundle 180° face)

9G7. Loop Assembly, Top half of face #4 (Bundle 270° face)

9G8. Loop Assembly, Bottom half of face #4 (Bundle 270° face)

9G9. Loop Assmbly, Through-mirror view of bottom of bundle (face #1 up)

11G1. WL-01, Shiny axial patch

11G.2. WL-01, Low-luster surface (bottom of target)

11G3. WL-01, Light-to-dark transition

11G4. WL-01, Shiny surface (upper middle)

11G5. WL-01, Upper weld (shows end-fitting grip marks)

11G6. WL-27, General pitting (typical)

11G7. WL-27, Large pit (typical)

11G8. WL-27, Large pit (typical)

11G9. WL-27, Barrier transition (typical)

11G10. WL-27, Spacer grid marks (typical)

11G11. WL-26, General pitting

11G12. WL-26, Lower tip

11G13. WL-22, Typical barrier (bottom, front)

11G14. WL-22, Typical barrier (bottom, back)

11G15. WL-22, Typical barrier (center) - Rotational composite, 328°

11G16. WL-22, Typical barrier (center) - Rotational composite, 28°

11G17. WL-22, Typical barrier (center) - Rotational composite, 88°

11G18. WL-22, Typical barrier (center) - Rotational composite, 148°

11G19. WL-22, Typical barrier (center) - Rotational composite, 207°

11G20. WL-22, Typical barrier (center) - Rotational composite, 207°

11G21. WL-22, Barrier islands

11G22. WL-22, Lower tip

11G23. WL-18, Footprints

11G24. WL-18, Bottom tip

11G25. WL-10, Dark pit

11G26. WL-09, Typical barrier (bottom) - Rotational composite, 119°

11G27. WL-09, Typical barrier (bottom) - Rotational composite, 179°

11G28. WL-09, Typical barrier (bottom) - Rotational composite, 239°

11G29. WL-09, Typical barrier (bottom) - Rotational composite, 299°

11G30. WL-09 , Typical barrier (bottom) - Rotational composite, 359°

11G31. WL-09, Typical barrier (bottom) - Rotational composite, 60°

11G32. WL-03, Footprints

11G33. WL-03, Top End

11G34. WL-03, Bottom End

11G35. WL-03, Dark stain

WL-10 Photo Composite:

15G1-15G4. W

15G5-15G8. W

15G9-15G12. W

15G13-15G16. W

-10, Angle of 270

-10, Angle of 0

-10, Angle of 90

-10, Angle of 180

WL-26 Photo Composite:

15G17-15G20. V

15G21-15G24. V

15G25-15G28. V

15G29 - 15G32. V

L-26, Angle of 270

L-26, Angle of 0

L-26, Angle of 90

L-26, Angle of 180

S1/B1 Photos:

96-659-1-30. WT-11, ATR Hot Cell Disassembly

96-659-2-26. WT-12, ATR Hot Cell Disassembly

96-659-2-24. WT-12, ATR Hot Cell Disassembly

10G1. WT-11, Disassembly

1

10G2. WT-12, Disassembly

14G1. WT-11, Top end

14G2. WT-11, Bottom end

14G3. WT-11, Typical scratches (rotation composite), 29°

14G4. WT-11, Typical scratches (rotation composite), 89°

14G5. WT-11, Typical scratches (rotation composite), 150°

14G6. WT-11, Typical scratches (rotation composite), 210°

14G7. WT-11, Typical scratches (rotation composite), 269°

14G8. WT-11, Typical scratches (rotation composite), 329°

14G9. WT-12, Top end

14G10. WT-12, Top end

14G11. WT-12, Bottom end

14G12. WT-12, Typical scratches (rotation composite), 291°, elev. 46.3 in.

14G13. WT-12, Typical scratches (rotation composite), 351°, elev. 46.3 in.

14G14. WT-12, Typical scratches (rotation composite), 52°, elev. 46.3 in.

14G15. WT-12, Typical scratches (rotation composite), 112°, elev. 46.3 in.

14G16. WT-12, Typical scratches (rotation composite), 171°, elev. 46.3 in.

14G17. WT-12, Typical scratches (rotation composite), 232°, elev. 46.3 in.

14G18. WT-12, Typical scratches (rotation composite), 292°, elev. 16.8 in.

14G19. WT-12, Typical scratches (rotation composite), 352°, 16.8 in.

14G20. WT-12, Typical scratches (rotation composite), 52°, 16.8 in.

14G21. WT-12, Typical scratches (rotation composite), 112°, elev. 16.8 in.

14G22. WT-12, Typical scratches (rotation composite), 172°, elev. 16.8 in.

14G23. WT-12, Typical scratches (rotation composite), 232°, elev. 16.8 in.

Appendix C
Neutron Radiography

Appendix C

Table of Contents

Loop-1

Photograph		Orientation
96-148	0° 0 in. WL-26, 10, 01, 03	Thermal (ruler visible)
96-148	0° 0 in. WL-26, 10, 01, 03	Epithermal (ruler not visible)
96-147	0° 16 in. WL-26, 10, 01, 03	Thermal
96-147	0° 16 in. WL-26, 10, 01, 03	Epithermal
96-146	0° 32 in. WL-26, 10, 01, 03	Thermal
96-146	0° 32 in. WL-26, 10, 01, 03	Epithermal
96-145	0° 48 in. WL-26, 10, 01, 03	Thermal
96-145	0° 48 in. WL-26, 10, 01, 03	Epithermal
96-152	90° 0 in. WL-26,10, 01, 03	Thermal
96-152	90° 0 in. WL-26,10, 01, 03	Epithermal
96-151	90° 16 in. WL-26,10, 01, 03	Thermal
96-151	90° 16 in. WL-26,10, 01, 03	Epithermal
96-150	90° 32 in. WL-26,10, 01, 03	Thermal
96-150	90° 32 in. WL-26,10, 01, 03	Epithermal
96-149	90° 48 in. WL-26,10, 01, 03	Thermal
96-149	90° 48 in. WL-26, 10, 01, 03	Epithermal
96-140	0° 0 in. WL-09, 18, 22, 27	Thermal
96-140	0° 0 in. WL-09, 18, 22, 27	Epithermal
96-139	0° 16 in. WL-09, 18, 22, 27	Thermal
96-139	0° 16 in. WL-09, 18, 22, 27	Epithermal
96-138	0° 32 in. WL-09, 18, 22, 27	Thermal
96-138	0° 32 in. WL-09, 18, 22, 27	Epithermal
96-137	0° 48 in. WL-09, 18, 22, 27	Thermal
96-137	0° 48 in. WL-09, 18, 22, 27	Epithermal
96-144	90° 0 in. WL-09, 18, 22, 27	Thermal
96-144	90° 0 in. WL-09, 18, 22, 27	Epithermal
96-143	90° 16 in. WL-09, 18, 22, 27	Thermal

Loop-1

Photograph	Orientation
96-143 90° 16 in. WL-09, 18, 22, 27	Epithermal
96-142 90° 32 in. WL-09, 18, 22, 27	Thermal
96-142 90° 32 in. WL-09, 18, 22, 27	Epithermal
96-141 90° 48 in. WL-09, 18, 22, 27	Thermal
96-141 90° 48 in. WL-09, 18, 22, 27	Epithermal

S1 and B1 Rods

Photograph	Orientation
96-171 0° 0 in. B1, S1	Thermal
96-171 0° 0 in. B1, S1	Epithermal
96-170 0° 16 in. B1, S1	Thermal
96-170 0° 16 in. B1, S1	Epithermal
96-169 0° 32 in. B1, S1	Thermal
96-169 0° 32 in. B1, S1	Epithermal
96-168 0° 48 in. B1, S1	Thermal
96-168 0° 48 in. B1, S1	Epithermal
96-175 0° 0 in. B1, S1	Thermal
96-175 0° 0 in. B1, S1	Epithermal
96-174 0° 16 in. B1, S1	Thermal
96-174 0° 16 in. B1, S1	Epithermal
96-173 0° 32 in. B1, S1	Thermal
96-173 0° 32 in. B1, S1	Epithermal
96-172 0° 48 in. B1, S1	Thermal
96-172 0° 48 in. B1, S1	Epithermal

To set up appendix pages, scan at a 300 DPI resolution; put on 11 × 17-in. paper; set top and side margins at 1 inch and bottom margin at ½ inch; center the page number at the bottom of each page starting with C-3; place two photos on each page, thermal above and epithermal below, keeping like numbered pairs together (i.e., 96-172 0° 48 in.); separate pictures by 1 inch; and add the applicable caption at the bottom of each page (taken from the above list that includes both pictures, for example: 96-172 0° 48 in. B1, S1 Thermal (above) and Epithermal (below)). The scanned positives cannot be oriented in a right-reading mode since they are not films.

96-148 0° 0 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

15 19 20 21 22 23 24 25

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

96-147 0° 16 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

96-146 0° 32 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

16 21 51 61 66 77 80 87

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

91 91 11 81 71 11 01 6

96-152 90° 0 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

96-151 90° 16 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

96-150 90° 32 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

96-149 90° 48 in. WL-26, 10, 01, 03 Thermal (above) and Epithermal (below)

96-140 0° 0 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

48 49 50 51 52 53 54 55

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

96-139 0° 16 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

96-138 0° 32 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

96-137 0° 48 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

96-144 90° 0 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

48 49 50 51 52 53 54 55

96-143 90° 16 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

96-142 90° 32 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

96-141 90° 48 in. WL-09, 18, 22, 27 Thermal (above) and Epithermal (below)

96-171 0° 0 in. B1, S1 Thermal (above) and Epithermal (below)

96-170 0° 16 in. B1, S1 Thermal (above) and Epithermal (below)

96-169 0° 32 in. B1, S1 Thermal (above) and Epithermal (below)

96-168 0° 48 in. B1, S1 Thermal (above) and Epithermal (below)

96-175 90° 0 in. B1, S1 Thermal (above) and Epithermal (below)

96-174 90° 16 in. B1, S1 Thermal (above) and Epithermal (below)

96-173 90° 32 in. B1, S1 Thermal (above) and Epithermal (below)

96-172 90° 48 in. B1, S1 Thermal (above) and Epithermal (below)

Appendix D
Gamma Scan

Appendix D

Table of Contents

WL-01 Gross
WL-01 Mn ⁵⁴
WL-01 Co ⁶⁰
WL-03 Gross
WL-03 Mn ⁵⁴
WL-03 Co ⁶⁰
WL-09 Gross
WL-09 Mn ⁵⁴
WL-09 Co ⁶⁰
WL-10 Gross
WL-10 Mn ⁵⁴
WL-10 Co ⁶⁰
WL-18 Gross
WL-18 Mn ⁵⁴
WL-18 Co ⁶⁰
WL-22 Gross
WL-22 Mn ⁵⁴
WL-22 Co ⁶⁰
WL-26 Gross
WL-26 Mn ⁵⁴
WL-26 Co ⁶⁰
WL-27 Gross
WL-27 Mn ⁵⁴
WL-27 Co ⁶⁰
WT-11 Gross
WT-11 Mn ⁵⁴
WT-11 Co ⁶⁰
WT-12 Gross
WT-12 Mn ⁵⁴
WT-12 Co ⁶⁰

ARGONNE NATIONAL LABORATORY - WEST
P. O. Box 2528, Idaho Falls, Idaho 83403-2528

**ENGINEERING
DIVISION**

(AL, TREAT, ZPPR, and HFEF)

**EXAMINATION
DATA
TRANSMITTAL**

TO:

Rob Bratton

DATE:

January 9, 1997

MATERIAL EXAMINED:

CLWR Loop-1 Target Rods (8)

TYPE OF DATA:

Gamma Scan

FORM OF DATA:

Tables, Charts, User Notes, and CD-ROM's (2)

NOTES AND CONDITIONS:

CC: w/Attachments

None

CC: w/o Attachments

CLWR Loop-1 file

APPROVED:

John. P. (Pete) Webb

EXPERIMENT COORDINATOR

Questions regarding this
data transmittal should be
directed to the Cognizant
Engineer at extension
(208) 533-7773

Revised: 4/17/95

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 14, 1997

MATERIAL EXAMINED:

Two Target Rods from CLWR S1/B1 Test

TYPE OF EXAMINATION:

Isotopic Gamma Scans

FORM OF DATA:

Charts, User Notes, and CD-ROM (2)

NOTES:

CC: w/Attachments

S1/B1 file (charts only)

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

PRECISION GAMMA SCANNING

USER NOTES

1. The Precision Gamma Scanner - II (PGS-II) is designed to intermittently traverse rod-like objects in front of a small-solid-angle collimator for collection of gamma spectra at a series of positions. Usually the increment of traverse is set equal to the collimator slit opening to provide complete object coverage. This process is called scanning.
2. The gamma-ray spectroscopy sub-system consists of an ultra-pure germanium (UPG) detector with a nominal efficiency of 10% (relative to a 2"x2" NaI detector). Active Compton-suppression is provided by detecting the time-coincidence of Compton events from a large volume NaI guard detector surrounding the UPG. A background suppression ratio of 6-10 (based on Co-60 peaks) is achieved.
3. The PGS-II is designed and calibrated to position the center of the collimator slit (with respect to the upper tip of the scanned object) to an accuracy of ± 0.005 in. for each positional measurement.
4. Data can be acquired in either gross or spectral mode. Gross mode counts gammas without regard to their energies. Spectral mode maps gamma energies (in the range of 50-1600 Kev) into 4096 channels (memory locations).
5. The collimator slit is adjustable from 0-100 mils, and is generally fixed for any given scan. Slit opening is reported in all data tables and charts.
6. The live time of each positional count is infinitely adjustable, but is usually fixed for any given scan. The live time used for a scan is reported in all data tables and charts.
7. Spectral analysis is performed by post-processing the collected data. The analysis is based on a fixed Channel-to-Energy calibration where:

$$\text{Channel} = 2.5E_{\gamma} \text{ (Kev)}$$

Selected isotopic peaks of interest are located within each spectrum, and a gross peak area is calculated by simple trapezoidal integration. Background for each peak is estimated by fitting (least squares) a straight line to the regions immediately above and below the peak. This background is subtracted from the gross peak area to generate the net peak area (in counts).

8. The isotopic count rate (net peak area divided by the live time) is usually reported at each position in chart and tabular form.
9. If requested, all isotopic data can be corrected for decay using the standard equation:

$$A_t = A_0 e^{-\lambda t}$$

This correction is only required when short-lived isotopes are being measured, and it removes the effect of decay during a given scan and between scans of sibling rods.

10. A measure of gross activity is obtained by summing the counts in all 4096 channels, and dividing by the live time. These data are usually reported in chart and tabular form.
11. Spectral data are sometimes provided in digital form on CD-ROM's or floppy disks. The data are stored as plain ASCII data in DOS file format (i.e., records are terminated by <CR><LF> pairs). The first 10 records contain self-explanatory header information, including the units of the data fields. Below the header records, spectral activity data are stored in tab-delimited fields as follows:

<Position><tab><Gross><tab><Isotope-1><tab>...<Isotope-N><CR><LF>

12. Gross-mode data are not available (at this time) in digital form.

ARGONNE NATIONAL LABORATORY Hot Fuel Examination Facility

Isotopic scan data for WL-01 Gross

ARGONNE NATIONAL LABORATORY Hot Fuel Examination Facility

Isotopic scan data for WL-01 Mn⁵⁴

ARGONNE NATIONAL LABORATORY Hot Fuel Examination Facility

Isotopic scan data for WL-01 Co⁶⁰

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Isotopic scan data for WL-03 Gross

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

Isotopic scan data for WL-03 Mn⁵⁴

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-03

Isotope**: Co60

Live Time: 120.0 sec.

: 0.100 in.

11/22/96

Isotopic scan data for WL-03 Co⁶⁰

ARGONNE NATIONAL LABORATORY Hot Fuel Examination Facility

Isotopic scan data for WL-09 Gross

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-09

Isotope**: Mn54

Live Time: 120.0 sec.

Slit: 0.100 in.

12/07/96

Isotopic scan data for WL-09 Mn⁵⁴

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-09

Isotope**: Co60

Live Time: 120.0 sec.

: 0.100 in.

12/07/96

Isotopic scan data for WL-09 Co⁶⁰

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Isotopic scan data for WL-10 Gross

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Isotopic scan data for WL-10 Mn⁵⁴

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-10

Isotope**: Co60

Live Time: 120.0 sec.

: 0.100 in.

11/15/96

Isotopic scan data for WL-10 Co⁶⁰

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-18

Isotope*: Gross

Live Time: 120.0 sec.

Slit: 0.100 in.

11/16/96

Isotopic scan data for WL-18 Gross

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-18

Isotope**: Mn⁵⁴

Live Time: 120.0 sec.

Slit: 0.100 in.

11/16/98

Isotopic scan data for WL-18 Mn⁵⁴

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-18

Isotope**: Co60

Live Time: 120.0 sec.

: 0.100 in.

11/16/98

Isotopic scan data for WL-18 Co⁶⁰

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-22

Isotope**: Gross

Live Time: 120.0 sec.

Slit: 0.100 in.

11/26/96

Isotopic scan data for WL-22 Gross

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Isotopic scan data for WL-22 Mn⁵⁴

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-22

Isotope**: Co60

Live Time: 120.0 sec.

: 0.100 in.

11/26/96

Isotopic scan data for WL-22 Co⁶⁰

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-26

Isotope*: Gross

Live Time: 120.0 sec.

Silt: 0.100 in.

11/19/96

Isotopic scan data for WL-26 Gross

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-26

Isotope**: Mn54

Live Time: 120.0 sec.

Slit: 0.100 in.

11/19/96

Isotopic scan data for WL-26 Mn⁵⁴

ARGONNE NATIONAL LABORATORY Hot Fuel Examination Facility

Isotopic scan data for WL-26 Co⁶⁰

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-27

Isotope**: Gross

Live Time: 120.0 sec.

Slit: 0.100 in.

11/27/96

Isotopic scan data for WL-27 Gross

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-27

Isotope**: Mn⁵⁴

Live Time: 120.0 sec.

Slit: 0.100 in.

11/27/96

Isotopic scan data for WL-27 Mn⁵⁴

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

S/A: LOOP-1

Pin ID: WL-27

Isotope**: Co60

Live Time: 120.0 sec.

: 0.100 in.

11/27/96

Isotopic scan data for WL-27 Co⁶⁰

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 14, 1997

MATERIAL EXAMINED:

Two Target Rods from CLWR S1/B1 Test

TYPE OF EXAMINATION:

Isotopic Gamma Scans

FORM OF DATA:

Charts, User Notes, and CD-ROM (2)

NOTES:

CC: w/Attachments

S1/B1 file (charts only)

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

PRECISION GAMMA SCANNING

USER NOTES

1. The Precision Gamma Scanner - II (PGS-II) is designed to intermittently traverse rod-like objects in front of a small-solid-angle collimator for collection of gamma spectra at a series of positions. Usually the increment of traverse is set equal to the collimator slit opening to provide complete object coverage. This process is called scanning.
2. The gamma-ray spectroscopy sub-system consists of an ultra-pure germanium (UPG) detector with a nominal efficiency of 10% (relative to a 2"x2" NaI detector). Active Compton-suppression is provided by detecting the time-coincidence of Compton events from a large volume NaI guard detector surrounding the UPG. A background suppression ratio of 6-10 (based on Co-60 peaks) is achieved.
3. The PGS-II is designed and calibrated to position the center of the collimator slit (with respect to the upper tip of the scanned object) to an accuracy of ± 0.005 in. for each positional measurement.
4. Data can be acquired in either gross or spectral mode. Gross mode counts gammas without regard to their energies. Spectral mode maps gamma energies (in the range of 50-1600 Kev) into 4096 channels (memory locations).
5. The collimator slit is adjustable from 0-100 mils, and is generally fixed for any given scan. Slit opening is reported in all data tables and charts.
6. The live time of each positional count is infinitely adjustable, but is usually fixed for any given scan. The live time used for a scan is reported in all data tables and charts.
7. Spectral analysis is performed by post-processing the collected data. The analysis is based on a fixed Channel-to-Energy calibration where:

$$\text{Channel} = 2.5 E_{\gamma} \text{ (Kev)}$$

Selected isotopic peaks of interest are located within each spectrum, and a gross peak area is calculated by simple trapezoidal integration. Background for each peak is estimated by fitting (least squares) a straight line to the regions immediately above and below the peak. This background is subtracted from the gross peak area to generate the net peak area (in counts).

8. The isotopic count rate (net peak area divided by the live time) is usually reported at each position in chart and tabular form.
9. If requested, all isotopic data can be corrected for decay using the standard equation:

$$A_t = A_0 e^{-\lambda t}$$

This correction is only required when short-lived isotopes are being measured, and it removes the effect of decay during a given scan and between scans of sibling rods.

10. A measure of gross activity is obtained by summing the counts in all 4096 channels, and dividing by the live time. These data are usually reported in chart and tabular form.
11. Spectral data are sometimes provided in digital form on CD-ROM's or floppy disks. The data are stored as plain ASCII data in DOS file format (i.e., records are terminated by <CR><LF> pairs). The first 10 records contain self-explanatory header information, including the units of the data fields. Below the header records, spectral activity data are stored in tab-delimited fields as follows:

<Position><tab><Gross><tab><Isotope-1><tab>...<Isotope-N><CR><LF>

12. Gross-mode data are not available (at this time) in digital form.

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: S1/B1

Pin ID: WT-11

Isotope**: Gross

Live Time: 120.0 sec.

