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XRF SPOT VERIFICATION OF LDUA MATERIALS

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Abstract: This document consists primarily of a Numatec Hanford Corporation letter report, NHC-9857331, describing x-ray fluorescent (XRF) testing performed on the Light Duty Utility Arm (LDUA) in order to determine/verify the materials of fabrication. Results of the testing indicate that some materials do not correspond to callouts in the governing fabrication drawing.

A "FORWARD" prefaces the report itself and describes disposition of the material discrepancies found during XRF testing.

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FORWARD

Except for this FORWARD, the remaining pages of this document represent the original engineering analysis report prepared by the Numatec Hanford Corporation, documenting x-ray fluorescence (XRF) testing of the materials of construction of a portion of the Light Duty Utility Arm (LDUA). The XRF testing was requested by TWRS Characterization Engineering as a result of at least one material discrepancy uncovered during a design vs. physical configuration walkdown performed on the LDUA system. The walkdown, and XRF testing, of the LDUA were commissioned by Characterization Engineering in order to ensure that the Characterization Project, in accepting the LDUA system, had accurate configuration knowledge of it.

The purpose of this FORWARD is to document resolution of additional material discrepancies uncovered during the XRF testing and reported on in the remainder of this document. XRF testing involved fifteen metallic surface locations on portions of the LDUA arm that would be exposed to the waste tank atmosphere during LDUA operations. Material disagreement with design drawing material callouts was found in five of these cases. As a result the parts list for the governing drawing, H-6-14176, was updated to reflect actual materials used during construction, since confirmed by the PNNL project engineer, for these five cases. Engineering Change Notice (ECN) #650181 was issued October 29, 1998, to revise the drawing. The material changes for the five discrepant XRF test points are as follows:

XRF#01	Finger Gripper	P/N 18	Material:	TITANIUM W/HASTELLOY C-22 COATING W/WEAR TEK TOP COATING
XRF#04	Arm, Half T.I.P.	P.N 39	Material:	TITANIUM TI-6AL-4V
XRF#06	Frame, Window	P/N 21	Material:	CRES 17-4-PH AMS-5643
XRF#08	Cover, Upper	P/N 07	Material:	CRES 304-ASTM A240
XRF#12	Tube, Push Plate	P/N 15	Material:	304 SST or 17-4 PH SST

Knowledge of the materials of construction for this portion of the LDUA is important for implementing Authorization Basis flammable gas ignition controls for LDUA operation inside waste tanks. The materials of construction are required to meet ignition controls by either being non-sparking or equivalently meeting them by virtue of how they are deployed and/or used. This portion of the LDUA was resubmitted to the Flammable Gas Equipment Advisory Board (FGEAB). The newly identified materials were reviewed and approved for use in flammable gas waste tanks and is documented in FGEAB report, FGEAB-97-019, Rev. 3.

NHC

Numatec Hanford Corporation
An SGN/Cogema, Inc. Company

HNF-3596, Rev. 0

September 10, 1998

NHC-9857331

DISTRIBUTION (see distribution list attached)

Dear Ms. Wickstrand and Gentlemen:

XRF SPOT VERIFICATION OF LIGHT DUTY UTILITY ARM (LDUA) MATERIALS -
FT8693a

Attached is the analytical report in support of this project

If you should have any questions regarding analysis, please contact Dr. W. S. Callaway
at 373-5703.

Very truly yours,

L. L. Lockrem, Manager
Numatec Hanford Corporation
Special Analytical Support

sir

Attachments

P.O. Box 1300, Richland, Washington 99352

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ATTACHMENT

ANALYSIS REPORT

for

NHC - SAS JOB FT8693a

XRF Spot Verification of LDUA Materials

Consisting of
40 Pages

TEST NARRATIVE

INTRODUCTION

The Hanford Light Duty Utility Arm (LDUA) is a remotely operated system designed for sampling and other characterization activities within radioactive waste storage tanks. LDUA components which actually enter a waste tank during these operations include the hydraulically powered arm and a collection of extenders and tools (effectors). The materials used in the fabrication of the LDUA in-tank components must be carefully selected in order to satisfy safety and operational considerations.

On August 6, 1998, personnel of the NHC Special Analytical Support group (SAS), under the direction of Characterization Project Operations (CPO), performed a series of screening measurements at fifteen (15), CPO selected locations on the in-tank LDUA components. The purpose of the measurements was to provide spot checks of the materials of fabrication of the selected LDUA components. This spot check data will support evaluation of the confidence which can be ascribed to the material call-outs found on LDUA engineering drawings.

All measurements were performed in the FMEF process cell where the LDUA system is currently deployed for testing, demonstration, and training. All measurements followed the Light Duty Utility Arm Verification Test Procedure: HNF-2969, were covered by RWP Number CS-685, and were witnessed by a LMHC Quality Assurance representative.