Slit: 0.100 in.

12/02/96

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: S1/B1 Pin ID: WT-11 Isotope**: Mn54 Live Time: 120.0 sec. Slit: 0.100 in. 12/02/96

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: S1/B1

Pin ID: WT-11

Isotope**: Co60

Live Time: 120.0 sec.

Slit: 0.100 in.

12/02/96

* From upper tip of pin

** Based on 1332 Kev. peak

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: S1/B1

Pin ID: WT-12

Isotope**: Gross

Live Time: 120.0 sec.

Slit: 0.100 in.

11/20/96

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: S1/B1

Pin ID: WT-12

Isotope**: Mn54

Live Time: 120.0 sec.

Slit: 0.100 in.

11/20/96

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

S/A: S1/B1

Pin ID: WT-12

Isotope**: Co60

Live Time: 120.0 sec.

Slit: 0.100 in.

11/20/96

Appendix E
Profilometry Plots

Appendix E

Table of Contents

WL-01	Profilometry traces at 0°
WL-01	Profilometry traces at 45°
WL-01	Profilometry traces at 90°
WL-01	Profilometry traces at 135°
WL-03	Profilometry traces at 0°
WL-03	Profilometry traces at 45°
WL-03	Profilometry traces at 90°
WL-03	Profilometry traces at 135°
WL-09	Profilometry traces at 0°
WL-09	Profilometry traces at 45°
WL-09	Profilometry traces at 90°
WL-09	Profilometry traces at 135°
WL-18	Profilometry traces at 0°
WL-18	Profilometry traces at 45°
WL-18	Profilometry traces at 90°
WL-18	Profilometry traces at 135°
WL-22	Profilometry traces at 0°
WL-22	Profilometry traces at 450°
WL-22	Profilometry traces at 90°
WL-22	Profilometry traces at 135°
WL-27	Profilometry traces at 0°
WL-27	Profilometry traces at 45°
WL-27	Profilometry traces at 90°
WL-27	Profilometry traces at 135°
WT-11	Profilometry traces at 0°
WT-11	Profilometry traces at 45°
WT-11	Profilometry traces at 90°
WT-11	Profilometry traces at 135°
WT-12	Profilometry traces at 0°
WT-12	Profilometry traces at 45°
WT-12	Profilometry traces at 90°
WT-12	Profilometry traces at 135°

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 12, 1997

MATERIAL EXAMINED:

Six Target Rods from CLWR Loop-1 Bundle

TYPE OF EXAMINATION:

Contact Profilometry

FORM OF DATA:

Charts, User Notes, and CD-ROM (2)

NOTES:

CC: w/Attachments

Loop-1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data
transmittal should be directed to
the Cognizant Engineer at
extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Element Contact Profilometry

USER NOTES

1. When fuel elements (pins) or capsules are significantly bowed, a situation can arise when the lower tip of the element or capsule exits the bottom guide roller near the end of the measurement. Depending on the direction and magnitude of the bow, the portion of the element or capsule below the upper guide roller can assume an angle with respect to the measuring probes causing an erroneously high reading. This is an inherent feature of the system that cannot be corrected, and the resultant data must be interpreted with caution.
2. Full-length scans usually start as high as possible on the element or capsule (but no higher than the upper cladding weld) and end at the lower cladding weld. Because of interference from the upper roller and the collet applied to the element or capsule, the topmost four inches cannot be measured.
3. The "Z-Position" reported on ANL-supplied plots is the raw position (Z_s , in inches) of the in-cell positioning stage, and has no fixed or known offset from the top or bottom of the element or capsule. Note that the stage Z-Position is higher toward the bottom of an element or capsule.
4. The "Diameter" reported on ANL-supplied plots is the profile dimension (in inches) perpendicular to the azimuthal position, ϕ_c (in degrees), as shown in the diagram below.
5. By convention, azimuthal positions increase counter-clockwise (CCW) from the azimuthal reference feature when viewed from the top of the element or capsule as shown in the diagram below.
6. During measurement of the profile, recorded data are sometimes corrupted by electronic noise. Until the source of this noise can be discovered and corrected, obvious data errors may have been removed from the attached data reports.
7. Copies of the profilometry data are provided on floppy disks or CD-ROM's. By convention, the data from each azimuthal angle is contained in a separate file with the name:

filename.ext

where:

filename = Element/Capsule ID

ext = Azimuthal Angle (eg., 045)

8. Within each file, the data are recorded as plain ASCII text with each line terminated by a <CR><LF>. The first three lines of data contain descriptive text information (such as S/A ID and PIN ID) that is self explanatory. Below this are three columns of tab-delimited numeric data corresponding (left-to-right) to: "Z-Position (in.)", " ϕ_s (°)" and "Diameter (in.)". The end of data are sometimes flagged by large contrasting numbers, usually a string of 9's (eg., "999.999").

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-09 Angle: 0 DEGREES 1/31/97 1:49 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-09

Angle: 45DEGREES

1/31/97 1:53 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-09 Angle: 90 DEGREES 1/31/97 2:00 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-09

Angle: 135 DEGREES

1/31/97 2:06 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-01 Angle: 0 DEGREES 1/31/97 3:03 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-01

Angle: 45 DEGREES

1/31/97 3:07 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-01

Angle: 90 DEGREES

1/31/97 3:12 PM

Z-Position (in.)

Page 3

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-01

Angle: 135 DEGREES

1/31/97 3:20 PM

E-10

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-03 Angle: 0 DEGREES 1/31/97 2:26 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-03

Angle: 45 DEGREES

1/31/97 2:32 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-03

Angle: 90 DEGREES

1/31/97 2:37 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-03

Angle: 135 DEGREES

1/31/97 2:43 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

11/25/96 10:16 AM

Angle: 0 DEGREES

Element: WL-18

S/A: Loop-1

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-18

Angle: 45 DEGREES

11/25/96 10:31 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-18

Angle: 90 DEGREES

11/25/96 10:40 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-18

Angle: 135 DEGREES

11/25/96 10:50 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-22 Angle: 0 DEGREES 1/31/97 12:22 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-22

Angle: 45 DEGREES

1/31/97 12:28 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-22 Angle: 90 DEGREES 1/31/97 12:33 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-22

Angle: 135 DEGREES

1/31/97 12:40 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1 Element: WL-27 Angle: 0 DEGREES 1/31/97 11:42 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-27

Angle: 45 DEGREES

1/31/97 11:47 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-27

Angle: 90 DEGREES

1/31/97

11:53 AM

Z-Position (in.)

Page 3

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: Loop-1

Element: WL-27

Angle: 135 DEGREES

1/31/97 12:00 PM

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 12, 1997

MATERIAL EXAMINED:

Two Target Rods from CLWR S1/B1 Test

TYPE OF EXAMINATION:

Contact Profilometry

FORM OF DATA:

Charts, User Notes, and CD-ROM (2)

NOTES:

CC: w/Attachments

S1/B1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data
transmittal should be directed to
the Cognizant Engineer at
extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: S1/B1

Element: WT-11

Angle: 0 DEGREES

1/31/97 10:56 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

1/31/97 11:06 AM

Angle: 45 DEGREES

Element: WT-11

S/A: S1/B1

Z-Position (in.)

Page 2

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: S1/B1

Element: WT-11

Angle: 90 DEGREES

1/31/97 11:13 AM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

1/31/97 11:19 AM

Angle: 135 DEGREES

Element: WT-11

S/A: S1/B1

Z-Position (in.)

Page 4

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

11/25/96 11:11 AM

Angle: 0 DEGREES

Element: WT-12

S/A: S1/B1

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: S1/B1

Element: WT-12

Angle: 45 DEGREES

11/25/96 12:05 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: S1/B1

Element: WT-12

Angle: 90 DEGREES

11/25/96 12:21 PM

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

ELEMENT CONTACT PROFILOMETRY

S/A: S1/B1

Element: WT-12

Angle: 135 DEGREES

11/25/96 12:41 PM

Appendix F
Bow and Length

Appendix F

Table of Contents

Number	
WL-01	Bow and Length
WL-03	Bow and Length
WL-09	Bow and Length
WL-10	Bow and Length
WL-18	Bow and Length
WL-22	Bow and Length
WL-26	Bow and Length
WL-27	Bow and Length
WT-11	Bow and Length
WT-12	Bow and Length

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 11, 1997

MATERIAL EXAMINED:

Eight Target Rods from CLWR Loop-1 Bundle

TYPE OF EXAMINATION:

Bow and Length

FORM OF DATA:

Data Table/Chart, Summary Report, and User Notes

NOTES:

CC: w/Attachments

Loop-1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Bow and Length Measurement

USER NOTES

MEASUREMENT PROCESS*

1. Normal operating procedures for the Bow & Length (B&L) System are contained in HFEF Operating Instruction OI-4325.
2. Bow and length measurements are made with the element (or capsule) hanging freely from a collet-style end-fitting applied to its top-end plug. The end-fitting is held rigidly in the gripper attached to the vertical carriage of the B&L examination stage.
3. The position of the element is measured in 3D space (x,y,z) at a number of axial locations (typically at 2-in. increments) along its length.
4. The hanging length of the element is measured by touching the bottom tip of the element to a conductive plate on the B&L gage assembly, and comparing that Z-position to the Z-position of a length standard similarly positioned.

STANDARD CALCULATION*

- A custom computer program uses the bow and length data acquired in steps 3 and 4 above to calculate bow, bow direction, and corrected length for each element measured.
- Bow and bow direction are reported for each elevation measured in step 3, along with the location and direction of the maximum bow.
- Bow is defined as the distance from the theoretical tip-to-tip centerline to the element's centerline at any axial position along the element. Bow direction is the azimuthal angle of the centerline of the element relative to an angular reference feature on the element, measured counter-clockwise around the tip-to-tip centerline.
- The tip-to-tip centerline is inferred from the bow and length data obtained in steps 3 and 4 by extrapolating the two extreme bow measurements at each end of the element to the theoretical axial locations of the tips based on the hanging length data.
- Corrected length is calculated by summing the segment lengths (from tip to tip) between the calculated 3D positions of the element centerline (i.e., the length along the bowed shape of the element).

STANDARD DATA REPORT

- The computer program that performs the data reduction described above provides a standard data report.
- Data are reduced in groups of similar elements that share a common length calibration.
- Included in this report is a table of bow data for each element, a table of maximum bow (and bow direction) for each element, and a table of the corrected length of each element.
- This report contains ASCII text only, with no plots or graphics of any kind. It is formatted for printer output, but can be captured to a file and provided to the end user in electronic form if requested.

SPECIAL REPORTS

- By importing the above standard data report into appropriate computer applications (like Excel), custom reports can be generated that include graphics and other enhancements.
- Because they are not standardized, such reports cannot be described here. Every effort is made to ensure that such special reports self-explanatory.
- If you have any questions about a special report, contact the Cognizant Engineer as described on the Data Transmittal cover sheet.

SPECIAL PROCEDURES

- Special measurement procedures may sometimes be employed that deviate from the standard methods described above. Such procedures are described in the appropriate HFEF work-control documentation, such as Non-Routine Procedures (NRP's) or Process Work Sheets (PWS's).

* See "Element Bow Measurement and Data Reduction at the Hot Fuel Examination Facility/North", by R. W. Keyes, Proceedings of the American Nuclear Society's 26th Conference on Remote Systems Technology, 1978.

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-01

DATE: 1/17/97

Z-Pos* (in.)	BOW (in.)	ANGLE (°)
0.00	0.000	
3.41	0.011	32
6.41	0.021	32
9.41	0.036	38
12.42	0.050	40
15.41	0.061	37
18.42	0.074	38
21.41	0.081	40
24.41	0.079	37
27.41	0.076	38
30.41	0.075	38
33.41	0.075	35
36.41	0.071	33
39.41	0.068	35
42.41	0.062	36
45.42	0.054	36
48.41	0.044	35
51.41	0.031	33
54.41	0.019	28
55.51	0.013	28
57.87	0.000

REMARKS:

Prepared by:

J. Robbins

Verified by:

M.E. Vaughn

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-03

DATE: 1/17/97

F-4

Z-Pos* (In.)	BOW (In.)	ANGLE (°)
0.00	0.000	
3.39	0.004	245
6.38	0.008	245
9.38	0.012	223
12.38	0.014	223
15.39	0.016	232
18.38	0.015	234
21.38	0.013	231
24.39	0.011	237
27.38	0.014	250
30.39	0.014	260
33.39	0.010	251
36.39	0.002	278
39.38	0.001	257
42.38	0.002	292
45.38	0.002	303
48.38	0.001	263
51.38	0.001	212
54.38	0.003	236
55.49	0.002	236
57.82	0.000

* From top of rod

REMARKS:

Prepared by:

J. R. Ricks

Verified by:

M. E. Vaughan

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-09

DATE: 1/17/97

Z-Pos* (In.)	BOW (In.)	ANGLE (°)
0.00	0.000	
3.40	0.008	313
6.40	0.014	313
9.40	0.016	299
12.39	0.020	282
15.39	0.023	287
18.40	0.025	272
21.40	0.026	260
24.39	0.028	257
27.39	0.027	248
30.40	0.027	244
33.39	0.027	238
36.40	0.028	232
39.39	0.029	224
42.40	0.024	221
45.40	0.019	217
48.40	0.014	215
51.40	0.011	210
54.40	0.004	196
55.50	0.003	196
57.84	0.000

* From top of rod

REMARKS:

Prepared by:

J. Robb

Verified by:

M. E. Vaughan

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-10

DATE: 1/17/97

F-6

Z-Pos* (in.)	BOW (in.)	ANGLE (°)
0.00	0.000	
3.41	0.008	258
6.40	0.016	258
9.41	0.025	259
12.40	0.031	253
15.41	0.038	257
18.40	0.046	259
21.41	0.054	260
24.40	0.057	263
27.41	0.062	262
30.41	0.065	263
33.41	0.065	263
36.41	0.064	263
39.40	0.058	262
42.41	0.051	262
45.40	0.044	263
48.40	0.034	264
51.41	0.024	264
54.40	0.013	261
55.51	0.009	261
57.83	0.000

REMARKS:

Prepared by:

J. Rebb

Verified by:

M. E. Vaughn

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-18

DATE:

1/17/97

Z-Pos* (in.)	BOW (in.)	ANGLE (°)
0.00	0.000	
3.33	0.001	135
6.33	0.003	135
9.33	0.007	116
12.33	0.009	121
15.34	0.010	140
18.33	0.012	141
21.34	0.011	142
24.34	0.008	155
27.34	0.005	155
30.34	0.005	145
33.33	0.005	152
36.33	0.003	170
39.34	0.006	157
42.34	0.005	130
45.33	0.005	116
48.34	0.005	86
51.34	0.002	52
54.33	0.002	327
55.44	0.001	327
57.77	0.000

REMARKS:

Prepared by:

J. Probst

Verified by:

M.E. Vaughan

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-22

DATE: 1/17/97

Z-Pos* (in.)	BOW (in.)	ANGLE (°)
0.00	0.000	
3.39	0.008	142
6.38	0.015	142
9.38	0.024	138
12.38	0.030	137
15.38	0.044	133
18.38	0.051	131
21.39	0.056	129
24.38	0.057	131
27.38	0.057	131
30.38	0.063	126
33.39	0.063	125
36.38	0.061	126
39.38	0.056	126
42.39	0.048	125
45.38	0.041	125
48.38	0.032	123
51.38	0.021	116
54.38	0.012	107
55.49	0.008	107
57.83	0.000

REMARKS:

Prepared by:

J. Rebb

Verified by:

M. E. Vaughan

F-9

TEST ID: Loop-1

ROD ID: WL-26

DATE: 1/17/97

Z-Pos* (in.)	BOW (in.)	ANGLE (°)
0.00	0.000	
3.35	0.017	227
6.35	0.032	227
9.35	0.045	224
12.35	0.062	220
15.35	0.071	218
18.35	0.082	218
21.35	0.088	218
24.35	0.092	218
27.35	0.094	218
30.35	0.094	219
33.35	0.089	218
36.35	0.083	219
39.35	0.073	220
42.35	0.065	218
45.35	0.055	217
48.35	0.045	216
51.35	0.032	215
54.35	0.018	214
55.45	0.012	214
57.76	0.000

REMARKS:

Prepared by:

Verified by:

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: Loop-1

ROD ID: WL-27

DATE: 1/17/97

F-10

Z-Pos* (In.)	BOW (In.)	ANGLE (°)
0.00	0.000	
3.39	0.014	157
6.39	0.027	157
9.39	0.042	156
12.39	0.052	156
15.39	0.063	156
18.39	0.073	154
21.39	0.082	154
24.39	0.085	152
27.39	0.089	152
30.39	0.091	150
33.39	0.090	151
36.39	0.084	149
39.39	0.076	148
42.39	0.066	146
45.39	0.056	145
48.39	0.041	146
51.39	0.027	147
54.39	0.013	148
55.49	0.009	148
57.84	0.000

REMARKS:

Prepared by:

J. Robb

Verified by:

M. E. Vaughan

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

BOW AND LENGTH
SUMMARY REPORT

CLWR Loop-1

ROD ID	CORRECTED LENGTH (in.)	MAXIMUM BOW			REMARKS
		BOW (in.)	Zpos (in.)	Phi (°)	
WL-01	57.88	0.081	21.41	40	
WL-03	57.82	0.016	15.39	232	
WL-09	57.85	0.029	39.39	224	
WL-10	57.83	0.065	33.41	263	
WL-18	57.80	0.012	18.33	141	
WL-22	57.83	0.063	33.39	125	
WL-26	57.77	0.094	30.35	219	
WL-27	57.85	0.091	30.39	150	

REMARKS:

Prepared by:

Verified by:

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 11, 1997

MATERIAL EXAMINED:

Two Target Rods from CLWR S1/B1 Test

TYPE OF EXAMINATION:

Bow and Length

FORM OF DATA:

Data Table/Chart, Summary Report, and User Notes

NOTES:

CC: w/Attachments

S1/B1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data
transmittal should be directed to
the Cognizant Engineer at
extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY
Hot Fuel Examination Facility

Bow and Length Measurement
USER NOTES

MEASUREMENT PROCESS*

1. Normal operating procedures for the Bow & Length (B&L) System are contained in HFEF Operating Instruction OI-4325.
2. Bow and length measurements are made with the element (or capsule) hanging freely from a collet-style end-fitting applied to its top-end plug. The end-fitting is held rigidly in the gripper attached to the vertical carriage of the B&L examination stage.
3. The position of the element is measured in 3D space (x,y,z) at a number of axial locations (typically at 2-in. increments) along its length.
4. The hanging length of the element is measured by touching the bottom tip of the element to a conductive plate on the B&L gage assembly, and comparing that Z-position to the Z-position of a length standard similarly positioned.

STANDARD CALCULATION*

- A custom computer program uses the bow and length data acquired in steps 3 and 4 above to calculate bow, bow direction, and corrected length for each element measured.
- Bow and bow direction are reported for each elevation measured in step 3, along with the location and direction of the maximum bow.
- Bow is defined as the distance from the theoretical tip-to-tip centerline to the element's centerline at any axial position along the element. Bow direction is the azimuthal angle of the centerline of the element relative to an angular reference feature on the element, measured counter-clockwise around the tip-to-tip centerline.
- The tip-to-tip centerline is inferred from the bow and length data obtained in steps 3 and 4 by extrapolating the two extreme bow measurements at each end of the element to the theoretical axial locations of the tips based on the hanging length data.
- Corrected length is calculated by summing the segment lengths (from tip to tip) between the calculated 3D positions of the element centerline (i.e., the length along the bowed shape of the element).

STANDARD DATA REPORT

- The computer program that performs the data reduction described above provides a standard data report.
- Data are reduced in groups of similar elements that share a common length calibration.
- Included in this report is a table of bow data for each element, a table of maximum bow (and bow direction) for each element, and a table of the corrected length of each element.
- This report contains ASCII text only, with no plots or graphics of any kind. It is formatted for printer output, but can be captured to a file and provided to the end user in electronic form if requested.

SPECIAL REPORTS

- By importing the above standard data report into appropriate computer applications (like Excel), custom reports can be generated that include graphics and other enhancements.
- Because they are not standardized, such reports cannot be described here. Every effort is made to ensure that such special reports self-explanatory.
- If you have any questions about a special report, contact the Cognizant Engineer as described on the Data Transmittal cover sheet.

SPECIAL PROCEDURES

- Special measurement procedures may sometimes be employed that deviate from the standard methods described above. Such procedures are described in the appropriate HFEF work-control documentation, such as Non-Routine Procedures (NRP's) or Process Work Sheets (PWS's).

* See "Element Bow Measurement and Data Reduction at the Hot Fuel Examination Facility/North", by R. W. Keyes, Proceedings of the American Nuclear Society's 26th Conference on Remote Systems Technology, 1978.

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: S-1

ROD ID: WT-11

DATE: 1/17/97

F-15

Z-Pos* (in.)	BOW (in.)	ANGLE (°)
0.00	0.000	
1.46	0.005	76
4.47	0.016	76
7.46	0.019	89
10.46	0.022	109
13.46	0.024	125
16.47	0.026	134
19.46	0.025	138
22.46	0.028	137
25.46	0.031	132
28.46	0.033	132
31.47	0.029	136
34.46	0.026	133
37.46	0.022	134
40.46	0.017	139
43.47	0.012	139
46.47	0.005	143
47.57	0.003	143
49.91	0.000

* From top of rod

REMARKS:

Prepared by:

J. Rebb

Verified by:

M. E. Vaughan

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

TEST ID: B-1

ROD ID: WT-12

DATE: 11/22/96

F-16

Z-Pos* (In.)	BOW (In.)	ANGLE (°)
0.00	0.000	
1.42	0.004	197
4.42	0.013	197
7.42	0.020	193
10.42	0.024	186
13.42	0.026	185
16.42	0.028	188
19.32	0.033	186
22.42	0.037	193
25.42	0.042	197
28.42	0.044	205
31.42	0.043	203
34.42	0.040	204
37.42	0.036	205
40.42	0.030	203
43.42	0.023	202
46.42	0.011	196
47.52	0.008	196
49.83	0.000

REMARKS:

Prepared by:

[Signature]

Verified by:

[Signature]

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

BOW AND LENGTH

SUMMARY REPORT

CLWR S1/B1

ROD ID	CORRECTED LENGTH (in.)	MAXIMUM BOW			REMARKS
		BOW (in.)	Zpos (in.)	Phi (°)	
WT-11	49.91	0.033	28.46	132	
WT-12	49.83	0.044	28.42	205	

REMARKS:

Prepared by:

J. H. Rebs

Verified by:

M. E. Vaughan

Appendix G
Dummy Rod Data

HFEF GASR TEST
CLWR-7 (CRIT2) DUMMY ROD
PRESSURE AT TEMPERATURE CERTIFICATION

Pressure Guage Description: HEISE, temperature compensated, 0-1,000 PSIA, Dial type mirrored ribbon face, tolerance ± 1 PSI., model 15079.

Calibration no. 705676, due date 10/14/97

Temperature Sensor Description: FLUKE Monitor, K/J thermometer, tolerance $\pm 1^\circ\text{F}$. Model 52

Calibration no 701703 due date 11/25/96

Temperature thermocouple: type K Calibration no. 707477 due date 12/29/96

Tube drawn down to a vacuum of 5×10^{-6} mbar l/s (cc/s) for 10 Minutes prior to backfilling with helium. Note the tube has been drawn down to 1×10^{-7} mbar l/s for several hours prior to this operation.

Ultra high purity Helium 99.999% pure used as backfill gas X Yes No.

Backfill pressure 500-510 PSIA. Actual measured pressure 507.5 PSIA.

Barometric pressure 25.30 Obtained from National Oceanic and Atmospheric Administration (NOAA) date 10/10/96 Time 2:35 AM X PM.

(Barometric pressure 25.30 $\times 14.7 \div 29.92 = 12.43$ PSIA).

Temperature measured on the outside of the tube approximately 4 $\frac{1}{2}$ " from the valved end.

Starting temperature 74 $^\circ\text{F}$ 2:31 PM Time. After pressurizing and stabilizing for 10 minutes 72.8 $^\circ\text{F}$ 3:15 Time

To set the pressure gauge for PSIA, obtain current barometric pressure, convert to PSIA, dial that into the guage and lock it. Draw a vacuum to bring the guage down to Zero. You are now reading PSIA on the dial face.

Welders Name H.J. Hall Welders certification expires 12/3/96 (see attached)

Welds helium leak checked down to 1×10^{-6} mbar l/s, Note the helium leak detector has no calibration sticker. X No leaks. Comments CHECKED FOR LEAKS ACROSS

THE VALVE TO 1×10^{-6} AS WELL. NO LEAKAGE INDICATED

Additional Comments: PRESS TO 507 DROPPED OF TO 505 AFTER 5 MIN 503 AFTER ANOTHER
5 MIN. PUMPED UP TO 507.1 BUMPED ROD RAISED TO 507.7 AFTER ANOTHER FIFTEEN MIN
AFTER ANOTHER 7 MIN STABILIZED AT 507.7 SHUT VALVE TO TUBE. LEFT OVER NITE
507.5 71.8 $^\circ\text{F}$ 8:10 AM

Technician Craig A. Robb Craig A. Robb Date 10/11/96

Lead Engineer Larry J. Whitmill Larry J. Whitmill Date 10/11/96

Quality Verification Daniel R. Tonks Daniel R. Tonks Date 10/11/96

507.5 PSIA 71.8 $^\circ\text{F}$

ASME AWS D1.1 AWS D1.2 AWS D1.3 AWS D9.1

[illegible]

(REV. 10-90)

om: EDRA --INELVM1
To: WIT --INELVM1 L J Whitmill

Date and time 10/02/96 08:13:52

From: Electronic Forms
Review and Approval System
Subject: CATALOG ORDER - 96274PRO2017

Document Form: SYSTEMS SUB-CONTRACTING

Your request has been APPROVED and is being Processed by SYSTEMS CONTRACTING @
FINAL Comments:

EDRA 96274PRO2017 GOOD
DATE: 10-02-96 TIME: 08:15:07

DELIVER TO: ROBB CRAIG A NHLF NA TOWN

THE FOLLOWING SSR NUMBERS WERE ASSIGNED TO YOUR SYSTEMS SUBCONTRACTING ORDER:

CONTRACT	SSR	LINE	DESCRIPTION	QTY	UNIT
C6	B	68429	1 HELIUM, UHP, 99.999% PURITY,	1	CY

WAREHOUSE ORDERS WILL BE ENTERED INTO THE IMMS REQUISITION SYSTEM.
SOME SYSTEMS SUBCONTRACTING ORDERS (FURNITURE, ETC.) MAY REQUIRE SPECIAL
APPROVAL AND NOT BE LISTED ABOVE. IF YOU HAVE QUESTIONS REGARDING THIS
ORDER, PLEASE CALL THE SYSCON ADMINISTRATOR (526-1669).

If you have any questions in the future, please check with them.

NOTE: EDRA is a service ID and not a real person.
Questions should be addressed to SYSTEMS CONTRACTING @ 6-1669

UNITED STATES WELDING, INC.

600 SOUTH SANTA FE DRIVE • DENVER, COLORADO 80223 • PHONE (303) 777-6671

the welder's supply house

PICKING/DELIVERY TICKET

PAGE

DATE	CUSTOMER NO.	CUSTOMER P.O. NO.	REQUISITION OR RELEASE NUMBER	DELIVERY TO
10/23/06	00187-00	DER#62420		371224
S O L D T O	LOOKHEED IDAHO		CUSTOMER PHONE	** SAME **
	ATTN:ACCTS PAYABLE		(208) 525-2324	*CHARG
	P.O. BOX 1625			
	IDAHO FALLS, ID 83415			
S H I P T O				
SHIPPED VIA		TERMS	SPECIAL SHIPPING DELIVERY INSTRUCTIONS	
OUR TRUCK NO CHARGE		NET 30 DAYS		

GASES					
CYL:CYL:	VOLUME	CODE	PRODUCT DESCRIPTION	HAZARD CLASS:NUMBER:	UNIT EXTENDED PRICE
1: 0:			1KHEUP:HELIUM, COMPRESSED	2.2:UN1048:	153.000 153.0
:	:	:	(K HE UHP SPED GAS)	NONFLAMMABLE:	
:	:	:	MSDS SENT 06/26-BOOK	GAS	
0 3:			ck Hel (K Helium		

HARDGOODS					
QUANTITY :	QUANTITY :				UNIT EXTENDED PRICE
ORDERED :	SHIPPED :	U/M :	PART NUMBER :	PRODUCT DESCRIPTION :	
				DELIVER TO NORTH HOLMES LAB	

* END OF ORDER
* PAGE 1 OF

TICKET PRINTED 10/23/06 AT 11:08AM

THIS IS TO CERTIFY THAT THE ABOVE-NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED, AND LABELED, AND ARE IN PROPER CONDITION FOR TRANSPORTATION, ACCORDING TO APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION.

BY

SELLER

PLACARDING
REQUIRED

☐ YES

☐ NO

JTE: VERIFY COUNT OF ALL CYLINDERS, REPORT ANY DIFFERENCES IMMEDIATELY. RETURN EMPTY CYLINDERS AND CAPS PROMPTLY. CUSTOMER WILL BE CHARGED FOR LOST CYLINDERS AND CAPS.

WARNING: I ACKNOWLEDGE THAT I HAVE BEEN INSTRUCTED THAT IT IS HIGHLY DANGEROUS AS WELL AS ILLEGAL TO TRANSPORT FLAMMABLE GASES IN A CLOSED VEHICLE OR ANY COMPARTMENT THEREON. I HAVE ALSO RECEIVED THE PROPER MSDS FORM.

BUYER OR HIS AGENT AGREES TO ALL
TERMS AND CONDITIONS OF SALE.

[Signature]

RECEIVED BY

G-4

ENT. BY

FILLED BY

DELIVERED BY

MS

Rob 10-9

INVOICE SUB-TOTAL

153.0

5.000%

TOTAL INVOICE

153.0

Craig A Roll

CUSTOMER

L0540-6
P16CL016

SYSTEMS SUB-CONTRACTING ORDER FORM
Total Cost \$ 79.89

\$\$REFNO\$\$

Date: 9/30/96

Release No: _____

Company: _____

Employee No:
034778

Name:
WHITMILL LARRY J

Mail Id:
WIT

Org No:
4130

Phone:
6-0357

Deliver to:
ROBB CRAIG A

Delivery Location:
IF NHLF na

Room/Grid No:
na

Phone:
5-0684

Hazardous Chemicals

These items are NOT hazardous chemicals per 29 CFR 1910.1200

1

Comments or Justification

dummy target rod, larry

Line No.	Charge No.	Sub-Cont. Org. No.	Manufacturer & Part No.	Qty	U/M	Stock List
1	184120410	4130 C6	00023	1	CY	B
	HELIUM, , HELIUM, UHP, 99.999% PURITY,, 240 CU FT ., CGA 580, W					
	Unit Cost: 79.89 Line Cost: 79.89					
2						
3						
4						
5						
6						
7						
8						
9						

\$\$DOCNO\$\$

***** Prepared By *****
LARRY J. WHITMILL
***** Electronic Authorizations Follow *****

om: OGM --INELVM1
To: WIT --INELVM1

Date and time 10/14/96 14:28:36

FROM: MICHAEL G OWENS
Subject: HELIUM PROCUREMENT

it was an input error on the part of the vendor. it has been noted and a credit will be forthcoming for the difference. thank you for bringing it to my attention.

*** Reply to note of 10/14/96 13:57

To: OGM --INELVM1 M G Owens
cc: WW4 --INELVM1 W D Wagner

FROM: LARRY J WHITMILL ORG. 4130, EROB-W2-D7
FAX 6-0425, PH. 6-0357, MS 3765
Subject: HELIUM PROCUREMENT

I ordered a bottle of helium on SSR 68429. It was listed at \$79.89. It was delivered by United States Welding Inc. with a delivery ticket that says the unit price is \$153.00. I don't understand, can you explain.....thanks

PISPM500-01
DROP: TOWN
SSR PAGE: 1

LOCKHEED IDAHO TECHNOLOGIES COMPANY
C6 U S WELDING

TIME: 18:17:32
PRINT DATE: 10/02/96
CONTRACT PAGE: 2

SSR: 68429

LIVERY LOC: NHLF NA

NAME: ROBB CRAIG A

EMP NO: 34778 NAME: WHITHILL, LARRY J ORGN: 4130 PHONE: 6-0357
CHARGE NO: 184120410 CEL: MSO LOC: IF EROB W2 C6 MS: 3765 SITE: T
END USE: DUMMY TARGET ROD, LARRY
PRIORITY LEVEL: 00

SSR#: STOCK-B

LN	MPN# / DESCRIPTION	U/M	QTY	UNIT PRICE	EXT PRICE
01	00023				
	HELIUM, UHP, 99.999% PURITY,	CY	1	79.890	79.890
				SUB TOTAL	79.890

WIRE OWENS

*** REQUESTOR MUST COUNT AND INSPECT RECEIPTS - NOTIFY BUYER ON DISCREPANCIES
BUYER: 203 NAME: A K BERRETT 6-2723

TOP COPY-RECEIVING 2ND COPY-VENDOR 3RD COPY-REQUESTOR

NAME: ROBB CRAIG A
LOC: NHLF NA MS: 3765
ORGN: 4130 PHONE: 6-0357
SSR#: 68429
LABEL 1 OF -
STOCK-B

NAME: ROBB CRAIG A
LOC: NHLF NA MS: 3765
ORGN: 4130 PHONE: 6-0357
SSR#: 68429
LABEL 2 OF -
STOCK-B

NAME: ROBB CRAIG A
LOC: NHLF NA MS: 3765
ORGN: 4130 PHONE: 6-0357
SSR#: 68429
LABEL 3 OF -
STOCK-B

NAME: ROBB CRAIG A
LOC: NHLF NA MS: 3765
ORGN: 4130 PHONE: 6-0357
SSR#: 68429
LABEL 4 OF -
STOCK-B

G-7

Lockheed Martin Idaho Technologies Company

NOTEGRAM

Date: Oct. 18, 1996

To: Wendell Wagner

From: Larry J. Whitmill *whit*

Subject: GASR Test Rod

I have returned the test rod and the spare to Argonne. I have not disclosed to them the condition or contents of the test rod. I have included here the documentation supporting the task I performed for you including the quality certification for the final rod conditions. In addition to labor and the requisitions, there will be a use charge of about \$25 for each instrument that we got from the instrument pool. Those charges are for three instruments. Total charge for the instruments should be no more than \$75.

I removed the handle from the valve on the test rod to prevent accidental opening of the valve. It is included here in case you want to keep it.

This notegram serves to close out my activities and forward all project documents to you for your files.

If I can be of any further assistance or you have any questions, feel free to call me at 6-0357.

.cc R. L. Davison

THIS DRAWING IS FURNISHED FOR USE UNDER SUBCONTRACT
Q20874-6-89 WITH BATTELLE PACIFIC NORTHWEST LABORATORIES
UNDER THEIR PRIME CONTRACT WITH THE U.S. DEPARTMENT OF ENERGY.
SINCE THIS DRAWING MAY CONTAIN PRELIMINARY OR PATENTABLE
INFORMATION, THE DRAWING OR ITS CONTENTS SHALL NOT BE PUBLISHED,
FURTHER DISSEMINATED, OR USED FOR OTHER PURPOSES WITHOUT PRIOR
APPROVAL OF DOE.

NOTES:

- ④ ASSEMBLE PER E-955096
- ③ HAND STRAIGHTENING PERMITTED
- ② WELDED AREA MUST PASS THRU $\phi .375$ MAX RING GAGE .75 MIN LG.
- ① GTAW PER E-432A70

QTY REQD	ITEM NO	NOMENCLATURE OR DESCRIPTION	FSC NO OR SYN	PART OR IDENTIFYING NO	MATERIAL/SPECIFICATION
	06	COMPRESSION SPRING		6946C73H01	
	05	PENCIL ASSEMBLY		4002258604	
	04	BOTTOM PENCIL ASSEMBLY		4002258608	
	03	TOP PLUG		4002258603	
	02	GETTER DISC ASSEMBLY		4002259603	
	01	CLADDING TUBE ASSEMBLY		4002256601	

UNLESS OTHERWISE SPECIFIED ANSI STANDARDS APPLY

DIMENSIONS IN INCHES AT 68° F

BREAK SHARP EDGES .02 MAX RADIUS OR CHAMFER

FILLET RADIUS ON INTERNAL CORNERS - .02 MAX

SURFACE TEXTURE THREADS: 250/ OTHER SURFACES: 250/

COUNTERSINK THREADS TO NOM OIA WITH A .03 TOL

TOLERANCES

3 PLACE DECIMALS ±.005 | 2 PLACE DECIMALS ±.02

CONCENTRICITY BETWEEN ANY TWO FEATURES MUST BE WITHIN THE SUM OF THE SIZE TOLERANCES OF THE FEATURES BEING COMPARED.

CONTRACT NO

DATE 11-1-89 APP

BY STAREHMAX

APP 12-1-89 APP 12-1-89

BY R. SPENCER G.V. STUBBS

APP 12-1-89 APP 12-1-89

BY P. S. CRENNANATIE R. ALLEN

APP 12-1-89 INGR 12-1-89

BY J. RACKI D. G. VILKINSON

DWG CODE CCL

0-SPEC 564A03-01

Westinghouse Electric Corporation

ADVANCED ENERGY SYSTEMS DIVISION

MALTZ MILL MADISON, PA, U.S.A.

FILE

ATR LOOP-1

TARGET ROD

ASSEMBLY

SIZE FSC NO

D 35952

DWG NO

400225512

SCALE 1/1

SHEET 1 OF 1

THIS DRAWING IS FURNISHED FOR USE UNDER SUBCONTRACT
 070874-A-R1 WITH BATTTELLE PACIFIC NORTHWEST LABORATORIES
 UNDER THEIR PRIME CONTRACT WITH THE U.S. DEPARTMENT OF ENERGY.
 SINCE THIS DRAWING MAY CONTAIN PRELIMINARY OR PATENTABLE
 INFORMATION, THE DRAWING OR ITS CONTENTS SHALL NOT BE PUBLISHED,
 FURTHER DISSEMINATED, OR USED FOR OTHER PURPOSES WITHOUT PRIOR
 APPROVAL OF DOE.

49.875±0.60

D

C

A

SECTION A-8

VOID VOL = 1.96 cc in = 32.14 cc = 32.14 mL = .058

REVISIONS			
ZONE (REV)	DESCRIPTION	DATE	APPROVED

LOOP-1/B-1/S-1 SOW
CLWR/A-96-001
Addendum 2
Attachment 6.2
Revision 1
Page 1

NOTES:

- 11 WELDED AREA MUST PASS THRU $\phi .375$ MAX RING GAGE .75 MIN LG. AFTER COATING.
- 10 APPLY ALUMINIZED COATING TO I.D. OF ITEM 13 AND TO INSIDE OF ITEM 01 PER 01-1312L
- 9 APPLY Ni PLATING .0002⁺.0010_{-.0000} THICK TO ALL SURFACES PER E-955095, EXCEPT THAT PROCEDURE QUALIFICATION AND PRODUCTION SAMPLING SHALL BE ACCORDING TO A PLAN FOR SMALL LOT QUANTITIES DEVELOPED BY THE FABRICATOR AND APPROVED FOR USE BY THE PURCHASER.
- 8 APPLY ALUMINIZED COATING TO O.D. & I.D. OF ITEM 02 AND TO OUTSIDE AND INSIDE OF ITEM 01 PER 01-13120
- 7 DIMENSIONAL LIMITS APPLY AFTER PLATING/COATING.
- 6 BEND TABS OF SHROUD OVER AS SHOWN. (BOTH ENDS OF ITEM 09 & ONE END OF ITEM 05)
- 5 LITHIUM ENRICHMENT VARIES. DENSITY 2.49 G/CC $\pm .06$ G/CC
- 4 PRELOAD 1.50 LBS.
- 3 HAND STRAIGHTENING PERMITTED
- 2 WELDED AREA MUST PASS THRU $\phi .375$ MAX RING GAGE .75 MIN LG.
- 1 GTAW PER E-955075

$\phi .187^{+.005}_{-.000}$

$\phi .093^{+.005}_{-.000}$

BOTTOM OF CORE

7 8 10

1

	1	-	13	CLADDING TUBE		SST ASTM-A-771 TYPE 316
	1	1	12	INNER SHROUD		ZIRCONIUM ASTM-B-352 GR R60001
	1	1	11	GETTER		ZIRCALOY TUBING
	1	1	10	INNER SHROUD		ZIRCONIUM ASTM-B-352 GR R60001
	3	3	09	GETTER SHROUD		ZIRCALOY TUBING
	1	1	08	COMPRESSION SPRING		SST ASTM-A-313 TYPE 302
	1	1	07	DISC		ZIRCALOY
	1	1	06	DISC		ZIRCALOY
	1	1	05	GETTER SHROUD		ZIRCALOY TUBING
	ARIAR		04	PELLET		LI AL O2 5
	1	1	03	TOP END PLUG		SST ASTM-A-276 TYPE 316
	-	1	02	CLADDING TUBE		SST ASTM-A-771 TYPE 316
	1	1	01	BOTTOM END PLUG		SST ASTM-A-276 TYPE 316
D3	02	01	ITEM	NOMENCLATURE OR DESCRIPTION	FSCH NO OR SYM	PART OR IDENTIFYING NO
	GROUP		NO			MATERIAL/SPECIFICATION
QTY REQD PARTS LIST						

UNLESS OTHERWISE SPECIFIED ANSI STANDARDS APPLY		CONTRACT NO		Westinghouse Electric Corporation	
DIMENSIONS IN INCHES AT 68° F		12-01-01APP		ADVANCED ENERGY SYSTEMS DIVISION	
BREAK SHARP EDGES .02 MAX RADIUS OR CHAMFER		11-01-01APP		WALTZ KELL MADISON, PA. U.S.A.	
FILLET RADIUS ON INTERNAL CORNERS - .02 MAX		10-01-01APP		TITLE	
SURFACE TEXTURE THREADS: 63/ OTHER SURFACES: 320		09-01-01APP		ATR WATER CAPSULE	
COUNTERSINK THREADS TO NOM DIA WITH A $\pm .03$ TOL		08-01-01APP		TARGET ROD	
TOLERANCES		07-01-01APP		LAYOUT	
3 PLACE DECIMALS $\pm .005$ 2 PLACE DECIMALS $\pm .02$		DVG CODE CCL		SIZE FSCH NO	
CONCENTRICITY BETWEEN ANY TWO FEATURES MUST BE WITHIN THE SUM OF THE SIZE TOLERANCES OF THE FEATURES BEING COMPARED		D-SPEC 56407-01		D1 35952	
				DVG NO 4D02260	
				SHEET 1 OF 1	

4

3

2

1

PACKING LIST

FROM

CPV MANUFACTURING, INC.
851 N. Preston Street
Philadelphia, PA 19104-1598
Phone (215) 386-6508
Fax (215) 387-9043

CONTAINER NO.	CUSTOMER'S NO.	OUR NO.
	1114ATS-1	187987
SHIPPED VIA	FOR A/C OF	DATE
UN		10-1-96
SHIPPED TO	LMIT CO 2525 FREMONT AVE. W2-D7 IDAHA FALLS, ID 83415	

VISA

WHEN REFERRING TO THIS SHIPMENT BE SURE TO GIVE ALL DETAILS

[illegible]**PACKED BY**

BY
GW. 10-1-96 2# 10710-1

The Ultimate in Positive Fluid Control

...a unique system of soft-seated valves that slip right in

Now you can combine the performance advantages of these low torque, soft-seated valves with the superior sealing and unlimited accessibility of Mark VIII O-SEAL fittings.