REQUESTED ANALYSIS / DELIVERABLE(S)

Sample ID:	LDUA-01 through LDUA-15		
SAS Job ID:	FT8693a - HTI: XRF Screening of LDUA Components		
Standard ID:	AISI 304 Stainless Steel:	Part #:	IARM-2B
		Certificate #:	2B-081594-ARM-F
	AISI 17-4 PH Stainless Steel:	Part #:	IARM-23B
		Certificate #:	23B-053098-ARM-F
	Hastelloy C-22:	Part No:	IARM-65B
		Certificate #:	65B-030498-ARM-P
Standard Source:	Analytical Reference Materials International, Inc. Evergreen, Colorado 80439-2246		
Analysis:	(1) Collect EDXRF spectra for stainless steel and nickel alloy standards. Analysis time: 60 seconds (live time).		
	(2) Collect EDXRF spectra at each of fifteen (15) locations on the LDUA. Instrument set-up and analysis times will		

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be identical to those used for standard alloys. The 15 spots for EDXRF analysis will be designated and documented by Characterization Process Operations personnel.

- (3) Collect duplicate XRF spectra for alloy standards prior to LDUA testing; repeat single measurements after collection of 10 LDUA spot spectra; and, repeat single standard measurements at completion of testing.
- (4) Save XRF spectra for each LDUA material verification measurement and for alloy standards.

- Deliverable(s):
- (1) Qualitative comparison of LDUA and standard alloy XRF spectra.
 - (2) Evaluation of accuracy of call-outs of materials of fabrication on LDUA engineering drawing.
 - (3) Print-outs of XRF spectra for LDUA screens and alloy standards.
 - (4) Letter report summarizing test measurements.

QUALITY CONTROL

The following QC measurements were included in the LDUA XRF testing protocol.

- (1) Resolution and energy calibration of the XRF spectrometer system checked before initiation of and at the conclusion of the screening measurements.
- (2) XRF spectra for a test control standard collected at the beginning of, during, and at the end of the LDUA screens to verify controlled operation of the EDXRF spectrometer.
- (3) XRF spectra for alloy standards collected in duplicate at the initiation of LDUA screening, after 10 LDUA measurements, and, at the completion of the LDUA analyses.

All quality control measurements verified that the XRF measurement system was under verifiable control over the course of the LDUA screening measurements.

ANALYSIS

The LDUA spot verification analyses were performed by energy dispersive X-ray fluorescence (EDXRF) spectrometry. In this technique, a sample material is irradiated with X-rays or γ rays from an excitation source. This excitation causes the elemental constituents of the sample to undergo rearrangements of inner shell electrons which are accompanied by the emission, or fluorescence, of X-rays. The energies of the X-rays emitted are characteristic of the fluorescing

atoms and provide a qualitative indicator of the presence of specific elemental components in a sample. The measured intensities of characteristic X-ray energies are directly proportional to the concentrations of the fluorescing elements in the sample and may be used for semi-quantitative and/or quantitative analysis.

A portable, isotopic source, energy dispersive XRF spectrometer supplied by Metorex Corporation (Princeton, NJ) was used for the LDUA material verification testing. The X-Met 920[®] spectrometer system consists of a SSPS probe module and a field hardened computer/control module. The SSPS probe houses a Cd-109 source for sample excitation and a liquid nitrogen cooled, solid state detector for collection and resolution (by energy) of the fluorescent X-ray signals. Signal processing and data storage is accomplished in the control module.

The decay of the Cd-109 source generates a flux of silver (Ag) X-rays (22.1 keV and 25.0 keV) which serve as the fluorescence excitation source. This source is well suited to exciting the characteristic X-ray fluorescence of elements ranging from scandium (Sc) through molybdenum (Mo) and from barium (Ba) through uranium (U). The X-ray fluorescence of the major alloying elements of the stainless steels and nickel alloys specified in the LDUA in-tank material call outs is efficiently excited by this source.

There was a great deal of variation in the shapes, sizes, surface texture, and surface curvature of the LDUA areas (spots) selected for analysis. Furthermore, all the alloy standards used were flat, highly polished, homogeneous, 31 mm diameter metal disks. Due to the resulting, and unavoidable, differences in specimen areas and measurement geometries, direct comparison of the absolute intensities of individual XRF signals between different LDUA areas or between alloy standards and LDUA spots is not possible. The presence/absence and relative intensities of the XRF signals for major elemental components of an alloy are, however, generally unaffected by these measurement constraints. Evaluation of the LDUA screening measurements were, therefore, based on comparison of the "fingerprint" spectra from the LDUA analysis spots with those of the well characterized alloy standards. While such a comparison cannot unequivocally identify the specific metal alloy from which a specific LDUA component is fabricated, a good qualitative and scaled semi-quantitative match of a screening and standard spectra does establish with "reasonable confidence" that the LDUA material has an elemental composition similar to that of the alloy standard.

ANOMALIES

No test anomalies were noted during the course of the testing activities (08/06/98). Successful collection and storage of all required measurements was completed and verified.

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RESULTS

SUMMARY

The LDUA-## XRF spectra from the following spot verification locations indicate an elemental composition consistent with the material(s) specified in the drawing parts list.

LDUA-##	Identification	Alloy Standard
LDUA-02	Tooling Interface Plate	Hastelloy C-22
LDUA-03	Camera Housing	304 Stainless
LDUA-05	Cover, Manifold	17-4 PH Stainless
LDUA-07	Frame, Window	304 Stainless
LDUA-11	Camera Housing	304 Stainless
LDUA-13	Extension Tree	304 Stainless
LDUA-14	HRSVS #2 End Bumper	304 Stainless
LDUA-15	Ring, Outer Mast	304 Stainless

The LDUA-## XRF spectra from the following spot verification locations also indicate an elemental composition consistent with the material(s) specified in the drawing parts list. Since a specific alloy was not identified in the material call outs, direct comparison with an alloy standard spectra was not possible.

LDUA-##	Identification	Closest Standard
LDUA-09	Extension Tube Assy	304 Stainless
LDUA-10	Extension Tube Assy	304 Stainless

The elemental compositions indicated by the XRF spectra from the following LDUA spot verification locations were not consistent with the fabrication materials specified in the LDUA drawing parts list:

LDUA-##	Identification	Reference Standard
LDUA-01	Finger Gripper	Hastelloy C-22
LDUA-04	Arm, Half T.I.P.	17-4 PH Stainless
LDUA-06	Frame, Window	304 Stainless
LDUA-08	Cover, Upper	17-4 PH Stainless
LDUA-12	Tube, Push Plate	304 Stainless
		17-4 PH Stainless

DISCUSSION

The identifications of the spots on the LDUA selected for XRF screening measurements and their identification and numbering on the associated materials drawing (H-6-14176) are given in Table 1. The fabrication material specified on

the drawing for each spot is also shown. A copy of Essential Drawing H-6-14176, with the XRF screening locations indicated, is included as Figure 1.

A representative XRF spectrum for each of the alloy standards--304 stainless steel, 17-4 PH steel, and Hastelloy C-22 nickel alloy--are provided in Figure 2. A copy of the standard certificate containing elemental composition data and certification information is also included for each standard alloy.

The XRF spectrum for each of the fifteen LDUA analysis spots are included in Figure 3. The energy scale is the same for all the LDUA spot spectra and is also identical to that selected for the alloy standards in Figure 2.

A summary of the evaluation of the XRF spectra collected at LDUA spots -01 through -15 is provided in Table 2. Table 2 also includes evaluations as to whether the elemental compositions of the materials at the screening locations, as indicated by the XRF spectra, are consistent with the material call outs found in the parts list for drawing H-6-14176. As indicated in the Analysis section of the Test Narrative, these evaluations are based solely on qualitative comparison of the XRF spectra from the selected spot verification locations with the spectra of the alloy standards.

Analysis comments and discussion for each LDUA spot verification XRF measurement follow below.

LDUA-01 Finger Gripper

The material call out indicates that this component has a Hastelloy C-22 coating. The LDUA-01 XRF spectrum indicates that the base material is titanium (Ti). The residual LDUA-01 spectrum, after subtraction of the Ti peaks, does not, however, compare well with the spectrum for the C-22 standard. Specifically, no characteristic Mo peaks are observed and the relative intensities of the Ni peaks, as compared to the Cr signals, are smaller than would be expected.

Based on the LDUA-01 XRF spectrum, the material call out on H-6-14176 can not be verified with reasonable confidence.

LDUA-02 Tooling Interface Plate

The material call out indicates that this component has a Hastelloy C-22 coating. As for the Finger Gripper (LDUA-01), XRF spectrum LDUA-02 indicates the base material is Ti. The residual LDUA-02 spectrum is a good match with the Hastelloy C-22 standard spectra.

[Note: The relative intensities of the peaks resulting from the scattering of the source Ag X-rays by the sample (not shown in LDUA-02 plot) also support the presence of a thin C-22 layer on a Ti substrate.]

Based on the LDUA-02 XRF spectrum, the material call out on H-6-14176 is verified with reasonable confidence.