CPV Mark VIII Shutoff and Regulating valves employ a stem with a resilient insert that presses against a raised, flat metal seat to assure "bubble-tight" closure. This Kel-F insert is securely swaged in the valve stem, and the sealing force is distributed over a large circular sealing area to assure long valve life. Two valve configurations are available:

Figure A.
Shutoff Valve

Figure B.
Regulating (Needle) Valve

CPV MARK VIII Shutoff and Regulating Valves Provide Slip-In Installation And Trouble-Free Operation.

A Proven Design Concept Pioneered by CPV. Many of the key design elements of the Mark VIII valve are based upon CPV's early pioneering work in soft-seated valve design. CPV valves have proven themselves to be the ultimate in positive fluid control in over three decades of use aboard U.S. Navy nuclear submarines and in numerous industrial applications; including chemical process piping and mixed gas diving systems. This same high reliability is now available for your most demanding instrumentation and process piping needs.

Valve slips right in, stays leaktight. Only the Mark VIII system of valves and fittings gives you this instant, easy access plus high reliability sealing. The basic Mark VIII system comprises a soft-seated valve with union-type end connections. An O-ring recessed in a close tolerance groove in each valve end seals against a mating flat-faced fitting.

The result is a valve that you can slip straight in or out without springing or cutting lines—no axial clearance is required. So you can easily remove the valve at will without disturbing other components.

This slip-in feature permits the design of exceptionally compact systems without penalizing the installer. Accessibility to components is assured by the valve's flat-faced design.

And you'll never have to worry about fitting leakage—no matter how often these connections are broken and remade. Once the

union nuts are tightened, the sealing action of the resilient O-ring assures absolutely leaktight valve connections under all conditions.

Positive Sealing of Liquids and Gases—even elusive helium and hydrogen. All wetted surfaces are of 316 stainless steel to assure contaminant-free operation even after extended service in most aggressive environments. The valves also employ a captive soft seat design that provides absolutely leaktight sealing and exceptionally long valve life. To accommodate almost any fluid media, the valves can be furnished with Buna-N, Viton, Ethylene Propylene, or TFE seals. A TFE backup ring above the stem seal is standard.

Keeps Ultra-Pure Systems Contaminant Free. Valve threads are above the stem seal—completely isolated from the system fluid. This eliminates thread corrosion problems and permits stem thread lubrication without fear of fluid contamination.

Galling-Free, Low Torque Valve Operation. Mark VIII valves are easy to open and close. The stainless steel stem threads into a

bronze bonnet that is nickel-plated. These dissimilar materials plus external thread lubrication effectively eliminate galling, and subsequently reduce torque requirements.

Non-Clog Operation Even in Severe Service. To ensure reliable performance even under the most demanding service conditions, the valves also feature a one piece stem design that eliminates clogging due to contamination trapping. Because this design has no cavities for corrosive materials to collect in, thorough flushing can be accomplished if desired. This one piece stem also ends backlash problems as well as chatter when used for metering.

Ideal for Instrumentation or Process Systems. These panel-mountable Mark VIII shutoff and regulating valves offer exceptional adaptability. They are available in angle or inline body styles with choice of flow coefficients, and with seals to suit specific requirements. They can be furnished with a variety of valve end configurations including Mark VIII unions, female pipe threads, male pipe threads, female straight threads, and direct weld/braze ends in sizes from $\frac{1}{8}$ " to $\frac{3}{8}$ ". Valve dimensions, ordering information and C_v charts are given on the following pages to allow you to select the Mark VIII valves best suited to your particular applications.

Technical Data

Valve Specifications

Body 316 Stainless Steel
Stem 316 Stainless Steel
Bonnet and Panel Nut Bronze, nickel-plated
Insert Kel-F
Mark VIII End Connections:
Tailpiece (fitting) 316 Stainless Steel
Union Nut 304 Stainless Steel

Operating Pressure 0-3000 psi
Maximum Temperature Rating 250°F.
Flow Coefficient—Cv:
Inline Body Style:
 0.156" Orifice 0.25
 0.297" Orifice 1.00
Angle Body Style:
 0.156" Orifice 0.40
 0.297" Orifice 1.60

How to Order Mark VIII Valves*

Select the part number for the valve desired. Add a suffix to the part number to indicate the seal material required. Seal material you specify will be furnished for stem and bonnet seals as well as end seals where applicable.

Typical part number shown broken down:

Product Line	Orifice	Valve Type	Body Style	Body End Configuration	Tube O.D.	Seal Material *
8	04 0.156" 08 0.297"	S Shutoff N Regulating	G Inline A Angle	U Mark VIII union H Direct weld/braze T Straight thread M Male pipe NPT F Female pipe NPT	-02 1/8" -03 3/16" -04 1/4" -05 5/16" -06 3/8" -08 1/2" -10 5/8"	B Buna-N C Viton D Ethylene Propylene T TFE

*When ordering, be sure to include the appropriate letter for the seal material desired: B-Buna-N; C-Viton; D-Ethylene Propylene; T-TFE (consult factory before ordering).

Sil-Braze Rings for Valves with Brazed End Connections

Part No.	Tube O.D.
H801-2	1/8
H801-3	3/16
H801-4	1/4
H801-5	5/16
H801-6	3/8
H801-8	1/2
H801-10	5/8

Grade VII Sil-Braze Alloy

CPV Mark VIII Shutoff & Regulating Valves

BRAZE/WELD END CONNECTION (H)

PART NUMBER		VALVE TYPE	DIMENSIONS (INCHES)										
INLINE	ANGLE		ORIFICE	A TUBE O.D.	B	B'	C		D	E MAX.	F	G	H
							OPEN	CLOSED					
804SGH-04 804NGH-04	804SAH-04 804NAH-04	Shutoff Regulating	0.156	1/4	1 5/8	1 3/16	2 19/32	2 7/16	1 7/32	1/4	1 7/32	1 3/8	3/16
804SGH-06 804NGH-06	804SAH-06 804NAH-06	Shutoff Regulating		3/8									1/4
808SGH-06 808NGH-06	808SAH-06 808NAH-06	Shutoff Regulating		3/8									1/4
808SGH-08 808NGH-08	808SAH-08 808NAH-08	Shutoff Regulating		1/2									2 3/8
808SGH-10 808NGH-10	808SAH-10 808NAH-10	Shutoff Regulating	0.297	5/8	2 3/8	1 3/16	3 15/32	3 3/16	1 21/32	3/8	2 5/32	1 7/8	3/8

* When ordering, be sure to include the appropriate letter for the seal material desired:
B-Buna-N; C-Viton; D-Ethylene Propylene; T-TFE (consult factory before ordering).

NOTE: Order Sil-Braze rings
(H801) separately. See page 4.

STRAIGHT THREAD END CONNECTION (T)

PART NUMBER		VALVE TYPE	DIMENSIONS (INCHES)									
INLINE	ANGLE		ORIFICE	A STR. THD.	B	B'	C		D	E MAX.	F	G
							OPEN	CLOSED				
804SGT-02 804NGT-02	804SAT-02 804NAT-02	Shutoff Regulating	0.156	5/16-24	2 3/8	1 1/16	2 19/32	2 7/16	1 7/32	1/4	1 7/32	1 3/8
804SGT-04 804NGT-04	804SAT-04 804NAT-04	Shutoff Regulating		7/16-20								
808SGT-06 808NGT-06	808SAT-06 808NAT-06	Shutoff Regulating	0.297	9/16-18	2 3/8	1 7/16	3 15/32	3 3/16	1 21/32	3/8	2 5/32	1 7/8
808SGT-08 808NGT-08	808SAT-08 808NAT-08	Shutoff Regulating		3/4-16								

* When ordering, be sure to include the appropriate letter for the seal material desired:
B-Buna-N; C-Viton; D-Ethylene Propylene; T-TFE (consult factory before ordering).

**For Leakproof Reliability and Positive Flow Control
of Liquids and Gases, Specify CPV Valves and Fittings**

CPV 6000 psi O-SEAL Valves and Fittings—a system of soft-seated valves and fittings in pipe and O.D. tube sizes from 1/8" to 2". For positive control and leakproof containment of liquids or gases. Request Catalog 68.

CPV 10,000 psi O-SEAL Valves and Fittings—1/4" pipe size and 9/16" O.D. tube. Request Catalog 80.

CPV MARK VIII Tube Fittings—heat-sealed, separable tube fittings for vacuum to 3000 psi. Sizes from 1/8" to 2". Request Catalog 74.

CPV MARK VIII Valves—soft-seated regulating and shut-off valves with various end connections. Request Catalog 84.

CPV MARK VIII Hose Fittings—easy connect/disconnect fittings for medium and high pressure hose per SAE 100R5 and 100R2. Request Catalog 75.

CPV MARK VIII Direct Braze/Weld Tube Fittings—couplings, tees, elbows and reducers in sizes from 1/4" to 2" for permanent, hermetically-sealed tube to tube connections. Request Catalog 77.

CPV DYNAIR High Pressure Booster—air-operated pumps for generating liquid pressures to 5000 or 10,000 psi with a regulated air supply of only 80 psi. Request Catalog 20.

CPV Silent Check Valves—spring-actuated; close automatically and silently as soon as forward flow stops. Sizes from 1/2" to 24" Pressures from 125 to 2500 psi. Request Catalog 800.

For immediate
assistance,
please contact:

GENE AMBROSE	PHONE
AMBROSE TECHNICAL SALES INC	801
P O BOX 3251	621
OGDEN	5341
UT 84404	

Please fill in and mail the card below. Thank you.

1. What do you want us to send to you?

- ☐ More product data on _____
- ☐ A quotation on _____
- ☐ Other _____

2. What is your application? _____

3. Is your requirement ☐ immediate ☐ 1-3 months ☐ 4-6 months ☐ 7-12 months ☐ longer

4. What is your telephone number? _____ / _____ Ext. _____

☐ I would like to discuss my requirements with a CPV representative.

P1089 041	45412 0013 82	8
LARRY WHITMILL		
E G & G IDAHO INC		
P O BOX 1625		
IDAHO FALLS	ID 83415	

Is the label correct? Please make any changes right on the label.
Thank you very much for enabling us to be of further service to you.

lip right in

FLOW MEDIA—permits
out fluid contamination
erating torque . . . increases

BLE—all Mark VIII valves
ith panel nuts.

NLESS STEEL STEM—elim-
; chattering and corro-
mination traps . . .
flushing if required.

M SEALS—use of a resil-
m seal with a TFE
actively eliminates

RFACES 316 STAINLESS STEEL
: performance for the

PLATED BONNET—resists
nizes torque.

SEAT DESIGN—
a of the captive,
ind broad valve seat
tight shutoff and
ng valve life.

SSAGES—minimize
rough valve. Choice
25 to 1.60 depending
d body style.

NG SEALED FITTINGS—
; VIII O-SEAL fittings
f connections that
se . . . valve can be
t without
ting the line.

SEALED TUBE ENDS—
L fittings are permanently
d to the tubing.

configurations are
ages 6 and 7.

6166

Figure A.
Shutoff Valve

Figure B.
Regulating (Needle) Valve

MODIFICATIONS TO THE TARGET ROD
 Approved per TELECON w/ Glenn Hollenberg PNNL
 (509) 376-5515

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 Dummy					DATE: 1/16/97		1 OF 1	
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		19.1 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		18.75 Psia		232.58				
11						SLOPE "B" = 0.643882005			
12						INTERCEPT ' 0.001561985			
13	NOMINAL	INITIAL	EXPANDED ELEMENT VOL.		PRESSUR	Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.				
15	Atmospheric	12.32	7.93	2.712	499	7.93418828	0.004188282	1.7542E-05	0.05189014
16	15	15.01	9.71	2.770	489	9.66623087	-0.04376913	0.00191574	Sum of sqrs
17	17	17.08	10.99	2.708	500	10.9990666	0.009066624	8.2204E-05	0.00269259
18	20	20.19	12.99	2.707	500	13.0015397	0.011539658	0.00013316	Variance
19	22	22.17	14.27	2.712	499	14.276426	0.006426028	4.1294E-05	0.00029918
20	25	25.19	16.21	2.710	499	16.2209497	0.010949681	0.0001199	Stdev slope
21	27	27.20	17.51	2.714	499	17.5151525	0.005152511	2.6548E-05	0.00056107
22	30	30.28	19.49	2.712	499	19.4983091	0.008309085	6.9041E-05	
23	32	32.28	20.78	2.714	499	20.7860731	0.006073094	3.6882E-05	
24	35	35.28	22.72	2.718	498	22.7177191	-0.00228089	5.2025E-06	
25	45	45.23	29.14	2.723	497	29.1243451	-0.01565495	0.00024508	
26	Sum of sqrs		8191.6381			P*V	Sum Yhat-Y	Avg of Yhat-Y 2Sigma N-1	
27	Avg	25.6572727	AVERAGE		2.718	498	1353.6	9.76996E-15	8.8818E-16 0.0328182
28	Sum (P1 - Avg)^2		950.386018		2 SIGMA N-1	0.035	6		
29	Solution by simultaneous equations:				118.205	19	2282.9		
30									
31						"A" SLOPE 0.366865432			
32						"A" INT. -0.00342526			
33	Cal Data	P1	P2	Yhat	Yhat - Y			Square Yh-Y	Sq rt sm sqrs
34		5.07	1.87	1.856582477	-0.01341752			0.00018003	0.02703562
35		7.08	2.60	2.593981996	-0.006018			3.6216E-05	Sum of sqrs
36		10.06	3.68	3.687240983	0.00724098			5.2432E-05	0.00073093
37		12.30	4.50	4.509019551	0.00901955			8.1352E-05	Variance
38		15.15	5.56	5.554586033	-0.00541397			2.9311E-05	0.00008
39		17.18	6.30	6.29932286	-0.00067714			4.5852E-07	Stdev slope
40		20.22	7.41	7.414593773	0.00459377			2.1103E-05	0.00023653
41		25.24	9.25	9.256258242	0.00625824			3.9166E-05	
42		30.20	11.07	11.07591079	0.00591079			3.4937E-05	
43		35.30	12.94	12.94692449	0.00692449			4.7949E-05	Sig
44		45.30	16.63	16.61557881	-0.01442119	Avg of Yhat-Y 2Sigma N-1		0.00020797	
45	Average	20.2818182	7.437273	7.437272727	-1.1304E-15	-1.1304E-15	0.01709883		
46		Sum of "x^2"		Sum of "Y^2"	Sum of "Yhat^2"				
47		3856.02740	518.96340	518.65638					
48	Vcap =	2.7412	*Pcap=	531.6	P*V=	1457.1			
49	Sum of (P1-Avg)^2	1451.67317							
50									
51	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
52	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
53	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
54	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
55	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) = 232.58 PSIA								
56	232.5840723

ARGONNE NATIONAL LABORATORY - WEST
Analytical Laboratory

FINAL REPORT

Requester: P. WEBB, R. ELLIOTT, R. WISNER, D. HAGAN
Facility: HFEF

Login Name: CLWR PIN GAS (DUMMY ROD)
AL Log #: 073825

COC #:
Date Received: 16-Jan-97 13:30

Approved by

Date

Sample #: 1 of 1
Sample ID: CYL #15
Where Taken: HFEF

Sampling Date: 16-Jan-97 12:00
Barcode No.: N/A

GROUP	ANALYTES	RESULTS	ERROR @ 2 sigma UNITS	
MASS SPEC	H2	0.02	± 25%	Mole %
	He	99.46	± 1.0%	Mole %
	N2	0.37	± 25%	Mole %
	O2	0.06	± 25%	Mole %
	Ar	0.09	± 25%	Mole %
	CO2	<0.01	n/a	Mole %

GROUP	ANALYTES	RESULTS	ERROR @ 2 sigma UNITS	
ASS SPEC	He 3 Isotopic	ND	n/a	n/a
	He 4 Isotopic	100.0	± 1.0%	a/o

COMMENT: ND = Not Detectable.

Appendix H

Calibration Sheets and Puncture Data

Appendix H

Table of Contents

Calibration Sheets

1-21-97
1-27-97
1-30-97
2-03-97
2-04-97
2-05-97

Puncture data

WL-01
WL-03
WL-09
WL-10
WL-18
WL-22
WL-26
WL-27
WT-11
WT-12

Sample Bottle Data Tables

Sample Bottle ID
Sample Bottles Used in WL-18 Backfill Analysis
Sample Bottle Volumes

ANL-W Spread Sheets Pressure and Void Volume

WL-01
WL-03
WL-09
WL-10
WL-18
WL-22
WL-26
WL-27
WT-11
WT-12

GASR System Volumes

Table

MATHCAD

File on pressure and void volume calculation

Appendix B

Page 1 of 1

SYSTEM CALIBRATION DATA SHEET

Date: 1-21-97

Gauge Calibration Data			
Nominal Pressure (psia)	Calibrated Gauge (PI-6)	Seal Head (PI-1)	Manifold (PI-2)
5	5.01	5.0	5.01
7	7.01	7.0	7.00
10	10.00	10.0	10.00
Atmospheric	11.97	12.0	11.97
15	15.05	15.1	15.05
17	17.05	17.1	17.04
20	20.04	20.1	20.05
25	25.06	25.1	25.06
30	30.04	30.1	30.05
35	35.02	35.1	35.04
45	45.04	45.1	45.03

Seal Head/Manifold Ratio Data		
Nominal Pressure (psia)	Initial (PI-2)	Expanded (PI-2)
5	5.04	1.84
7	7.04	2.56
10	10.05	3.65
Atmospheric	12.03	4.39
15	15.13	5.51
17	17.13	6.24
20	20.15	7.34
25	25.19	9.18
30	30.20	11.02
35	35.22	12.85
45	45.25	16.54

Seal Head .174
Rod Block (Saddle) .375

Appendix B

Page 1 of 1

SYSTEM CALIBRATION DATA SHEET

Date: 1-27-97

Gauge Calibration Data			
Nominal Pressure (psia)	Calibrated Gauge (PI-6)	Seal Head (PI-1)	Manifold (PI-2)
5	5.00	5.0	5.01
7	7.03	7.0	7.02
10	10.00	10.0	10.00
Atmospheric	12.24	12.2	12.23
15	15.03	15.0	15.04
17	17.03	17.0	17.04
20	20.00	20.0	20.01
25	25.02	25.0	25.01
30	30.03	30.0	30.01
35	35.04	35.0	35.03
45	45.03	45.0	45.04

Seal Head/Manifold Ratio Data		
Nominal Pressure (psia)	Initial (PI-2)	Expanded (PI-2)
5	5.03	1.87
7	7.05	2.60
10	10.05	3.70
Atmospheric	12.28	4.52
15	15.11	5.57
17	17.12	6.31
20	20.12	7.42
25	25.15	9.25
30	30.17	11.09
35	35.21	12.94
45	45.26	16.64

Seal Head .174
Rod Block (Saddle) .375

Appendix B

Page 1 of 1

SYSTEM CALIBRATION DATA SHEET

Date: 1-30-97

Gauge Calibration Data			
Nominal Pressure (psia)	Calibrated Gauge (PI-6)	Seal Head (PI-1)	Manifold (PI-2)
5	5.01	5.0	5.01
7	7.00	7.0	7.00
10	10.00	10.0	10.02
Atmospheric	12.28	12.3	12.28
15	15.01	15.0	15.03
17	17.03	17.0	17.05
20	20.03	20.0	20.03
25	25.01	25.0	25.03
30	30.01	30.0	30.03
35	35.02	35.0	35.06
45	45.02	45.0	45.00

Seal Head/Manifold Ratio Data		
Nominal Pressure (psia)	Initial (PI-2)	Expanded (PI-2)
5	5.03	1.86
7	7.03	2.59
10	10.06	3.69
Atmospheric	12.34	4.53
15	15.10	5.54
17	17.13	6.28
20	20.13	7.38
25	25.16	9.22
30	30.18	11.06
35	35.23	12.91
45	45.22	16.60