LDUA-03 Housing, Camera
LDUA-07 Frame, Window
LDUA-13 Extension Tree

The material call outs indicate that these components are fabricated from 304 Stainless Steel. XRF spectra LDUA-03, -07, and -13 are excellent matches with the 304 Stainless Steel standard spectra. The closeness of the observed matches of the "fingerprint" XRF spectra indicate, at a minimum, that the relative concentrations of the key alloying elements, chromium (Cr), iron (Fe), and nickel (Ni), in the materials at the LDUA spot locations are similar to those found in a 304 stainless steel.

Based on the LDUA-03, -07, and -13 XRF spectra, the material call outs on drawing H-6-14176 are verified with reasonable confidence.

LDUA-04 Arm, Half T.I.P.

The material call out indicates this component is fabricated from 17-4 PH steel. XRF spectrum LDUA-04, however, indicates that the material is titanium (Ti) with only trace amounts of other elements observed.

Based on the LDUA-04 XRF spectrum, the material call out on H-6-14176 can not be verified with reasonable confidence.

LDUA-05 Cover, Manifold

The material call out indicates that this component is fabricated from a 17-4 PH stainless steel. XRF spectrum LDUA-05 is an excellent match with the spectrum obtained from the 17-4 PH steel standard. The closeness of the match of the "fingerprint" XRF spectra indicates, at a minimum, that the relative concentrations of the key alloying elements, Cr, Fe, Ni, and copper (Cu), in the material at the LDUA-05 spot location are very similar to those found in a 17-4 PH steel.

Based on the LDUA-05 XRF spectrum, the material call out on H-6-14176 is verified with reasonable confidence.

LDUA-06 Frame, Window

The material call out indicates that this component is fabricated from a 304 series stainless steel. XRF spectrum LDUA-06 is, however, an excellent match with the spectrum for the 17-4 PH steel standard; not with the spectrum for the 304 stainless steel standard. The significant Cu signal observed and the relative weakness of the Ni peaks, as compared to those for Cr, are not features expected in a 304 stainless steel XRF spectrum.

Based on the LDUA-06 XRF spectrum, the material call out on H-6-14176 can not be verified with reasonable confidence.

LDUA-08 Cover, Upper

The material call out indicates that this component is fabricated from a 17-4 PH steel. XRF spectrum LDUA-08 is, however, an excellent match with the spectrum for the 304 stainless steel standard; not with the 17-4 PH standard. Both the absence of characteristic Cu peaks and the relative strength of the Ni peaks, as compared to the Cr signals, are unrepresentative of a 17-4 PH steel spectrum.

Based on the LDUA-08 XRF spectrum, the material call out on H-6-14176 can not be verified with reasonable confidence.

LDUA-09 Extension Tube Assembly
LDUA-10 Extension Tube Assembly

The material call outs indicate that these components are fabricated from a 300 Series stainless steel. XRF spectra LDUA-09 and -10 show the same general relationship between the relative intensities for the major alloying elements, Cr, Fe and Ni, as observed in the 304 stainless steel standard. The molybdenum (Mo) peak is, however, significantly larger and the relative intensity of the Ni peaks, as compared to the Cr signals, is somewhat larger. These spectral features are not inconsistent with fabrication of the Extension Tube Assembly from a 300 series stainless steel. For example, note the general composition ranges for 304, 316, and 317 series stainless steels shown below:

Element	304 SST Wt. %	316 SST Wt. %	317 SST Wt. %
Cr	18 - 20	16 - 18	18 - 20
Ni	8 - 10	10 - 14	11 - 15
Mo	-----	1.75 - 3.00	3.00 - 4.00

The LDUA-09 and -10 spectra are representative of the XRF spectra which might be expected for either a 316 or a 317 stainless steel alloy.

Based on the LDUA-09 and LDUA-10 XRF spectra, the material call outs on H-6-14176 can be verified with reasonable confidence.

LDUA-11 Camera Housing

The material call out indicates that this component is fabricated from a 300 Series stainless steel. XRF spectrum LDUA-11 is an excellent match with the 304 stainless steel standard.

Based on the LDUA-11 XRF spectrum, the material call out on H-6-14176 is verified with "reasonable" confidence.

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LDUA-12 Tube, Push Plate

The material call out indicates that this component is fabricated from a 17-4 PH steel. XRF spectrum LDUA-12, however, is more characteristic of the spectrum which might be expected from a 300 series stainless steel alloy. Indeed, the LDUA-12 spectrum is very similar to XRF spectra LDUA-09 and LDUA-10 which are specified as 300 Series stainless steel components. [See LDUA-09 and -10 Discussion.] The absence of observable Cu peaks and the relative strength of the Ni peaks, as compared to the Cr signals, are not representative features of the XRF spectrum expected for a 17-4 PH steel alloy.

Based on the LDUA-12 XRF spectrum, the material call out on H-6-14176 can not be verified with reasonable confidence.