Seal Head .174
Rod Block (Saddle) .375

Appendix B

Page 1 of 1

SYSTEM CALIBRATION DATA SHEET

Date: 2-3-97

Gauge Calibration Data			
Nominal Pressure (psia)	Calibrated Gauge (PI-6)	Seal Head (PI-1)	Manifold (PI-2)
5	5.02	5.0	5.07
7	7.01	7.0	7.02
10	10.06	10.0	10.08
Atmospheric	12.19	12.2	12.21
15	15.01	15.0	15.05
17	17.00	17.0	17.03
20	20.03	20.0	20.08
25	25.02	25.0	25.04
30	30.00	30.0	30.01
35	35.00	35.0	35.03
45	45.09	45.1	45.10

Seal Head/Manifold Ratio Data		
Nominal Pressure (psia)	Initial (PI-2)	Expanded (PI-2)
5	5.11	1.90
7	7.06	2.61
10	10.13	3.73
Atmospheric	12.26	4.51
15	15.12	5.58
17	17.11	6.31
20	20.18	7.43
25	25.17	9.26
30	30.16	11.08
35	35.20	12.92
45	45.32	16.65

Seal Head .174
Rod Block (Saddle) .375

Appendix B
Page 1 of 1

SYSTEM CALIBRATION DATA SHEET

Date: 2-4-97

Gauge Calibration Data			
Nominal Pressure (psia)	Calibrated Gauge (PI-6)	Seal Head (PI-1)	Manifold (PI-2)
5	5.01	5.0	5.03
7	7.06	7.1	7.06
10	10.00	10.0	10.01
Atmospheric	12.18	12.2	12.18
15	15.02	15.0	15.02
17	17.02	17.0	17.04
20	20.00	20.0	20.01
25	25.04	25.0	25.02
30	30.03	30.0	30.01
35	35.05	35.0	35.07
45	45.05	45.0	45.01

Seal Head/Manifold Ratio Data		
Nominal Pressure (psia)	Initial (PI-2)	Expanded (PI-2)
5	5.06	1.86
7	7.10	2.61
10	10.06	3.69
Atmospheric	12.24	4.49
15	15.09	5.54
17	17.13	6.29
20	20.11	7.38
25	25.14	9.22
30	30.16	11.06
35	35.24	12.92
45	45.24	16.60

Seal Head .174
Rod Block (Saddle) .375

Appendix B
Page 1 of 1

SYSTEM CALIBRATION DATA SHEET

Date: 2-5-97

Gauge Calibration Data			
Nominal Pressure (psia)	Calibrated Gauge (PI-6)	Seal Head (PI-1)	Manifold (PI-2)
5	5.01	5.0	5.02
7	7.03	7.0	7.02
10	10.00	10.00	10.00
Atmospheric	12.16	12.1	12.16
15	15.00	15.0	15.01
17	17.05	17.0	17.07
20	20.02	20.0	20.2
25	25.02	25.0	25.01
30	30.01	30.0	30.00
35	35.01	35.0	35.02
45	45.04	45.0	45.00

Seal Head/Manifold Ratio Data		
Nominal Pressure (psia)	Initial (PI-2)	Expanded (PI-2)
5	5.05	1.85
7	7.06	2.57
10	10.05	3.67
Atmospheric	12.21	4.46
15	15.08	5.52
17	17.15	6.28
20	20.12	7.37
25	25.14	9.20
30	30.15	11.03
35	35.19	12.87
45	45.23	16.56

Seal Head .174
Rod Block (Saddle) .375

Pressure/Volume Determination

Appendix C
Page 1 of 1

S/A No.	CLWR-1	CE	Pete Webb	Sealing Head	174
Cap/EI No.	WL-01	Date of Puncture	2-5-97 1:40 PM	Rod Block	375
Pressure Detection System Parameters			Sample Parameters		
Initial Vacuum (milliTorr)	Puncture Pressure (psia)		Puncture Location: 2 1/2" from top		
Man PI-3	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V-4 Siml PI-2	Auxiliary Volumes and Locations
30m	A.9	19.22	8.54	6.74	#3 1/4
Backfill Volume Check: He Purge Gas					
Nominal Press (psia)	Initial Press (psia)	Expanded Press (psia)	Capsule/Element Rewelding		
Atmospheric	12.25	7.68	Watts/Scale	HV/Scale	Focus
15	15.08	9.45	.25	.8	370
17	17.08	10.70	NO WELD		
20	20.11	12.59			
22	22.14	13.86			
25	25.13	15.74			
27	27.13	16.99			
30	30.14	18.88			
32	32.16	20.14			
35	35.19	22.03			
45	45.23	28.34			
Weld Check by Backfill			Weld Check by Backfill		
Nominal Press (psi)	Cell Temp.	Time	pps	Time	Expanded PI-2
45	79°F	2sec	15	2sec	45
Cap/EI Temp (°F)	Time	pps/Scale	HV/Scale	Focus	Activity (mtr)
78°F	1/2 sec	20	1.4	410	<0.1
Cap/EI Temp (°F)	Time	pps/Scale	HV/Scale	Focus	No. of Samples
78°F	1/2 sec	20	1.4	410	2

①
Pressure/Volume Determination

S/A No.		CLWR-1		CE		P. Webb		Sealing Head		.174													
Cap/El No.		42-03		Date of Pinoture		2-5-97 08:40		Rod Block		.375													
Pressure Detection System Parameters								Puncturing Parameters				Sample Parameters											
Initial Vacuum (milliTorr)		Puncture Pressure (psia)				Auxiliary Volumes and Locations		Puncture Location: <u>2 1/2" From Top</u>															
Man PI-3	Smpl PI-4	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V-4 Smpl PI-2	SH	Man	Watts/Scale	HV/Scale	Focus/ap'rture	PPS/scale	Time	Cap/El Temp (°F)	Sample Cap/El Temp (°F)	Activity (mr)	No. of Samples							
30 ^{HT}	30 ^{HT}	19.1	18.45	8.17	6.43	#3 65922	N/A	.4	1.4	410	20	1/2 sec	79°F	22°C	<0.1	2							
Backfill Volume Check: He Purge Gas						Capsule/Element Rewelding						Weld Check by Backfill											
Nominal Press (psia)		Initial Press (psia)		Expanded Press (psia)		Watts/Scale		HV/Scale		Focus		PPS		Time		Cell Temp		Nominal Press (psi)		Initial PI-2		Expanded PI-2	
Atmospheric		17.27		7.65		.25		.8		370		15		2 sec		79°F		45		45.21		28.21	
15		15.07		9.40																			
17		17.08		10.65		NO WELD																	
20		20.09		12.53																			
22		22.12		13.79																			
25		25.13		15.67																			
27		27.13		16.92																			
30		30.14		18.80																			
32		32.17		20.07																			
35		35.17		21.94																			
45		45.20		28.22																			

Pressure/Volume Determination

S/A No.	CLWR-1	CE	P. Webb	Sealing Head	.174
Cap/EI No.	WL-09	Date of Puncture	2-9-97 12:38 PM	Rod Block	.375
Pressure Detection System Parameters			Puncture Parameters		
Initial Vacuum (milliTorr)		Puncture Pressure (psia)		Puncture Location: 2 1/2" from Top	
Man PI-3	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V4 Simul PI-2	Auxiliary Volumes and Locations
30MT	30.5	17.7	8.88	7.01	SH Man
Backfill Volume Check: He Purge Gas			Capsule/Filament Rewelding		
Nominal Press (psia)	Initial Press (psia)	Expanded Press (psia)	Watts/Scale	HV/Scale	Focus
Atmospheric	12.29	7.69	.25	.8	370
15	15.24	9.55			15
17	17.10	10.69			2 sec.
20	20.10	12.56			79°F
22	22.11	13.81			45
25	25.14	15.70			Initial PI-2
27	27.13	16.95			Nominal Press (psi)
30	30.15	18.83			45
32	32.15	20.08			Expanded PI-2
35	35.16	21.96			28.24
45	45.27	28.25			
NO WELD					

Pressure/Volume Determination

Appendix C
Page 1 of 1

S/A No.	CLWR-1		CE		P. Webb		Sealing Head		.174		
Cap/EI No.	WL-10		Date of Puncture		1-30-97		Rod Block		.375		
Pressure Detection System Parameters											
Initial Vacuum (milliTorr)		Puncture Pressure (psia)		Auxiliary Volumes and Locations		Puncture Location: 2 1/2" from Top					
Man Pl-3	Smpl Pl-4	SH Pl-1	Man Pl-2	V10 Press Pl-2	V5 & V-4 Smpl Pl-2	SH	Man	Watts/Scale	HV/Scale	Focus/aperture	
30mt	30mt	21.9	20.95	9.32	7.34	23	N/A	.4	1.4	410	
Backfill Volume Check: He Purge Gas		Expanded Press (psia)		Initial Press (psia)		Nominal Press (psia)		Cell Temp		Weld Check by Backfill	
Atmospheric		7.67		12.25		7.67		79°F		Nominal Press (psi)	
15		9.43		15.08		9.43		79°F		Expanded Pl-2	
17		10.69		17.11		10.69		79°F		Initial Pl-2	
20		12.57		20.11		12.57		79°F		Nominal Press (psi)	
22		13.91		22.25		13.91		79°F		Expanded Pl-2	
25		15.71		25.13		15.71		79°F		Initial Pl-2	
27		16.97		27.14		16.97		79°F		Nominal Press (psi)	
30		18.85		30.15		18.85		79°F		Expanded Pl-2	
32		20.20		32.30		20.20		79°F		Initial Pl-2	
35		22.00		35.17		22.00		79°F		Nominal Press (psi)	
45		28.30		45.21		28.30		79°F		Expanded Pl-2	
<p style="text-align: center;">No weld</p>											

Pressure/Volume Determination

S/A No.		CLWR-1		CE		P. Webb		Sealing Head		.174													
Cap/El No.		WL-18		Date of Puncture		1-21-97		Rod Block		.375													
Pressure Detection System Parameters								Puncturing Parameters				Sample Parameters											
Initial Vacuum (milliTorr)		Puncture Pressure (psia)				Auxiliary Volumes and Locations		Puncture Location: <u>2 1/2" From Top</u>															
Man PI-3	Smpl PI-4	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V-4 Smpl PI-2	SH	Man	Watts/Scale	HV/Scale	Focus/ap'rture	PPS/scale	Time	Cap/El Temp (°F)	Cap/El Temp (°F)	Activity (mr)	No. of Samples							
30 MT	30 MT	20.0	19.32	4.40	3.19	#3 65.922	N/A	.4	1.4	410	20	1/2 sec	79°F	79°F	<0.1	7							
Backfill Volume Check: He Purge Gas						Capsule/Element Rewelding						Weld Check by Backfill											
Nominal Press (psia)		Initial Press (psia)		Expanded Press (psia)		Watts/Scale		HV/Scale		Focus		PPS		Time		Cell Temp		Nominal Press (psi)		Initial PI-2		Expanded PI-2	
Atmospheric		12.07		7.52		.25		.8		370		15		2 sec.		82°F		45		45.22		15.84	
15		15.07		9.39		welded to pin hole																	
17		17.10		10.66																			
20		20.11		12.53																			
22		22.15		13.80																			
25		25.14		15.67																			
27		27.15		16.93																			
30		30.16		18.80																			
32		32.17		20.06																			
35		35.19		21.95																			
45		45.23		28.23																			

Pressure/Volume Determination

Appendix C
Page 1 of 1

S/A No.	CLWR-1	CE	P. Webb	Sealing Head	0.174
Cap/El No.	WL-22	Date of Puncture	2-4-97 08:50	Rod Block	0.375
Pressure Detection System Parameters			Puncturing Parameters		
Initial Vacuum (milliTorr)			Puncture Location: 2 1/2" from Top		
Man PI-3	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V14 Siml PI-2	Auxiliary Volumes and Locations
30.05	20.3	19.64	8.72	6.87	SH 63.572.3
Backfill Volume Check: He Purge Gas			Capsule/Element Rewelding		
Nominal Press (psia)	Initial Press (psia)	Expanded Press (psia)	Watts/Scale	HV/Scale	Watts/Scale
Atmospheric	11.78	7.37	.25	.8	.25
15	15.20	9.48			
17	17.09	10.66			
20	20.08	12.52			
22	22.13	13.80			
25	25.14	15.67			
27	27.15	16.93			
30	30.84	19.23			
32	32.18	20.07			
35	35.18	21.94			
45	45.22	28.23			
Weld Check by Backfill			Sample Parameters		
Nominal Press (psi)	Cell Temp	Initial PI-2	Expanded PI-2	Cap/El Temp (°F)	Time
45	79°F	95.29	28.26	80°F	1.55
* 12.16 → 11.78 (Valve V-8 did not seat properly)					
12.24 → 7.64					

Pressure/Volume Determination

S/A No.		CLWR-1		CE		P. Webb		Sealing Head		.174													
Cap/EI No.		WL-26		Date of Puncture		1-30-97		Rod Block		.375													
Pressure Detection System Parameters								Puncturing Parameters				Sample Parameters											
Initial Vacuum (milliTorr)		Puncture Pressure (psia)				Auxiliary Volumes and Locations		Puncture Location: <u>2 1/2" from Top</u>															
Man PI-3	Smpl PI-4	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V-4 Smpl PI-2	SH	Man	Watts/Scale	HV/Scale	Focus/ap'rture	PPS/scale	Time	Cap/EI Temp (°F)	Sample Cap/EI Temp (°F)	Activity (mr)	No. of Samples							
30 MT	30 MT	23.4	22.71	10.10	7.97	#3 65.922 in	N/A	.4	1.4	410	20	1/2 sec	78°F	22°C	<0.1	2							
Backfill Volume Check: He Purge Gas						Capsule/Element Rewelding						Weld Check by Backfill											
Nominal Press (psia)		Initial Press (psia)		Expanded Press (psia)		Watts/Scale		HV/Scale		Focus		PPS		Time		Cell Temp		Nominal Press (psi)		Initial PI-2		Expanded PI-2	
Atmospheric		12.31		7.71		.25		.8		370		15		2 sec		70°F		45		45.25		28.32	
15		15.08		9.44		<u>No WELD</u>																	
17		17.09		10.69																			
20		20.12		12.58																			
22		22.12		13.84																			
25		25.12		15.72																			
27		27.13		16.97																			
30		30.15		18.86																			
32		32.18		20.13																			
35		35.18		22.01																			
45		45.23		28.31																			

Pressure/Volume Determination

S/A No.		CLWR-1		CE		P. Webb		Sealing Head		.174						
Cap/El No.		WL-27		Date of Puncture				Rod Block		.375						
Pressure Detection System Parameters						Puncturing Parameters						Sample Parameters				
Initial Vacuum (milliTorr)		Puncture Pressure (psia)				Auxiliary Volumes and Locations		Puncture Location: <u>2 1/2" from top</u>								
Man PI-3	Smpl PI-4	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V-4 Smpl PI-2	SH	Man	Watts/Scale	HV/Scale	Focus/aperture	PPS/Scale	Time	Cap/El Temp (°F)	Sample Cap/El Temp (°F)	Activity (mr)	No. of Samples
30 mT	30 mT	23.1 20.2	22.2 12.60	5.59	4.40	#3 65.922 in	N/A	.04	1.4	410	20	1/2 sec	79°F	21°C	<0.1	2
Backfill Volume Check: He Purge Gas						Capsule/Element Rewelding						Weld Check by Backfill				
Nominal Press (psia)	Initial Press (psia)	Expanded Press (psia)		Watts/Scale	HV/Scale	Focus	PPS	Time	Cell Temp	Nominal Press (psi)	Initial PI-2	Expanded PI-2				
Atmospheric	12.26	7.66		.27	.8	370	15	2 sec	79°F	45	45.22	28.25				
15	15.08	9.41														
17	17.08	10.66														
20	20.09	12.55														
22	22.12	13.81														
25	25.11	15.68														
27	27.14	16.94														
30	30.16	18.82														
32	32.15	20.07														
35	35.19	21.97														
45	45.22	28.25		<p>* V-8 shut</p> <p>evacuated manifold & V-10 to 30 mT re-expanded</p> <p>Seal Head to extract sample:</p> <p>SH = 20.2</p> <p>man = 12.60</p>												

Pressure/Volume Determination

Appendix C
Page 1 of 1

S/A No.	CLWR		CE		P. Webb		Sealing Head		.174				
Cap/El No.	WT-11		Date of Puncture		2-3-97		Rod Block		.375				
Pressure Detection System Parameters										Sample Parameters			
Initial Vacuum (milliTorr)		Puncture Pressure (psia)		Auxiliary Volumes and Locations		Puncture Location: $2\frac{1}{2}$ " From Top							
Man PI-3	SH PI-1	Man PI-2	V10 Press PI-2	V5 & V-4 SmpI PI-2	SH	Watts/Scale	HV/Scale	Focus/aperture	PPS/Scale	Time	Cap/El Temp (°F)	Activity (mr)	No. of Samples
30 mT	13.6	13.15	5.63	4.42	N/A	.4	1.4	410	20	$\frac{1}{2}$ sec	81°F	22°C	2
Backfill Volume Check: He Purge Gas										Weld Check by Backfill			
Nominal Press (psia)	Initial Press (psia)	Expanded Press (psia)		Watts/Scale		HV/Scale	Focus	PPS	Time	Cell Temp	Nominal Press (psi)	Initial PI-2	Expanded PI-2
Atmospheric	12.29	7.37		.25		.8	370	15	2 sec.	80°F	45	45.23	27.13
15	15.07	9.04											
17	17.09	10.25											
20	20.10	12.05											
22	22.12	13.26											
25	25.14	15.67											
27	27.16	16.28											
30	30.16	18.08											
32	32.16	19.27											
35	35.17	21.09											
45	45.21	27.11											

NO WELD

Pressure/Volume Determination

Appendix C
Page 1 of 1

S/A No.	CLWR		CE	P. Webb		Sealing Head	.174	
Cap/EI No.	B-1(WT-12)		Date of Puncture	1-27-97		Rod Block	.375	
<div> <div>Pressure Detection System Parameters</div> <div> <div>Initial Vacuum (milliTorr)</div> <div>Man Pl-3</div> <div>30 mT</div> </div> <div> <div>Puncture Pressure (psia)</div> <div>SH Pl-1</div> <div>19.8</div> </div> <div> <div>V10 Press Pl-2</div> <div>5.13</div> </div> <div> <div>V5 & V-4 Smpl Pl-2</div> <div>4.01</div> </div> <div> <div>Auxiliary Volumes and Locations</div> <div>SH</div> <div>11.99</div> </div> <div> <div>Man</div> <div>16.922</div> </div> <div> <div>Watts/Scale</div> <div>.4</div> </div> <div> <div>HV/Scale</div> <div>1.4</div> </div> <div> <div>Focus/aperture</div> <div>410</div> </div> <div> <div>PPS/scale</div> <div>20</div> </div> <div> <div>Time</div> <div>1/2 sec</div> </div> <div> <div>Cap/EI Temp (°F)</div> <div>81°F</div> </div> <div> <div>Sample Temp (°F)</div> <div>21.5°C</div> </div> <div> <div>Activity (mr)</div> <div><0.1</div> </div> <div> <div>No. of Samples</div> <div>2</div> </div> </div>								

Sample Parameters

Watts/Scale

.8

HV/Scale

370

PPS

15

Time

2 sec.