**LDUA-14 HRSVS #2 End Bumper
LDUA-15 Ring, Outer Mast**

The material call outs indicate that these components are fabricated from a 304 Series stainless steel. XRF spectra LDUA-14 and LDUA-15 are very similar to each other; both match well with the 304 stainless steel standard spectra for the major alloying elements (i.e. Cr, Fe and Ni); and, both show a slightly elevated XRF Mo peak intensity (relative to the 304 standard).

The configuration of the XRF spectrometer used in these tests optimizes the measurement sensitivity for Mo. The observed increase in the Mo peak intensity, if real, would be equivalent to an increase of only ≈ 50 ppm Mo.

The LDUA-14 spot was a relatively small, highly curved analysis target. It is possible that this measurement geometry could produce a small, artificial enhancement of the Mo XRF peak.

The LDUA-15 spot also presented a relatively small specimen area and was in close proximity to the 300 Series stainless steel of the Extension Tube Assembly (see LDUA-09 and -10). If a portion of the tube assembly was included in the LDUA-15 Outer Ring Mast measurement spot, the elevated Mo content of the 300 series stainless steel could have resulted in the observed increase in the Mo XRF signal.

Based on the LDUA-14 and LDUA-15 XRF spectra, the material call outs on H-6-14176 can be verified with reasonable confidence.

REFERENCES

- Analytical Reference Materials International Inc., Standard Certificates 2B-081594-ARM-F (08/15/94); 23B-053098-ARM-F (05/30/98); and 65B-030498-ARM-P (03/04/98). Evergreen, Colorado.
- Craig, B. D., *Practical Oil-Field Metallurgy*. PennWell Publishing Company, Tulsa, Oklahoma, 1984.
- U. S. Department of Energy, Hanford Operations Office, *Essential Drawing: LDUA In-Tank Materials*. Drawing Number H-6-14176, Rev. 0. 2 sheets.

TABLE 1. Identification of Spot #s of XRF Verification Analyses and Identification of Tested LDUA Components. Drawing List ID #s, Part #s, Component Descriptions, and Material Call Outs taken from Essential Drawing H-6-14176, "LDUA IN-TANK MATERIALS".

XRF Spot #	Drawing Material List		Description	Material Call Out
	ID #	Part #		
LDUA - 01	18	H-6-14322-22	Finger Gripper	Hastelloy C-22 Coating
LDUA - 02	03	H-6-14160	Tooling Interface Plate	Hastelloy C-22 Coating
LDUA - 03	19	H-6-14321-020	Housing, Camera	ASTM A240, 304 SST
LDUA - 04	39	200194	Arm, Half T.I.P.	CRES 17-4 PH AMS 5643
LDUA - 05	08	200163-1	Cover, Manifold	CRES 17-4 PH AMS 5643
LDUA - 06	21	200141-3	Frame, Window	CRES 304 ASTM A240
LDUA - 07	20	200141-1	Frame, Window	CRES 304 ASTM A240
LDUA - 08	07	200162-1	Cover, Upper	CRES 17-4 PH AMS 5643
LDUA - 09	12	H-6-14244-1	Extension Tube Assy	300 Series SST
LDUA - 10	12	H-6-14244-1	Extension Tube Assy	300 Series SST
LDUA - 11	13	H-6-14242-010	Camera Housing	300 Series SST
LDUA - 12	15	EREE-97018	Tube, Push Plate	CRES 17-4 PH
LDUA - 13	30	EREE-97025	Extension Tree	304 SST
LDUA - 14	14	H-6-14242-84	HRSVS #2 End Bumper	304 SST
LDUA - 15	23	200363 SH3	Ring, Outer Mast	304 Series SST

FIGURE 1

LDUA MATERIALS VERIFICATION TESTING

Essential Drawing H-6-14176: LDUA In-Tank Materials
with
Locations of XRF Verification Test Spots

Consisting of 3 Pages

TABLE 2. Summary of XRF Spot Verification Observations. A synopsis of the analysis of XRF spectra LDUA - 01 through LDUA - 15 as compared to reference spectra for Hastelloy C-22, 17-4 PH, and 304 SST standards is presented. The agreement of the Material Call Out in the parts list on LDUA drawing H-6-14176 and the actual component material indicated by the XRF analysis is also indicated. "YES" or "NO" indicate agreement or disagreement based on direct comparison with a standard spectra. "YES (?)" is an indication of provisional agreement based on reference to and extrapolation from standard spectra.