Cell Temp

81°F

Nominal Press (psi)

45

Initial Pl-2

45.26

Expanded Pl-2

16.33

Pin hole weld

Sample Bottle ID			
Rod	Gas Composition Sample bottle ID	Tritium Analysis Sample bottle ID	Pressure (psia) at degree Celsius
WL-01	2	5	6.74@22
WL-03	1	4	6.43@22
WL-09	16	15	7.01@22
WL-10	8	7	7.34@23
WL-18	10	11	3.19@22
WL-22	10	11	6.87@22
WL-26	5	6	7.97@22
WL-27	12	13	4.4@21
WT--12	2	14	4.01@21.5
WT-11	15	3	4.42@22

Sample Bottles Used in WL-18 Backfill Analysis		
Backfill	Tritium Analysis	Pressure (psia)
Pressure	Sample Bottle ID	at degree Celsius
Atms.	16	2.93@22
15 psia	9	3.65@22
17 psia	13	4.15@22
35 psia	12	8.55@23
45 psia	15	10.99@23

Sample Bottle Volumes			
Sample Bottle #	Volume (cc)	Sample Bottle #	Volume (cc)
1	26.5	9	26.2
2	26.3	10	26.5
3	26.2	11	26.1
4	26.2	12	26.3
5	26.2	13	26.4
6	26.2	14	26.2
7	26.4	15	26.5
8	26.1	16	26.3

DRAFT

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-01					DATE: 2/5/97		1 OF 1	
3	SEALHEAD VOLU 1.3179 Cubic inches								
4	MANIFOLD VOLU 2.2311 Cubic inches								
5	AUXVOL: 65.922 Cubic inches								
6	CAP/CELL TEMP: 79 ° F 26.1 ° CENTIGRA 299.3 KELVIN								
7									
8									
9	SEAL HEAD PI-1 19.9 Psia		CALC. PMAN W/O AUX VOL						
10	MANIFLD PI-2 19.22 Psia		232.58						
11						SLOPE "B" = 0.626318184			
12						INTERCEPT ' 0.000340598			
13	NOMINAL	INITIAL	EXPANDED	ELEMENT VOL.	PRESSUR	Y hat	Yhat-Y	Square Yh-Y	Sq rtsm sqrs
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.				
15	Atmospheric	12.25	7.68	2.432	568	7.67273836	-0.00726164	5.2731E-05	0.02042258
16	15	15.08	9.45	2.427	569	9.44521882	-0.00478118	2.286E-05	Sum of sqrs
17	17	17.08	10.70	2.424	570	10.6978552	-0.00214481	4.6002E-06	0.00041708
18	20	20.11	12.59	2.417	572	12.5955993	0.005599284	3.1352E-05	Variance
19	22	22.14	13.86	2.417	572	13.8670252	0.007025198	4.9353E-05	4.6342E-05
20	25	25.13	15.74	2.422	571	15.7397166	-0.00028343	8.0333E-08	Stdev slope
21	27	27.13	16.99	2.420	571	16.9923529	0.002352938	5.5363E-06	0.0002212
22	30	30.14	18.88	2.423	570	18.8775707	-0.00242933	5.9016E-06	
23	32	32.16	20.14	2.420	571	20.1427334	0.002733405	7.4715E-06	
24	35	35.19	22.03	2.417	572	22.0404775	0.010477503	0.00010978	
25	45	45.23	28.34	2.426	570	28.3287121	-0.01128793	0.00012742	
26	Sum of sqrs	8158.115				P*V	Sum Yhat-Y	Avg of Yhat-Y	2Sigma N-1
27	Avg	25.6036364	AVERAGE	2.422	570	1381.8	-8.8818E-15	-8.0743E-16	0.01291638
28	Sum (P1 - Avg)^2	947.106855	2 SIGMA N-1	0.009	2				
29	Solution by simultaneous equations:					61.743	20	1254.9	
30									
31						"A" SLOPE 0.366156723			
32						"A" INT. -0.00583998			
33	Cal Data	P1	P2	Yhat	Yhat - Y			Square Yh-Y	Sq rtsm sqrs
34		5.05	1.85	1.843251466	-0.00674853			4.5543E-05	0.02062592
35		7.06	2.57	2.579226479	0.00922648			8.5128E-05	Sum of sqrs
36		10.05	3.67	3.674035079	0.00403508			1.6282E-05	0.00042543
37		12.21	4.46	4.4649336	0.0049336			2.434E-05	Variance
38		15.08	5.52	5.515803394	-0.00419661			1.7612E-05	0.00005
39		17.15	6.28	6.27374781	-0.00625219			3.909E-05	Stdev slope
40		20.12	7.37	7.361233276	-0.00876672			7.6855E-05	0.00018074
41		25.14	9.20	9.199340024	-0.00065998			4.3557E-07	
42		30.15	11.03	11.0337852	0.0037852			1.4328E-05	
43		35.19	12.87	12.87921509	0.00921509			8.4918E-05	Sig
44		45.23	16.56	16.55542858	-0.00457142			2.0898E-05	
45	Average	20.2209091	7.398182	7.398181818	2.1397E-15	2.1397E-15	0.01304498		
46		Sum of "x^2"	Sum of "Y^2"	Sum of "Yhat^2"					
47		3836.92810	513.72880	513.86463					
48	Vcap =	2.4506	*Pcap=	566.6	P*V=	1388.6			
49	Sum of (P1-Avg)^2	1446.94532							
50	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
51	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
52	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
53	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
54	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
55	232.5840723					232.58 PSIA			
56									
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-03					DATE: 2/5/97 1 OF 1			
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		19.1 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		18.45 Psia		232.58				
11						SLOPE "B" = 0.624467367			
12						INTERCEPT ' -0.01738878			
13	NOMINAL	INITIAL	EXPANDED	ELEMENT VOL.	PRESSUR	INTERCEPT			
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.	Y hat	Yhat-Y	Square Yh-Y	Sq rtsm sqrs
15	Atmospheric	12.27	7.65	2.376	558	7.64482582	-0.00517418	2.6772E-05	0.01836804
16	15	15.07	9.40	2.381	557	9.39333444	-0.00666556	4.443E-05	Sum of sqrs
17	17	17.08	10.65	2.377	558	10.6485139	-0.00148615	2.2086E-06	0.00033739
18	20	20.09	12.53	2.380	557	12.5281606	-0.00183937	3.3833E-06	Variance
19	22	22.12	13.79	2.376	558	13.7958294	0.005829382	3.3982E-05	3.7487E-05
20	25	25.13	15.67	2.378	557	15.6754762	0.005476157	2.9988E-05	Stdev slope
21	27	27.13	16.92	2.379	557	16.9244109	0.004410892	1.9456E-05	0.0001991
22	30	30.14	18.80	2.381	557	18.8040577	0.004057667	1.6465E-05	
23	32	32.17	20.07	2.383	556	20.0717264	0.001726423	2.9805E-06	
24	35	35.17	21.94	2.382	557	21.9451285	0.005128524	2.6302E-05	
25	45	45.20	28.22	2.390	555	28.2085362	-0.01146378	0.00013142	
26	Sum of sqrs	8153.1379				P*V	Sum Yhat-Y	Avg of Yhat-Y 2Sigma N-1	
27	Avg	25.5972727	AVERAGE	2.380	557	1325.7	-2.6645E-14	-2.4223E-15	0.01161697
28	Sum (P1 - Avg)^2	945.713818	2 SIGMA N-1	0.008	2				
29	Solution by simultaneous equations:				62.011	20	1209.6		
30									
31						"A" SLOPE 0.366156723			
32						"A" INT. -0.00583998			
33	Cal Data	P1	P2	Yhat	Yhat - Y	Square Yh-Y			
34		5.05	1.85	1.843251466	-0.00674853	4.5543E-05			
35		7.06	2.57	2.579226479	0.00922648	8.5128E-05			
36		10.05	3.67	3.674035079	0.00403508	1.6282E-05			
37		12.21	4.46	4.4649336	0.0049336	2.434E-05			
38		15.08	5.52	5.515803394	-0.00419661	1.7612E-05			
39		17.15	6.28	6.27374781	-0.00625219	3.909E-05			
40		20.12	7.37	7.361233276	-0.00876672	7.6855E-05			
41		25.14	9.20	9.199340024	-0.00065998	4.3557E-07			
42		30.15	11.03	11.0337852	0.0037852	1.4328E-05			
43		35.19	12.87	12.87921509	0.00921509	8.4918E-05			
44		45.23	16.56	16.55542858	-0.00457142	2.0898E-05			
45	Average	20.2209091	7.398182	7.398181818	2.1397E-15	2.1397E-15	0.01304498	Sig	
46		Sum of "x^2"	Sum of "Y^2"	Sum of "Yhat^2"					
47		3836.92810	513.72880	513.86463					
48	Vcap =	2.4212	*Pcap=	570.7	P*V=	1381.8			
49	Sum of (P1-Avg)^2	1446.94532							
50	"WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?"								
51	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
52	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
53	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
54	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
55	232.58 PSIA								
56	232.5840723								
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-09					DATE: 2/4/97 1 OF 1			
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		20.5 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		19.89 Psia		232.58				
11						SLOPE "B" = 0.624185553			
12						INTERCEPT ' 0.015297221			
13	NOMINAL	INITIAL	EXPANDED ELEMENT VOL/L PRESSUR		Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs	
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.				
15	Atmospheric	12.29	7.69	2.412	593	7.68653766	-0.00346234	1.1988E-05	
16	15	15.26	9.55	2.414	592	9.54036875	-0.00963125	9.2761E-05	
17	17	17.10	10.69	2.403	595	10.6888702	-0.00112983	1.2765E-06	
18	20	20.10	12.56	2.399	596	12.5614268	0.001426828	2.0358E-06	
19	22	22.11	13.81	2.394	597	13.8160398	0.006039788	3.6479E-05	
20	25	25.14	15.70	2.393	597	15.707322	0.007322013	5.3612E-05	
21	27	27.13	16.95	2.397	596	16.9494513	-0.00054874	3.0111E-07	
22	30	30.15	18.83	2.393	597	18.8344916	0.004491631	2.0175E-05	
23	32	32.15	20.08	2.394	597	20.0828627	0.002862736	8.1953E-06	
24	35	35.16	21.96	2.394	597	21.9616612	0.001661249	2.7597E-06	
25	45	45.22	28.25	2.396	597	28.2409679	-0.00903209	8.1579E-05	
26	Sum of sqrs	8160.9593			P*V	Sum Yhat-Y	Avg of Yhat-Y 2Sigma N-1		
27	Avg	25.6190909	AVERAGE	2.399	596	1429.5	-3.6415E-14	-3.3105E-15 0.01115637	
28	Sum (P1 - Avg)^2	941.243291	2 SIGMA N-1	0.015	4				
29	Solution by simultaneous equations:		71.431	21	1491.3				
30									
31						"A" SLOPE 0.366698626			
32						"A" INT. 0.003989716			
33	Cal Data	P1	P2	Yhat	Yhat - Y		Square Yh-Y	Sq rt sm sqrs	
34		5.06	1.86	1.859484762	-0.00051524		2.6547E-07	0.01247393	
35		7.10	2.61	2.607549959	-0.00245004		6.0027E-06	Sum of sqrs	
36		10.06	3.69	3.692977891	0.00297789		8.8678E-06	0.0001556	
37		12.24	4.49	4.492380895	0.00238089		5.6687E-06	Variance	
38		15.09	5.54	5.537471978	-0.00252802		6.3909E-06	0.00002	
39		17.13	6.29	6.285537174	-0.00446283		1.9917E-05	Stdev slope	
40		20.11	7.38	7.378299079	-0.00170092		2.8931E-06	0.0001093	
41		25.14	9.22	9.222793166	0.00279317		7.8018E-06		
42		30.16	11.06	11.06362027	0.00362027		1.3106E-05		
43		35.24	12.92	12.92644929	0.00644929		4.1593E-05	Sig	
44		45.24	16.60	16.59343554	-0.00656446	Avg of Yhat-Y 2Sigma N-1	4.3092E-05		
45	Average	20.2336364	7.423636	7.423636364	-1.6149E-15	-1.6149E-15	0.007889208		
46		Sum of "x^2"	Sum of "Y^2"	Sum of "Yhat^2"					
47		3843.25810	517.22590	517.17536					
48	Vcap =	2.4137	*Pcap=	572.0	P*V=	1380.8			
49	Sum of (P1-Avg)^2	1447.09891							
50	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
51	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
52	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
53	P1 V1 = P2 V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
54	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
55	232.5840723								
56	232.58 PSIA								
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H
1								
2	GASR WORKSHEET FOR : CLWR-1 WL-10					DATE: 1/21/9 1 OF 1		
4	SEALHEAD VOLL		1.3179 Cubic inches					
5	MANIFOLD VOLU		2.2311 Cubic inches					
6	AUXVOL:		65.922 Cubic inches					
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN	
8								
9	SEAL HEAD PI-1		21.9 Psia		CALC. PMAN W/O AUX VOL			
10	MANIFLD PI-2		20.95 Psia		232.58			
11						SLOPE "B" = 0.625985087		
12						INTERCEPT = -0.01501781		
13	NOMINAL	INITIAL	EXPANDED ELEMENT VOL.		PRESSUR			
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.	Y hat	Yhat-Y	Square Yh-Y
15	Atmospheric	12.25	7.67	2.418	623	7.6532995	-0.0167005	0.00027891
16	15	15.08	9.43	2.406	626	9.42483729	-0.00516271	2.6654E-05
17	17	17.11	10.69	2.397	628	10.695587	0.00558702	3.1215E-05
18	20	20.11	12.57	2.402	627	12.5735423	0.00354228	1.2548E-05
19	22	22.25	13.91	2.403	627	13.9131504	0.003150366	9.9248E-06
20	25	25.13	15.71	2.403	627	15.7159874	0.005987416	3.5849E-05
21	27	27.14	16.97	2.405	626	16.9742174	0.00421744	1.7787E-05
22	30	30.15	18.85	2.404	626	18.8584326	0.008432552	7.1108E-05
23	32	32.30	20.20	2.407	626	20.2043005	0.004300488	1.8494E-05
24	35	35.17	22.00	2.409	625	22.0008777	0.000877687	7.7033E-07
25	45	45.21	28.30	2.416	623	28.285768	-0.01423204	0.00020255
26	Sum of sqrs	8170.9776		P*V		Sum Yhat-Y		Avg of Yhat-Y
27	Avg	25.6272727	AVERAGE	2.406	626	1505.8	-3.5527E-15	-3.2297E-16
28	Sum (P1 - Avg)^2	946.649418	2 SIGMA N-1	0.012	3			
29	Solution by simultaneous equations:				47.884	23	1077.5	
30								
31			P1	P2	Yhat	Yhat - Y		
32	Cal Data	5.03	1.86	1.849451863	-0.01054814	0.00011126		
33		7.03	2.59	2.582546429	-0.00745357	5.5556E-05		
34		10.06	3.69	3.693184697	0.0031847	1.0142E-05		
35		12.34	4.53	4.528912502	-0.0010875	1.1827E-06		
36		15.10	5.54	5.540583003	0.000583	3.3989E-07		
37		17.13	6.28	6.284673988	0.00467399	2.1846E-05		
38		20.13	7.38	7.384315837	0.00431584	1.8626E-05		
39		25.16	9.22	9.228048671	0.00804867	6.4781E-05		
40		30.18	11.06	11.06811603	0.00811603	6.587E-05		
41		35.23	12.91	12.91917981	0.00917981	8.4269E-05		
42		45.22	16.60	16.58098717	-0.01901283	0.00036149		
43	Average	20.2372727	7.42363636	7.423636364	-5.4502E-16	-5.4502E-16	0.017836638	
44		Sum of "x^2"	Sum of "Y^2"	Sum of "Yhat^2"				
45		3842.21230	517.22440	516.77308				
46	Vcap =	2.4431	*Pcap=	567.9	P*V=	1387.4		
47	Sum of (P1-Avg)^2	1446.9471						
48								
49								
50	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE							
51	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.							
52	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:							
53	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...							
54	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) = 232.58 PSIA							
55								

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-18					DATE: 1/21/97 1 OF 1			
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		20.0 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		19.32 Psia		232.58				
11						SLOPE "B" = 0.624439767			
12						INTERCEPT ' -0.02407018			
13	NOMINAL	INITIAL	EXPANDED	ELEMENT VOL.	PRESSUR	Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.				
15	Atmospheric	12.07	7.52	2.370	586	7.51291781	-0.00708219	5.0157E-05	0.01995816
16	15	15.07	9.39	2.370	586	9.38623711	-0.00376289	1.4159E-05	Sum of sqrs
17	17	17.10	10.66	2.375	584	10.6538498	-0.00615016	3.7825E-05	0.00039833
18	20	20.11	12.53	2.370	586	12.5334135	0.003413533	1.1652E-05	Variance
19	22	22.15	13.80	2.369	586	13.8072707	0.007270658	5.2862E-05	4.4259E-05
20	25	25.14	15.67	2.374	585	15.6743456	0.004345561	1.8884E-05	Stdev slope
21	27	27.15	16.93	2.378	584	16.9294695	-0.00053051	2.8144E-07	0.0002156
22	30	30.16	18.80	2.374	585	18.8090332	0.00903319	8.1599E-05	
23	32	32.17	20.06	2.378	584	20.0641571	0.004157121	1.7282E-05	
24	35	35.19	21.95	2.381	583	21.9499652	-3.4783E-05	1.2098E-09	
25	45	45.23	28.23	2.387	582	28.2193405	-0.01065952	0.00011363	
26	Sum of sqrs		8158		P*V	Sum Yhat-Y		Avg of Yhat-Y2Sigma N-1	
27	Avg	25.5945455	AVERAGE	2.375	584	1388.1	-3.2863E-14	-2.9875E-15	0.01262265
28	Sum (P1 - Avg)^2		952.111673		2 SIGMA N-1	0.011	3		
29	Solution by simultaneous equations:				62.072	20	1267.8		
30									
31						"A" SLOPE 0.365523658			
32						"A" INT. -0.01667521			
33	Cal Data	P1	P2	Yhat	Yhat - Y	Square Yh-Y		Sq rt sm sqrs	
34		5.04	1.84	1.825564029	-0.01443597	0.0002084		0.03030775	
35		7.04	2.56	2.556611345	-0.00338865	1.1483E-05		Sum of sqrs	
36		10.05	3.65	3.656837557	0.00683756	4.6752E-05		0.00091856	
37		12.03	4.39	4.3805744	-0.0094256	8.8842E-05		Variance	
38		15.13	5.51	5.51369774	0.00369774	1.3673E-05		0.00010	
39		17.13	6.24	6.244745057	0.00474506	2.2516E-05		Stdev slope	
40		20.15	7.34	7.348626504	0.0086265	7.4417E-05		0.00026512	
41		25.19	9.18	9.190865741	0.01086574	0.00011806			
42		30.20	11.02	11.02213927	0.00213927	4.5765E-06			
43		35.22	12.85	12.85706803	0.00706803	4.9957E-05		Sig	
44		45.25	16.54	16.52327032	-0.01672968	0.00027988			
45	Average	20.2209091	7.37454545	7.374545455	1.2717E-15	1.2717E-15	0.019168304		
46		Sum of "x^2"		Sum of "Y^2"	Sum of "Yhat^2"				
47		3837.61440	511.58800	511.15436					
48	Vcap =	2.4243	*Pcap=	569.9	P*V=	1381.7			
49	Sum of (P1-Avg)^2		1452.08022						
50	"WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?"								
51	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
52	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
53	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
54	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
55	232.58 PSIA								
56	232.5840723								
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-22					DATE: 2/4/97		1 OF 1	
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		20.3 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		19.64 Psia		232.58				
11						SLOPE "B" = 0.623768065			
12	NOMINAL		INITIAL		EXPANDED ELEMENT VOL: L. PRESSUR		INTERCEPT ' 0.003166528		
13	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.	Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs
14	Atmospheric	11.78	7.37	2.411	586	7.35115433	-0.01884567	0.00035516	0.04379188
15	15	15.20	9.48	2.380	593	9.48444111	0.004441113	1.9723E-05	Sum of sqrs
16	17	17.09	10.66	2.381	593	10.6633628	0.003362756	1.1308E-05	0.00191773
17	20	20.08	12.52	2.377	594	12.5284293	0.008429269	7.1053E-05	Variance
18	22	22.08	13.80	2.401	588	13.7759654	-0.0240346	0.00057766	0.00021308
19	25	25.14	15.67	2.374	594	15.6846957	0.014695677	0.00021596	Stdev slope
20	27	27.15	16.93	2.378	593	16.9384695	0.008469488	7.1732E-05	0.00047002
21	30	30.84	19.23	2.378	594	19.2401736	0.010173647	0.0001035	
22	32	32.18	20.07	2.380	593	20.0760229	0.006022853	3.6275E-05	
23	35	35.18	21.94	2.379	593	21.947327	0.007327048	5.3686E-05	
24	45	45.22	28.23	2.389	591	28.2099584	-0.02004158	0.00040166	
25	Sum of sqrs		8190.8902		P*V		Sum Yhat-Y		Avg of Yhat-Y 2Sigma N-1
26	Avg	25.6309091	AVERAGE		2.384	592	1411.3	1.06581E-14	9.6892E-16 0.02769642
27	Sum (P1 - Avg)^2		964.511691		2 SIGMA N-1		0.023		5
28	Solution by simultaneous equations:				65.074		21		1347.8
29									
30									
31		P1	P2	Yhat	Yhat - Y	"A" SLOPE 0.366698626			
32	Cal Data	5.06	1.86	1.859484762	-0.00051524	"A" INT. 0.003989716		Square Yh-Y	Sq rt sm sqrs
33		7.10	2.61	2.607549959	-0.00245004			2.6547E-07	0.01247393
34		10.06	3.69	3.692977891	0.00297789			6.0027E-06	Sum of sqrs
35		12.24	4.49	4.492380895	0.00238089			8.8678E-06	0.0001556
36		15.09	5.54	5.537471978	-0.00252802			5.6687E-06	Variance
37		17.13	6.29	6.285537174	-0.00446283			6.3909E-06	0.00002
38		20.11	7.38	7.378299079	-0.00170092			1.9917E-05	Stdev slope
39		25.14	9.22	9.222793166	0.00279317			2.8931E-06	0.0001093
40		30.16	11.06	11.06362027	0.00362027			7.8018E-06	
41		35.24	12.92	12.92644929	0.00644929			1.3106E-05	
42		45.24	16.60	16.59343554	-0.00656446	Avg of Yhat-Y 2Sigma N-1		4.1593E-05	Sig
43	Average	20.2336364	7.423636	7.423636364	-1.6149E-15	-1.6149E-15 0.007889208		4.3092E-05	
44		Sum of "x^2"		Sum of "Y^2"	Sum of "Yhat^2"				
45		3843.25810		517.22590	517.17536				
46	Vcap =	2.4072	*Pcap=	573.0	P*V=	1379.2			
47	Sum of (P1-Avg)^2		1447.09891						
48									
49	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
50	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
51	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
52	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
53	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
54	232.58 PSIA								
55	232.5840723								
56									
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-26					DATE: 1/30/97 1 OF 1			
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		23.4 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		22.71 Psia		232.58				
11						SLOPE "B" = 0.625736168			
12						INTERCEPT ' -0.00146691			
13	NOMINAL	INITIAL	EXPANDED ELEMENT VOL.	PRESSUR		Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs
14	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.				
15	Atmospheric	12.31	7.71	2.422	674	7.70134532	-0.00865468	7.4903E-05	0.01858069
16	15	15.08	9.44	2.416	676	9.43463451	-0.00536549	2.8788E-05	Sum of sqrs
17	17	17.09	10.69	2.409	678	10.6923642	0.002364209	5.5895E-06	0.00034524
18	20	20.12	12.58	2.405	679	12.5883448	0.008344799	6.9636E-05	Variance
19	22	22.12	13.84	2.411	677	13.8398171	-0.00018286	3.3439E-08	3.836E-05
20	25	25.12	15.72	2.413	676	15.7170256	-0.00297436	8.8468E-06	Stdev slope
21	27	27.13	16.97	2.409	678	16.9747553	0.00475534	2.2613E-05	0.00020142
22	30	30.15	18.86	2.409	678	18.8644786	0.004478568	2.0058E-05	
23	32	32.18	20.13	2.409	678	20.134723	0.00472299	2.2307E-05	
24	35	35.18	22.01	2.411	677	22.0119315	0.001931495	3.7307E-06	
25	45	45.23	28.31	2.415	676	28.30058	-0.00942001	8.8737E-05	
26	Sum of sqrs	8160.1309				P*V	Sum Yhat-Y	Avg of Yhat-Y2Sigma N-1	
27	Avg	25.61	AVERAGE	2.412	677	1632.5	-3.6415E-14	-3.3105E-15	0.01175146
28	Sum (P1 - Avg)^2	945.5378	2 SIGMA N-1	0.009	3				
29	Solution by simultaneous equations: 72.114 24 1718.3								
30									
31						"A" SLOPE 0.366373713			
32						"A" INT. 0.008232417			
33	Cal Data	P1	P2	Yhat	Yhat - Y			Square Yh-Y	Sq rt sm sqrs
34		5.03	1.86	1.851092192	-0.00890781			7.9349E-05	0.02096449
35		7.03	2.59	2.583839618	-0.00616038			3.795E-05	Sum of sqrs
36		10.06	3.69	3.693951967	0.00395197			1.5618E-05	0.00043951
37		12.34	4.53	4.529284033	-0.00071597			5.1261E-07	Variance
38		15.10	5.54	5.54047548	0.00047548			2.2608E-07	0.00005
39		17.13	6.28	6.284214117	0.00421412			1.7759E-05	Stdev slope
40		20.13	7.38	7.383335255	0.00333526			1.1124E-05	0.00018361
41		25.16	9.22	9.226195031	0.00619503			3.8378E-05	
42		30.18	11.06	11.06539107	0.00539107			2.9064E-05	
43		35.23	12.91	12.91557832	0.00557832			3.1118E-05	Sig
44		45.25	16.60	16.58664292	-0.01335708	Avg of Yhat-Y2Sigma N-1		0.00017841	
45	Average	20.24	7.423636	7.423636364	-4.239E-16	-4.239E-16	0.013259111		
46		Sum of "x^2"		Sum of "Y^2"	Sum of "Yhat^2"				
47		3844.92640		517.22440	516.88822				
48	Vcap =	2.4401	*Pcap=	568.2	P*V=	1386.5			
49	Sum of (P1-Avg)^2	1448.5104							
50	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
51	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
52	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
53	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
54	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
55	232.58 PSIA								
56	232.5840723								
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WL-27					DATE: 2/3/97 1 OF 1			
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		23.1 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		22.22 Psia		232.58				
11						SLOPE "B" = 0.624590562			
12	NOMINAL		INITIAL		EXPANDED ELEMENT VOL.		INTERCEPT ' -0.00588202		
13	BACKFILL PSI	PI-2	PI-2	Cu. in.	Psia.	Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs
14	Atmospheric	12.26	7.66	2.397	666	7.65159827	-0.00840173	7.0589E-05	0.02226671
15	15	15.08	9.41	2.385	669	9.41294365	0.002943654	8.6651E-06	Sum of sqrs
16	17	17.08	10.66	2.387	669	10.6621248	0.002124777	4.5147E-06	0.00049581
17	20	20.09	12.55	2.396	667	12.5421424	-0.00785763	6.1742E-05	Variance
18	22	22.12	13.81	2.390	668	13.8100612	6.12086E-05	3.7465E-09	5.509E-05
19	25	25.11	15.68	2.392	668	15.677587	-0.00241301	5.8226E-06	Stdev slope
20	27	27.14	16.94	2.387	669	16.9455058	0.005505829	3.0314E-05	0.0002412
21	30	30.16	18.82	2.385	669	18.8317693	0.011769325	0.00013852	
22	32	32.15	20.07	2.389	668	20.0747045	0.004704543	2.2133E-05	
23	35	35.19	21.97	2.390	668	21.9734599	0.003459851	1.1971E-05	
24	45	45.22	28.25	2.396	666	28.2381032	-0.01189681	0.00014153	
25	Sum of sqrs	8155.8672			P*V	Sum Yhat-Y	Avg of Yhat-Y 2Sigma N-1		
26	Avg	25.6	AVERAGE	2.390	668	1596.8	-3.0198E-14	-2.7453E-15	0.0140827
27	Sum (P1 - Avg)^2	946.9072	2 SIGMA N-1	0.009	2				
28	Solution by simultaneous equations:				55.017	24	1301.3		
29									
30									
31		P1	P2	Yhat	Yhat - Y	"A" SLOPE 0.366744969			
32	Cal Data	5.11	1.90	1.897874605	-0.0021254	"A" INT. 0.023807811		Square Yh-Y	Sq rt sm sqrs
33		7.06	2.61	2.613027295	0.0030273			4.5173E-06	0.02689991
34		10.13	3.73	3.738934351	0.00893435			9.1645E-06	Sum of sqrs
35		12.26	4.51	4.520101136	0.01010114			7.9823E-05	0.00072361
36		15.12	5.58	5.568991748	-0.01100825			0.00010203	Variance
37		17.11	6.31	6.298814237	-0.01118576			0.00012118	0.00008
38		20.18	7.43	7.424721293	-0.00527871			0.00012512	Stdev slope
39		25.17	9.26	9.25477869	-0.00522131			2.7865E-05	0.00023564
40		30.16	11.08	11.08483609	0.00483609			2.7262E-05	
41		35.20	12.92	12.93323073	0.01323073			2.3388E-05	
42		45.32	16.65	16.64468982	-0.00531018	Avg of Yhat-Y 2Sigma N-1		0.00017505	Sig
43	Average	20.2563636	7.452727	7.452727273	2.4223E-16	2.4223E-16	0.017012997	2.8198E-05	
44		Sum of "x^2"	Sum of "Y^2"	Sum of "Yhat^2"					
45		3850.43700	519.96040	520.16861					
46	Vcap =	2.4199	*Pcap=	571.2	P*V=	1382.2			
47	Sum of (P1-Avg)^2	1447.92178							
48									
49	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
50	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
51	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
52	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
53	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
54	232.5840723								
55	232.58 PSIA								
56									
57									
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 WT-11					DATE: 2/3/97		1 OF 1	
3									
4	SEALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRA		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		13.6 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		13.15 Psia		232.58				
11									
12	NOMINAL				EXPANDED ELEMENT VOL. PRESSUR		SLOPE "B" = 0.599487321		
13	BACKFILL PSI				PI-2 Cu. in. Psia.		INTERCEPT = 0.001127837		
14	Atmospheric				12.29 7.37 2.024 464		Y hat Yhat-Y Square Yh-Y Sq rt sm sqrs		
15	15				15.07 9.04 2.027 464		7.36882702 -0.00117298 1.3759E-06 0.01521528		
16	17				17.09 10.25 2.025 464		9.03540177 -0.00459823 2.1144E-05 Sum of sqrs		
17	20				20.10 12.05 2.022 465		10.2463662 -0.00363384 1.3205E-05 0.0002315		
18	22				22.12 13.26 2.021 465		12.050823 0.000822995 6.7732E-07 Variance		
19	25				25.14 15.07 2.021 465		13.2617874 0.001787384 3.1947E-06 2.5723E-05		
20	27				27.16 16.28 2.021 465		15.0722391 0.002239095 5.0135E-06 Stdev slope		
21	30				30.16 18.08 2.021 465		16.2832035 0.003203484 1.0262E-05 0.00016495		
22	32				32.16 19.27 2.017 466		18.0816654 0.001665448 2.7737E-06		
23	35				35.17 21.09 2.024 465		19.2806401 0.01064009 0.00011321		
24	45				45.21 27.11 2.024 465		21.0850969 -0.00490307 2.404E-05		
25	Sum of sqrs				8157.9709		P*V Sum Yhat-Y Avg of Yhat-Y 2Sigma N-1		
26	Avg				25.6063636		AVERAGE 2.023 465 940.1 -2.1316E-14 -1.9378E-15 0.00962299		
27	Sum (P1 - Avg)^2				945.426455		2 SIGMA N-1 0.005 1		
28	Solution by simultaneous equations:				63.880 14		886.7		
29									
30									
31							"A" SLOPE 0.366744969		
32	Cal Data						"A" INT. 0.023807811		
33							Square Yh-Y Sq rt sm sqrs		
34							4.5173E-06 0.02689991		
35							9.1645E-06 Sum of sqrs		
36							7.9823E-05 0.00072361		
37							0.00010203 Variance		
38							0.00012118 0.00008		
39							0.00012512 Stdev slope		
40							2.7865E-05 0.00023564		
41							2.7262E-05		
42							2.3388E-05		
43							0.00017505 Sig		
44							2.8198E-05		
45	Average				20.2563636 7.452727 7.452727273		2.4223E-16 2.4223E-16 0.017012997		
46							Sum of "x^2" Sum of "Y^2" Sum of "Yhat^2"		
47							3850.43700 519.96040 520.16861		
48							Vcap = 2.0474 *Pcap= 632.8 P*V= 1295.6		
49							Sum of (P1-Avg)^2 1447.92178		
50									
51	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
52	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
53	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
54	P1 V1 = P2 V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
55	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) =								
56	232.5840723								
57	232.58 PSIA								
58									
59									
60									
61									

	A	B	C	D	E	F	G	H	I
1									
2	GASR WORKSHEET FOR : CLWR-1 B1(WT-12)					DATE: 1/27/97 1 OF 1			
3									
4	EALHEAD VOLU		1.3179 Cubic inches						
5	MANIFOLD VOLU		2.2311 Cubic inches						
6	AUXVOL:		65.922 Cubic inches						
7	CAP/CELL TEMP:		79 ° F		26.1 ° CENTIGRADE		299.3 KELVIN		
8									
9	SEAL HEAD PI-1		19.8 Psia		CALC. PMAN W/O AUX VOL				
10	MANIFLD PI-2		19.39 Psia		232.58				
11						SLOPE "B" = 0.599365005			
12	NOMINAL					INTERCEPT ' -0.01100819			
13	BACKFILL PSI	INITIAL PI-2	EXPANDED PI-2	ELEMENT Cu. in.	VOLL. PRESSUR Psia.	Y hat	Yhat-Y	Square Yh-Y	Sq rt sm sqrs
14	Atmospheric	12.35	7.40	2.017	687	7.39114962	-0.00885038	7.8329E-05	0.01932671
15	15	15.08	9.03	2.012	689	9.02741608	-0.00258392	6.6766E-06	Sum of sqrs
16	17	17.10	10.24	2.012	689	10.2381334	-0.00186661	3.4842E-06	0.00037352
17	20	20.11	12.04	2.011	689	12.0422221	0.002222055	4.9375E-06	Variance
18	22	22.13	13.25	2.011	689	13.2529394	0.002939365	8.6399E-06	4.1502E-05
19	25	25.12	15.04	2.011	689	15.0450407	0.005040729	2.5409E-05	Stdev slope
20	27	27.14	16.25	2.011	689	16.255758	0.005758039	3.3155E-05	0.00020967
21	30	30.15	18.06	2.015	688	18.0598467	-0.0001533	2.35E-08	
22	32	32.17	19.27	2.015	688	19.270564	0.000564014	3.1811E-07	
23	35	35.17	21.06	2.012	689	21.068659	0.008659028	7.4979E-05	
24	45	45.23	27.11	2.020	686	27.098271	-0.01172902	0.00013757	
25	Sum of sqrs		8160.6951		P*V		Sum Yhat-Y		Avg of Yhat-Y 2Sigma N-1
26	Avg	25.6136364	AVERAGE		2.014	688	1386.1	-2.4869E-14	-2.2608E-15 0.01222329
27	Sum (P1 - Avg)^2		944.053055		2 SIGMA N-1		0.006 2		
28	Solution by simultaneous equations:				104.197		20		2089.2
29									
30									
31						"A" SLOPE 0.367197682			
32						"A" INT. 0.017286898			
33	Cal Data	P1	P2	Yhat	Yhat - Y			Square Yh-Y	Sq rt sm sqrs
34		5.03	1.87	1.864291239	-0.00570876			3.259E-05	0.02305946
35		7.05	2.60	2.606030556	0.00603056			3.6368E-05	Sum of sqrs
36		10.05	3.70	3.707623602	0.0076236			5.8119E-05	0.00053174
37		12.28	4.52	4.526474433	0.00647443			4.1918E-05	Variance
38		15.11	5.57	5.565643873	-0.00435613			1.8976E-05	0.00006
39		17.12	6.31	6.303711213	-0.00628879			3.9549E-05	Stdev slope
40		20.12	7.42	7.405304259	-0.01469574			0.00021596	0.00020194
41		25.15	9.25	9.252308599	0.0023086			5.3296E-06	
42		30.17	11.09	11.09564096	0.00564096			3.182E-05	
43		35.21	12.94	12.94631728	0.00631728			3.9908E-05	Sig
44		45.26	16.64	16.63665398	-0.00334602	Avg of Yhat-Y 2Sigma N-1		1.1196E-05	
45	Average	20.2318182	7.446364	7.446363636	0	0 0.014584081			
46	Sum of "x^2"		Sum of "Y^2"		Sum of "Yhat^2"				
47	3843.32810		519.73540		519.86420				
48	Vcap =	2.0432	*Pcap=	633.9	P*V=		1295.2		
49	Sum of (P1-Avg)^2		1448.74528						
50									
51	*WHAT WOULD THE PRESSURE BE IN THE MANIFOLD IF THE AUXILIARY VOLUME HAD NOT BEEN IN PLACE AND OPEN?								
52	THIS VALUE IS NEEDED IN ORDER TO CALCULATE PCAP USING THE SLOPE METHOD.								
53	CALCULATIONALLY "FORCING" THE GAS BACK INTO THE SH, MAN, AND CAPSULE WE HAVE:								
54	P1V1 = P2V2 AND P1 = 19.32 AND V1 = (VSH + VAUX + VMAN + VCAP) AND V2 = (VSH + VMAN + VCAP) SO...								
55	P2 = 19.32*(1.3179 + 65.922 + 2.2311 + 2.423)/(1.3179 + 2.2311 + 2.423) = 232.58 PSIA								
56	232.5840723								

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies, Co.
EROB MS-3760
Idaho Falls, ID 834

DATE:

March 11, 1997

MATERIAL EXAMINED:

Eight Target Rods from CLWR Loop-1 Bundle

TYPE OF EXAMINATION:

Gas Analysis, Sample, and Recharge (GASR)

FORM OF DATA:

Summary Report and User Notes

NOTES:

CC: w/Attachments

Loop-1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data
transmittal should be directed to
the Cognizant Engineer at
extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Gas Analysis, Sample, & Recharge (GASR) System

USER NOTES

STANDARD GAS-SAMPLING PROCESS

1. Normal operating procedures for the GASR System are contained in HFEF Operating Instruction OI-4381.
2. The system is prepared for operation by calibrating and/or checking the calibration of all system instrumentation. If needed, system volumes are augmented by attaching selected chambers of known volume.
3. With the Seal Head (SH) of the GASR system blocked off, a series of back-fills and expansions are performed to establish a pressure ratio (Slope A) that is used in later check calculations.
4. The preferred puncture site on capsules to be punctured is clamped against a saddle-shaped gasket in the Seal Head.
5. The entire volume of the GASR system, including the sample chambers, is evacuated to < 30 mtorr.
6. Valves are closed to isolate the Seal Head from the Manifold (MAN) and the sampling chamber(s).
7. The laser is operated to drill a small hole (5-10 mils dia.) in the capsule. Gas from the capsule expands into the Seal Head, where pressure is monitored on a high-range meter (P_1).
8. When pressure in the Seal Head has equilibrated, the valve to the Manifold is opened, and the gas expands into the Manifold, where pressure is monitored on an accurate low-range meter (P_2), and capsule temperature is monitored on an in-cell thermocouple.
9. The valves to the sample line are opened to allow the gas to expand into the sample chamber(s). Isolation valves integral to the sample chamber(s) are closed to capture the gas sample(s), which are hand-carried to the Analytical Laboratory for analysis of the gas. Sample pressure is monitored on P_2 , and sample temperature is monitored on a thermometer inside the sampling cabinet.
10. A series of back-fills and expansions are performed to accurately determine the capsule void volume (and establish Slope B). Helium is used to back-fill the capsule to selected target pressures (in the range 5-45 psia, as monitored on P_2). The Seal Head is isolated, and the Manifold is re-evacuated to < 30 mtorr. The helium in the Capsule/Seal Head is then expanded into the manifold where the pressure is monitored on P_2 .
11. If desired, the capsule may be back-filled with any gas of choice and the puncture site plugged by de-focusing the laser beam to create a "puddle" weld. No assurance of leak-tightness is available.

STANDARD CALCULATION

- Using the Ideal Gas Law, the capsule void volume (V_{cap}) is calculated from the backfill/expansion data acquired in step 10 above. A statistical estimate of error is derived from the replicated readings.
- Again using the Ideal Gas Law, the capsule initial pressure (P_{cap}) is calculated from V_{cap} and data acquired in step 8 above.

CHECK CALCULATIONS

- Using the Ideal Gas Law, V_{cap} and P_{cap} can be calculated directly from the data acquired in steps 7 and 8 above. This quality of this result is poor because of inaccuracy in the P_1 observation.
- Using Slope A and Slope B, V_{cap} and P_{cap} can be calculated without apriori knowledge of the volumes of the GASR system. While potentially better than the standard calculation, this method has not been validated, nor has it received peer review.

SPECIAL PROCEDURES

- Special procedures may sometimes be employed that deviate from the standard methods described above. Such procedures are described in the appropriate HFEF work-control documentation, such as Non-Routine Procedures (NRP's) or Process Work Sheets (PWS's).

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Gas Analysis, Sample, and Recharge (GASR) System

SUMMARY REPORT

S/A or TEST: **Loop-1**

3/11/97

ROD ID	VOLUME*		PRESSURE*		TEMPERATURE (°F)	REWELD STATUS	SAMPLE DATE	REMARKS
	(in ³)	2Sigma	(psia)	2Sigma				
WL-01	2.442	0.009	570	2	78	fail	2/5/97	placed in Swagelok sealed tube
WL-03	2.380	0.008	557	2	79	fail	2/5/97	placed in Swagelok sealed tube
WL-09	2.399	0.015	596	4	79	fail	2/4/97	placed in Swagelok sealed tube
WL-10	2.406	0.012	626	3	79	fail	1/30/97	placed in Swagelok sealed tube
WL-18	2.375	0.011	584	3	79	pinhole	1/21/97	placed in Swagelok sealed tube
WL-22	2.382	0.020	592	5	80	fail	2/4/97	placed in Swagelok sealed tube
WL-26	2.412	0.009	677	3	78	fail	1/30/97	placed in Swagelok sealed tube
WL-27	2.390	0.009	668	2	79	fail	2/3/97	placed in Swagelok sealed tube

* Determined by the backfill/expansion method.

REMARKS:

Prepared by:

J. Probs

Verified by:

M. E. Vaughan

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO: R. L. Bratton	ADDRESS: Lockheed Martin Idaho Technologies, Co. EROB MS-3760 Idaho Falls, ID 834	DATE: March 11, 1997
---------------------------------	--	------------------------------------

MATERIAL EXAMINED: Two Target Rods from CLWR S1/B1 Test

TYPE OF EXAMINATION: Gas Analysis, Sample, and Recharge (GASR)
--

FORM OF DATA: Summary Report and User Notes

NOTES:

CC: w/Attachments S1/B1 file	
CC: w/o Attachments 	

APPROVED: John P. Webb, COGNIZANT ENGINEER	Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.
---	---

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

Gas Analysis, Sample, and Recharge (GASR) System

SUMMARY REPORT

S/A or TEST: S1/B1

3/11/97

ROD ID	VOLUME*		PRESSURE*		TEMPERATURE (°F)	REWELD STATUS	SAMPLE DATE	REMARKS
	(in ³)	2Sigma	(psia)	2Sigma				
WT-11	2.032	0.005	465	1	81	fail	2/3/97	placed in Swagelok sealed tube
WT-12	2.014	0.006	688	2	81	pinhole	1/27/97	placed in Swagelok sealed tube

* Determined by the backfill/expansion method.

REMARKS:

Prepared by:

Verified by:

GASR System Volumes

Component	Volumes (in.³)
Manifold	2.2311
Driver seal head	1.3179
Auxiliary volume 1 and piping	65.922

This analysis is of the gas puncture for the dummy and 10 CLWR rods. The rods were punctured in Argonne National Laboratory-West Hot Fuel Examination Facility during the time period of January 21 through February 5, 1997.