XRF Spot #	Description	Material Call Out	XRF Observation
LDUA- 01	Finger Gripper	Hastelloy C-22 Coating	Agreement with Call Out: NO Major metal observed is Ti. Presence of small peaks for Cr and Ni suggest that the Ti may be coated with a Ni/Cr alloy. The absence of an observable Mo peak indicates that the coating is not Hastelloy C-22.
LDUA- 02	Tooling Interface Plate	Hastelloy C-22 Coating	Agreement with Call Out: YES Major metal observed is Ti. The relative intensities of peaks for Cr, Fe, Ni, Mo, and W are consistent with the presence of a thin coating of Hastelloy C-22 on a Ti substrate.
LDUA- 03	Housing, Camera	ASTM A240, 304 SST	Agreement with Call Out: YES Observed XRF spectrum is an excellent match with the 304 SST standard spectrum.
LDUA- 04	Arm, Half T.I.P.	CRES 17-4 PH AMS 5643	Agreement with Call Out: NO Major, and only, metal observed is Ti. The only other signals observed were very small peaks for Zr and Mo indicating the presence of trace amounts of these elements. The component is not fabricated from 17-4 PH steel.
LDUA- 05	Cover, Manifold	CRES 17-4 PH AMS 5643	Agreement with Call Out: YES Observed XRF spectrum is an excellent match with the 17-4 PH standard spectrum.

TABLE 2 (Continued). Summary of XRF Spot Verification Observations.

XRF Spot #	Description	Material Call Out	XRF Observation
LDUA- 06	Frame, Window	CRES 304 ASTM A240	Agreement with Call Out: NO
			Observed XRF spectrum is an excellent match with the 17-4 PH standard spectrum. The relative intensities of the Cr, Fe, and Ni peaks and the observed Cu peak all indicate that this component is fabricated from 17-4 PH steel.
LDUA- 07	Frame, Window	CRES 304 ASTM A240	Agreement with Call Out: YES
			Observed XRF spectrum is an excellent match with the 304 SST standard spectrum.
LDUA- 08	Cover, Upper	CRES 17-4 PH AMS 5643	Agreement with Call Out: NO
			Observed XRF spectrum is an excellent match with the 304 SST standard spectrum. The relative intensities of the Cr, Fe, and Ni peaks and the absence of an observable Cu peak indicate that this component is not fabricated from 17-4 PH.
LDUA- 09	Extension Tube Assy	300 Series SST	Agreement with Call Out: YES (?)
			The observed XRF spectrum is consistent with that expected from a 300 Series SST. The relative intensities of the Cr, Fe, and Ni peaks are consistent with those expected for a 300 Series SST. The increases in the Ni and Mo peaks, relative to the 304 SST standard, are consistent with those which would be expected in a 316 or 317 SST with 10 - 15 % Ni and 2.00 - 4.00 % Mo.
LDUA- 10	Extension Tube Assy	300 Series SST	Agreement with Call Out: YES (?)
			The observed XRF spectrum is consistent with that expected from a 300 Series SST. The spectrum is the same as that observed for LDUA-09. [See LDUA-09 comments]

TABLE 2 (Continued). Summary of XRF Spot Verification Observations.

XRF Spot #	Description	Material Call Out	XRF Observation
LDUA- 11	Camera Housing	300 Series SST	Agreement with Call Out: YES Observed XRF spectrum is an excellent match with the 304 SST standard spectrum.
LDUA- 12	Tube, Push Plate	CRES 17-4 PH	Agreement with Call Out: NO The observed XRF spectrum is a close match to the "300 Series SST" spectra observed for LDUA-09 and -10. [See LDUA-09 comments] The relative intensities of the Cr, Fe, and Ni peaks and the absence of an observable Cu peak further indicate that this LDUA component is not fabricated from 17-4 PH steel.
LDUA- 13	Extension Tree	304 SST	Agreement with Call Out: YES Observed XRF spectrum is an excellent match with the 304 SST standard spectrum.
LDUA- 14	HRSVS #2 End Bumper	304 SST	Agreement with Call Out: YES Observed XRF spectrum is a very good match with the 304 SST standard spectrum. The slight elevation in the Mo peak, relative to the 304 SST standard spectrum, is not significant. The increase may represent a small increase in Mo content or may be the result of measurement geometry.
LDUA- 15	Ring, Outer Mast	304 Series SST	Agreement with Call Out: YES Observed XRF spectrum is a very good match with the 304 SST standard spectrum. The spectrum is the same as that observed for LDUA-14. [See LDUA-14 comments]

FIGURE 2

LDUA MATERIALS VERIFICATION TESTING

XRF Spectra and Standard Certificates for Alloy Standards:

304 Stainless Steel
17-4 PH Steel
Hastelloy C-22 Nickel Alloy

Consisting of 7 Pages

530402

AISI 304 STAINLESS STEEL
IARM-2B

ANALYTICAL REFERENCE MATERIALS INTERNATIONAL, INC. CERTIFICATE OF A CERTIFIED REFERENCE MATERIAL

Certificate No.: 2B-081594ARME-FE

Grade: AISI 304
Part Number (Q.A.NO.): LARM-2B

Certification Date: 08/15/94

INTERPRETATION OF DATA

1. Certified values listed below reflect analysis results submitted by qualified analytical laboratories using a combination of methods and instrumentation that emulate actual methods and instrumental techniques currently in use.
2. Any data reported and enclosed by a parenthesis () is a "best estimate" and is NOT CERTIFIED. This data could not be qualified sufficiently for certification. It was, however, reported by enough laboratories to be considered as potentially present in the matrix of the material being examined.
3. The "Interlaboratory Analysis Program" (ILAP) utilized in the generation of this data is an ongoing program with permanent membership. Certain elements may be selected by a consensus of the members for more extensive evaluation.
4. The "2-Sigma Confidence Interval at 95%" is enclosed by a parenthesis () below the individual element's certified value.

IMPORTANT: A "USER REGISTRATION CARD" ACCOMPANIES ALL SHIPMENTS. THIS CARD SHOULD BE COMPLETED IMMEDIATELY UPON RECEIPT OF MATERIALS WITH THE APPROPRIATE USER INFORMATION. THIS IS THE ONLY WAY IN WHICH A USER CAN GUARANTEE THE CUSTOMER UPDATES OR POSSIBLE DATA MODIFICATIONS.

CARBON	0.056 (0.0008)	MANGANESE	1.45 (0.011)	PHOSPHORUS	0.023 (0.0009)	SULFUR	0.026 (0.011)	SILICON	0.47 (0.013)	COPPER	0.41 (0.006)	NICKEL	8.35 (0.039)	CHROMIUM	18.17 (0.0894)
MOLYBDENUM	0.33 (0.004)	TUNGSTEN	0.03 (0.001)	CORALIT	0.19 (0.004)	VANADIUM	0.087 (0.0028)	ALUMINUM	0.003 (0.0012)	IRON	0.012 (0.0021)	LEAD	N/A	ARSENIC	N/A
TITANIUM	0.002 (0.0003)	NIOBIUM	0.014 (0.0014)	ZIRCONIUM	N/A	BOIRON	N/A	NITROGEN	0.002 (0.0016)	OXYGEN	0.0025 (0.0003)	CALCIUM	N/A		

The laboratories participating in the "Interlaboratory Analysis Program" (ILAP) and certification of this material are as follows:

Chicago Spectro Service Laboratories, Inc., Chicago, IL
Carle Analytical Services Company, Inc., Huntington, WV
EPA Environmental Sciences Laboratory, Las Vegas, NV
NMA Laboratories, Huntington Beach, CA
Martin Marietta Astronautics, Denver, CO

Metal Analysis Inc., Huntington Park, CA
Special Metals Corporation, New Hartford, NY
Wisconsin Centrifugal Corp., Wausau, WI

TRACEABILITY TO NIST: Members of the "Interlaboratory Analysis Program" (ILAP) listed above validate test methods and instrument performance utilizing SRMs produced by the National Institute of Standards & Technology (NIST). Validation may be in the form of one or both of two independent methods described as follows:

1. Selected laboratories from the above listing are furnished SRMs that have been chosen as the best available "Type Standards" in relation to the matrix composition of the test materials being analyzed. These SRMs are provided by and at the expense of Analytical Reference Materials International, Inc. The data resulting from these examinations are used to certify the test materials. The SRMs are provided by the National Institute of Standards & Technology (NIST). The specific NIST SRMs applicable to the material covered by this certificate were SRM1155, SRM1156, SRM1157, SRM1158, SRM1159, SRM1160, SRM1161, SRM1162, SRM1163, SRM1164, SRM1165, SRM1166, SRM1167, SRM1168, SRM1169, SRM1170, SRM1171, SRM1172, SRM1173, SRM1174, SRM1175, SRM1176, SRM1177, SRM1178, SRM1179, SRM1180, SRM1181, SRM1182, SRM1183, SRM1184, SRM1185, SRM1186, SRM1187, SRM1188, SRM1189, SRM1190, SRM1191, SRM1192, SRM1193, SRM1194, SRM1195, SRM1196, SRM1197, SRM1198, SRM1199, SRM1200, SRM1201, SRM1202, SRM1203, SRM1204, SRM1205, SRM1206, SRM1207, SRM1208, SRM1209, SRM1210, SRM1211, SRM1212, SRM1213, SRM1214, SRM1215, SRM1216, SRM1217, SRM1218, SRM1219, SRM1220, SRM1221, SRM1222, SRM1223, SRM1224, SRM1225, SRM1226, SRM1227, SRM1228, SRM1229, SRM1230, SRM1231, SRM1232, SRM1233, SRM1234, SRM1235, SRM1236, SRM1237, SRM1238, SRM1239, SRM1240, SRM1241, SRM1242, SRM1243, SRM1244, SRM1245, SRM1246, SRM1247, SRM1248, SRM1249, SRM1250, SRM1251, SRM1252, SRM1253, SRM1254, SRM1255, SRM1256, 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S17401