Variables used to describe the GASR system are the seal head volume (V_{seal}), the manifold volume (V_{man}), and the auxiliary volume (V_{aux}).

$$V_{\text{seal}} := 1.3179 \cdot \text{in}^3$$

$$V_{\text{aux}} := 65.922 \cdot \text{in}^3$$

$$V_{\text{man}} := 2.2311 \cdot \text{in}^3$$

The dummy rod was constructed from a critical assembly rod used to mock up the Loop-1 experiment. A valve was welded to the upper end of the rod and high purity helium was used to pressurize the rod to a pressure known only to LMITCO. This was a blind test for Argonne to benchmark the gas puncture system and analysis at Argonne-West. Below is a calculation of the void volume and pressure for the dummy rod using data from the puncture.

$P_{\text{di}} :=$	12.33	$P_{\text{de}} :=$	7.93
	15.01		9.71
	17.08		10.99
	20.19		12.99
	22.17		14.27
	25.19		16.21
	27.20		17.51
	30.28		19.49
	32.28		20.78
	35.28		22.72
	45.23		29.14

Dummy Rod Data

$$P_{\text{man}} := 18.75 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$\text{Void} := \frac{(P_{\text{de}} - P_{\text{di}}) \cdot V_{\text{seal}} + P_{\text{de}} \cdot V_{\text{man}}}{(P_{\text{di}} - P_{\text{de}})}$$

$$\text{Pressure} := \frac{P_{\text{man}} \cdot (\text{Void} + V_{\text{seal}} + V_{\text{man}} + V_{\text{aux}})}{\text{Void}}$$

	0
0	2.703
1	2.77
2	2.708
3	2.707
4	2.712
5	2.71
6	2.714
7	2.712
8	2.714
9	2.718
10	2.723

$$\text{Void} = 2.71 \cdot \text{in}^3$$

	0
0	500.625
1	489.056
2	499.702
3	499.873
4	499.017
5	499.494
6	498.745
7	499.028
8	498.77
9	497.997
10	497.154

$$\text{Pressure} = 498.745 \cdot \frac{\text{lb}}{\text{in}^2}$$

Mean of the dummy's void volume is $\text{Void_Mean} := \text{mean}(\text{Void})$ $\text{Void_Mean} = 2.717 \cdot \text{in}^3$

Standard Deviation of the void volume is $\text{Void_Std} := \text{stdev}(\text{Void})$ $\text{Void_Std} = 0.017 \cdot \text{in}^3$

Mean of the dummy's capsule pressure is $\text{Pressure_Mean} := \text{mean}(\text{Pressure})$ $\text{Pressure_Mean} = 498.133 \cdot \frac{\text{lb}}{\text{in}^2}$

Standard Deviation of the dummy's pressure is $\text{Pressure_Std} := \text{stdev}(\text{Pressure})$ $\text{Pressure_Std} = 3.004 \cdot \frac{\text{lb}}{\text{in}^2}$

WL-18 Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.07	$P_{exp} :=$	7.52
	15.07		9.39
	17.10		10.66
	20.11		12.53
	22.15		13.80
	25.14		15.67
	27.15		16.93
	30.16		18.80
	32.17		20.06
	35.19		21.95
	45.23		28.23

WL-18 Manifold Pressure

$$P_{man} := 19.32 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0
0	2.37
1	2.37
2	2.375
3	2.37
4	2.369
5	2.374
6	2.378
7	2.374
8	2.378
9	2.381
10	2.387

$$Void = 2.374 \cdot in^3$$

	0
0	585.749
1	585.525
2	584.402
3	585.596
4	585.778
5	584.71
6	583.725
7	584.588
8	583.764
9	583.038
10	581.598

$$Pressure = 584.71 \cdot \frac{lb}{in^2}$$

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.375 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 5.251 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 584.407 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 1.247 \cdot \frac{lb}{in^2}$$

B-1 Rod (WT-12)

This rod was punctured with V8 closed. This requires different equations to be used to calculate the capsule pressure.

$P_{int} :=$	12.35	$P_{exp} :=$	7.40
	15.08		9.03
	17.10		10.24
	20.11		12.04
	22.13		13.25
	25.12		15.04
	27.14		16.25
	30.15		18.06
	32.17		19.27
	35.17		21.06
	45.23		27.11

WT-12 Manifold Pressure

$$P_{man} := 11.99 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{aux}) \cdot (Void + V_{seal} + V_{man})}{Void \cdot (Void + V_{seal})}$$

	0
0	2.017
1	2.012
2	2.012
3	2.011
4	2.011
5	2.011
6	2.011
7	2.015
8	2.015
9	2.012
10	2.02

Void = $\cdot in^3$

	0
0	686.927
1	689.135
2	688.996
3	689.707
4	689.547
5	689.597
6	689.475
7	687.992
8	687.99
9	689.138
10	685.835

Pressure = $\cdot \frac{lb}{in^2}$

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.014 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 2.893 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 688.576 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 1.198 \cdot \frac{lb}{in^2}$$

WL-10 Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.25	$P_{exp} :=$	7.67
	15.08		9.43
	17.11		10.69
	20.11		12.57
	22.25		13.91
	25.13		15.71
	27.14		16.97
	30.15		18.85
	32.30		20.20
	35.17		22.00
	45.21		28.30

WL-10 Manifold Pressure

$$P_{man} := 20.95 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0
1	2.418
2	2.406
3	2.397
4	2.402
5	2.403
6	2.403
7	2.405
8	2.404
9	2.407
10	2.409
11	2.416

$$Void = 2.403 \cdot in^3$$

	0
1	622.745
2	625.896
3	628.101
4	626.973
5	626.548
6	626.625
7	626.116
8	626.392
9	625.674
10	625.091
11	623.36

$$Pressure = 626.625 \cdot \frac{lb}{in^2}$$

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.406 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 5.909 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 625.775 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 1.482 \cdot \frac{lb}{in^2}$$

WL-26 Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.31	$P_{exp} :=$	7.71
	15.08		9.44
	17.09		10.69
	20.12		12.58
	22.12		13.84
	25.12		15.72
	27.13		16.97
	30.15		18.86
	32.18		20.13
	35.18		22.01
	45.23		28.31

WL-26 Manifold Pressure

$$P_{man} := 22.71 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0
0	2.422
1	2.416
2	2.409
3	2.405
4	2.411
5	2.413
6	2.409
7	2.409
8	2.409
9	2.411
10	2.415

$$Void = \cdot in^3$$

	0
0	674.211
1	675.611
2	677.696
3	678.837
4	676.977
5	676.468
6	677.718
7	677.579
8	677.558
9	677.144
10	675.968

$$Pressure = \cdot \frac{lb}{in^2}$$

Mean of the dummy's void volume is $Void_Mean := mean(Void) \quad Void_Mean = 2.412 \cdot in^3$

Standard Deviation of the void volume is $Void_Std := stdev(Void) \quad Void_Std = 4.446 \cdot 10^{-3} \cdot in^3$

Mean of the dummy's capsule pressure is $Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 676.888 \cdot \frac{lb}{in^2}$

Standard Deviation of the dummy's pressure is $Pressure_Std := stdev(Pressure) \quad Pressure_Std = 1.204 \cdot \frac{lb}{in^2}$

WT-11 (S1) Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.29	$P_{exp} :=$	7.37
	15.07		9.04
	17.09		10.25
	20.10		12.05
	22.12		13.26
	25.14		15.07
	27.16		16.28
	30.16		18.08
	32.16		19.27
	35.18		21.09
	45.21		27.11

WT-11 (S-1) Manifold Pressure

$$P_{man} := 13.15 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0
0	2.024
1	2.027
2	2.025
3	2.022
4	2.021
5	2.021
6	2.021
7	2.021
8	2.017
9	2.022
10	2.024

$$Void = \cdot in^3$$

	0
0	464.458
1	463.86
2	464.174
3	464.992
4	465.132
5	465.177
6	465.277
7	465.095
8	465.96
9	465.036
10	464.546

$$Pressure = \cdot \frac{lb}{in^2}$$

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.022 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 2.485 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 464.882 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 0.555 \cdot \frac{lb}{in^2}$$

This rod was punctured with V8 open.

$P_{int} :=$	12.26
	15.08
	17.08
	20.09
	22.12
	25.11
	27.14
	30.16
	32.15
	35.19
	45.22

$P_{exp} :=$	7.66
	9.41
	10.66
	12.55
	13.81
	15.68
	16.94
	18.82
	20.07
	21.97
	28.25

WL-27 Manifold Pressure

$$P_{man} := 22.22 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

Void =	0
	2.397
	2.385
	2.387
	2.396
	2.39
	2.392
	2.387
	2.385
	2.389
	2.39
	2.396

Pressure =	0
	666.112
	669.489
	668.99
	666.569
	668.134
	667.577
	668.78
	669.489
	668.393
	668.121
	666.421

Mean of the dummy's void volume is Void_Mean := mean(Void) Void_Mean = 2.39 • in³

Standard Deviation of the void volume is Void_Std := stdev(Void) Void_Std = 4.251 • 10⁻³ • in³

Mean of the dummy's capsule pressure is Pressure_Mean := mean(Pressure) Pressure_Mean = 668.007 • $\frac{lb}{in^2}$

Standard Deviation of the dummy's pressure is Pressure_Std := stdev(Pressure) Pressure_Std = 1.148 • $\frac{lb}{in^2}$

WL-22 Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.24	$P_{exp} :=$	7.64
	15.2		9.48
	17.09		10.66
	20.08		12.52
	22.13		13.81
	25.14		15.67
	27.15		16.93
	30.84		19.23
	32.18		20.07
	35.18		21.94
	45.22		28.23

WL-22 Manifold Pressure

$$P_{man} := 19.64 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0
$Void =$	2.388
	2.38
	2.381
	2.377
	2.385
	2.374
	2.378
	2.378
	2.38
	2.379
	2.389

	0
$Pressure =$	591.081
	592.971
	592.696
	593.648
	591.623
	594.395
	593.394
	593.515
	592.989
	593.101
	590.71

Mean of the dummy's void volume is $Void_Mean := \text{mean}(Void) \quad Void_Mean = 2.381 \cdot in^3$

Standard Deviation of the void volume is $Void_Std := \text{stdev}(Void) \quad Void_Std = 4.514 \cdot 10^{-3} \cdot in^3$

Mean of the dummy's capsule pressure is $Pressure_Mean := \text{mean}(Pressure) \quad Pressure_Mean = 592.738 \cdot \frac{lb}{in^2}$

Standard Deviation of the dummy's pressure is $Pressure_Std := \text{stdev}(Pressure) \quad Pressure_Std = 1.085 \cdot \frac{lb}{in^2}$

WL-09 Loop Rod

This rod was punctured with V8 open.

	12.29		7.69
	15.26		9.55
	17.1		10.69
	20.1		12.56
	22.11		13.81
$P_{int} :=$	25.14	$P_{exp} :=$	15.7
	27.13		16.95
	30.15		18.83
	32.15		20.08
	35.16		21.96
	45.23		28.25

WL-09 Manifold Pressure

$$P_{man} := 19.89 \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0		0
	2.412		592.786
	2.414		592.381
	2.403		594.931
	2.399		595.96
	2.394		596.995
$Void =$	2.393	$Pressure =$	597.382
	2.397		596.364
	2.393		597.225
	2.394		597.117
	2.394		597.113
	2.394		597.067

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.399 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 7.203 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 595.938 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 1.724 \cdot \frac{lb}{in^2}$$

WL-03 Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.27	$P_{exp} :=$	7.65
	15.07		9.40
	17.08		10.65
	20.09		12.53
	22.12		13.79
	25.13		15.67
	27.13		16.92
	30.14		18.80
	32.17		20.07
	35.17		21.94
	45.20		28.22

WL-03 Manifold Pressure

$$P_{man} := 18.45 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

	0		0
0	2.376		557.8
1	2.381		556.787
2	2.377		557.57
3	2.38		557.009
4	2.376		557.993
5	2.378		557.494
6	2.379		557.115
7	2.381		556.787
8	2.383		556.369
9	2.382		556.533
10	2.39		554.723

$$Void = 2.376 \cdot in^3 \quad Pressure = 557.494 \cdot \frac{lb}{in^2}$$

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.38 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 3.787 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 556.925 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 0.855 \cdot \frac{lb}{in^2}$$

WL-01 Loop Rod

This rod was punctured with V8 open.

$P_{int} :=$	12.27	$P_{exp} :=$	7.65
	15.07		9.40
	17.08		10.65
	20.09		12.53
	22.12		13.79
	25.13		15.67
	27.13		16.92
	30.14		18.80
	32.17		20.07
	35.17		21.94
	45.20		28.22

WL-01 Manifold Pressure

$$P_{man} := 19.22 \cdot \frac{lb}{in^2}$$

$$Void := \frac{(P_{exp} - P_{int}) \cdot V_{seal} + P_{exp} \cdot V_{man}}{(P_{int} - P_{exp})}$$

$$Pressure := \frac{P_{man} \cdot (Void + V_{seal} + V_{man} + V_{aux})}{Void}$$

$Void =$	0	$Pressure =$	0
	0.06		581.079
	0.06		580.024
	0.06		580.84
	0.06		580.256
	0.06		581.281
	0.06		580.761
	0.06		580.366
	0.06		580.024
	0.061		579.589
	0.061		579.759
	0.061		577.874

Mean of the dummy's void volume is

$$Void_Mean := mean(Void) \quad Void_Mean = 2.38 \cdot in^3$$

Standard Deviation of the void volume is

$$Void_Std := stdev(Void) \quad Void_Std = 3.787 \cdot 10^{-3} \cdot in^3$$

Mean of the dummy's capsule pressure is

$$Pressure_Mean := mean(Pressure) \quad Pressure_Mean = 580.168 \cdot \frac{lb}{in^2}$$

Standard Deviation of the dummy's pressure is

$$Pressure_Std := stdev(Pressure) \quad Pressure_Std = 0.891 \cdot \frac{lb}{in^2}$$

Appendix I

Plenum Gas Analysis

Appendix I

Table of Contents

- CLWR Test Loop-1 Gas Analysis for WL-01 through WL-27
- CLWR Test Gas Analysis for WL-11 and WL-12

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies Co.
P. O. Box 1625
EROB MS-3760
Idaho Falls, ID 83415

DATE:

March 14, 1997

MATERIAL EXAMINED:

Eight Rods from CLWR Test Loop-1

TYPE OF EXAMINATION:

Gas Analysis (AL)

FORM OF DATA:

Revision 1 of Summary Tables (2)

NOTES:

This is an augmented re-transmittal of the gas analysis data. Additional information has been added in the form of: sample container data; dates of radiochemical analyses; and tritium measurement of five backfill/expansion samples. The original transmittal (dated 2/25/97) may be discarded in its entirety.

CC: w/Attachments

Loop-1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

SUMMARY OF RADIOCHEMICAL TRITIUM ANALYSES

PROGRAM: CLWR

TEST: Loop-1

DATE: 3/13/97

ROD ID #	SAMPLE CONTAINER						TRITIUM			REMARKS
	ID #	BACKFILL (psia)	Volume		Temperature (°C)	Pressure (psia)	Activity			
			(cc)	(Error* %)			(µCi)	(Error* %)	DATE	
WL-01	05		26.2	± 1	22	6.74	0.022	±30	2/5/97	first backfill/expansion sample second backfill/expansion sample third backfill/expansion sample next-to-last backfill/expansion sample last backfill/expansion sample
WL-03	04		26.2	± 1	22	6.43	0.024	±30	2/5/97	
WL-09	15		26.5	± 1	22	7.01	0.023	±30	2/4/97	
WL-10	07		26.4	± 1	23	7.34	0.034	±30	1/30/97	
WL-18	11		26.1	± 1	22	3.19	0.022	±30	1/21/97	
WL-18	16	atmos.	26.3	± 1	22	2.93	0.005	±30	1/21/97	
WL-18	13	15	26.4	± 1	22	3.65	0.011	±30	1/21/97	
WL-18	09	17	26.2	± 1	22	4.15	0.005	±30	1/21/97	
WL-18	12	35	26.3	± 1	23	8.55	0.022	±30	1/21/97	
WL-18	15	45	26.5	± 1	23	10.99	0.056	±30	1/21/97	
WL-22	11		26.1	± 1	22	6.87	0.028	±30	2/4/97	
WL-26	06		26.2	± 1	22	7.97	0.021	±30	1/30/97	
WL-27	13		26.4	± 1	21	4.40	0.017	±30	2/3/97	

* At 2 sigma

REMARKS:

PREPARED BY:

VERIFIED BY:

ARGONNE NATIONAL LABORATORY

Analytical Laboratory

SUMMARY OF GAS MASS-SPECTROSCOPY ANALYSES

PROGRAM: CLWR

TEST: Loop-1

DATE: 3/13/97

ROD ID	SAMPLE CONT. ID	Gas Composition (Mole %)								Isotopic Abundance (Atom %)					
		H ₂ (m/o)	He (m/o) (Error %)		N ₂ (m/o)	O ₂ (m/o)	Ar (m/o) (Error %)		CO ₂ (m/o)	He ³ (a/o) (Error %)		He ⁴ (a/o) (Error %)		He3/He4 (Ratio) (Error %)	
WL-01	02	<0.01	99.93	± 1.0	<0.01	<0.01	0.07	± 10	<0.01	1.56	± 10	98.44	± 1	0.0159	± 10
WL-03	01	<0.01	99.91	± 1.0	<0.01	<0.01	0.09	± 10	<0.01	1.69	± 10	98.31	± 1	0.0171	± 10
WL-09	16	<0.01	99.92	± 1.0	<0.01	<0.01	0.08	± 10	<0.01	1.57	± 10	98.43	± 1	0.0160	± 10
WL-10	08	<0.01	99.92	± 1.0	<0.01	<0.01	0.08	± 25	<0.01	1.43	± 10	98.57	± 1	0.0145	± 10
WL-18	10	<0.01	99.80	± 1.0	<0.01	<0.01	0.20	± 25	<0.01	1.55	± 10	98.45	± 1	0.0157	± 10
WL-22	10	<0.01	99.92	± 1.0	<0.01	<0.01	0.08	± 10	<0.01	1.57	± 10	98.43	± 1	0.0159	± 10
WL-26	05	<0.01	99.92	± 1.0	<0.01	<0.01	0.08	± 10	<0.01	1.32	± 10	98.68	± 1	0.0134	± 10
WL-27	12	<0.01	99.91	± 1.0	<0.01	<0.01	0.09	± 10	<0.01	1.37	± 10	98.63	± 1	0.0139	± 10

* At 2 sigma

REMARKS:

PREPARED BY:

J. Webb

VERIFIED BY:

M. E. Vaughan

ARGONNE NATIONAL LABORATORY

P. O. Box 2528, Idaho Falls, Idaho 83403-2528

ENGINEERING DIVISION

(TREAT, ZPPR, and HFEF)

EXAMINATION DATA TRANSMITTAL

TO:

R. L. Bratton

ADDRESS:

Lockheed Martin Idaho Technologies Co.
P. O. Box 1625
EROB MS-3760
Idaho Falls, ID 83415

DATE:

March 14, 1997

MATERIAL EXAMINED:

Two Rods from CLWR Test S1/B1

TYPE OF EXAMINATION:

Gas Analysis (AL)

FORM OF DATA:

Revision 1 of Summary Tables (2)

NOTES:

This is an augmented re-transmittal of the gas analysis data. Additional information has been added in the form of: sample container data; and dates of radiochemical analyses. The original transmittal (dated 2/25/97) may be discarded in its entirety.

CC: w/Attachments

S1/B1 file

CC: w/o Attachments

APPROVED:

John P. Webb, COGNIZANT ENGINEER

Questions regarding this data transmittal should be directed to the Cognizant Engineer at extension (208) 533-7773.

Revised: 2/11/97

ARGONNE NATIONAL LABORATORY

Analytical Laboratory

SUMMARY OF GAS MASS-SPECTROSCOPY ANALYSES

PROGRAM CLWR

TEST: S1/B1

DATE: 3/14/97

ROD ID	SAMPLE CONT. ID	Gas Composition (Mole %)									Isotopic Abundance (Atom %)					
		H ₂		He		N ₂ (m/o)	O ₂ (m/o)	Ar		CO ₂ (m/o)	He ³		He ⁴		He3/He4	
		(m/o)	(Error %)	(m/o)	(Error %)			(m/o)	(Error %)		(m/o)	(a/o)	(Error %)	(a/o)	(Error %)	(Ratio)
WT-11	02	<0.01	n/a	99.87	± 1.0	<0.01	<0.01	0.13	± 10	<0.01	1.14	± 10	98.86	±1	0.0116	± 10
WT-12	01	0.01	± 25	99.82	± 1.0	<0.01	<0.01	0.17	± 25	<0.01	0.78	± 10	99.22	±1	0.0078	± 10

* At 2 sigma

REMARKS:

PREPARED BY:

[Signature]

VERIFIED BY:

[Signature]

ARGONNE NATIONAL LABORATORY

Hot Fuel Examination Facility

SUMMARY OF RADIOCHEMICAL TRITIUM ANALYSES

PROGRAM: CLWR

TEST: S1/B1

DATE: 3/14/97

ROD ID #	SAMPLE CONTAINER						TRITIUM			REMARKS
	ID #	BACKFILL (psia)	Volume		Temperature (°C)	Pressure (psia)	Activity			
			(cc)	(Error* %)			(μCi)	(Error* %)	DATE	
Wt-11	03		26.2	± 1	22.0	4.42	0.006	±35	2/5/97	
Wt-12	14		26.2	± 1	21.5	4.01	0.025	±30	2/5/97	

* At 2 sigma

REMARKS:

PREPARED BY:

J. P. Webb

VERIFIED BY:

M. E. Vaughan