AISI 17-4 PH STEEL
IARM-23B

ANALYTICAL REFERENCE MATERIALS INTERNATIONAL CERTIFICATE OF A CERTIFIED REFERENCE MATERIAL

Grade : AISI 17-4 PH
Part Number (Q.A. NO.) : IARM-23B

Certificate No. : 23B-053098-AUM-F

Certification Date : 05/30/98

INTERPRETATION OF DATA

1. Certified values listed below reflect analysis results submitted by qualified analytical laboratories using a combination of methods and instrumentation that emulate actual methods and instrumental techniques currently utilized in the analytical community. Parentheses () is a "best estimate" and is NOT CERTIFIED. The data could not be quantified sufficiently for certification. It was, however, reported by enough laboratories to be considered as potentially present in the matrix of the material being examined.
2. The "Inter-laboratory Analysis Program" (ILAP) utilized in the establishment of the data is an ongoing program with permanent membership. Certain elements may be selected by a consensus of the members for more extensive testing. Therefore the data in parentheses () below the individual element's concentration.
3. The "Confidence Interval" in 95% is enclosed by a parentheses () below the individual element's concentration.

IMPORTANT : A "USER REGISTRATION CARD" ACCOMPANIES ALL SUBSAMPLINGS. THIS CARD SHOULD BE COMPLETED IMMEDIATELY UPON RECEIPT OF MATERIALS WITH THE APPROPRIATE USER INFORMATION. THIS IS THE ONLY WAY IN WHICH ARMCAN GUARANTEE CUSTOMER UPDATES OR POSSIBLE DATA MODIFICATIONS!

ALUMINUM	BORON	CARBON	COBALT	CHROMIUM	COPPER	MANGANESE	MOLYBDENUM
0.0011 (0.0011)	0.0007 (0.0004)	0.034 (0.0007)	0.038 (0.0037)	15.21 (0.0356)	3.67 (0.0342)	0.81 (0.0082)	0.19 (0.0078)
NITROGEN	NIOBIUM	NICKEL	OXYGEN	PHOSPHORUS	SILICON	SULFUR	TIN
0.0334 (0.0010)	0.22 (0.0042)	4.10 (0.0132)	0.0035 (0.0004)	0.014 (0.0016)	0.40 (0.0157)	0.009 (0.0009)	
TITANIUM	VANADIUM	TUNGSTEN					
0.002 (0.0007)	0.003 (0.0015)	0.020 (0.0049)					

The laboratories participating in the "Inter-Laboratory Analysis Program" (ILAP) and certification of this material are as follows :

Allegheny Ludlum Corp., Brackenridge, PA 15014
 Armeto Research & Technology, Midfield, OH 45043
 Chicago Spectro Service Laboratories, Chicago, IL 60638
 Earle M. Jorgensen Co., Seattle, WA 98108
 Laboratory Testing, Inc., Dublin, PA 19177
 Lockheed Martin Astronautics, Littleton, CO 80127
 Metal Analysis Inc., Huntington Park, CA 90255
 Southern California Edison, San Clemente, CA 92672
 Wisconsin Centrifugal, Inc., Waukegan, WI 53188

TRACEABILITY : All members of the "Inter-Laboratory Analysis Program" (ILAP) listed above validate test methods and instrument performance utilizing SRMs produced by the National Institute of Standards and Technology (NIST) as well as other CRMs and SRMs produced by recognized Certifying Bodies from around the world. This specific SRM, CRMs and SRMs applicable to the material covered by this certificate are :

NIST C2400, DS 58F, 17-4PH, 17-4PHB, NIST 348, 345, 123b, 160b, 133b, 101b, IARM 23A, NIST 1235, IARM 23A, LECO 301-644

A specific line of irreducibility is established to NIST and other Certifying Bodies for those elements that are used as "Certified Values" on the Certificates of Analysis referenced above.

SEE REVERSE SIDE FOR STATISTICAL DATA AND ADDITIONAL INFORMATION REGARDING THIS MATERIAL

SC2201

HASTELLOY C-22
IARM-65B

ANALYTICAL REFERENCE MATERIALS INTERNATIONAL
PROVISIONAL CERTIFICATE
CERTIFICATE OF A CERTIFIED REFERENCE MATERIAL

Grade: Hast C-22

Part Number (Q.A.NO.): IARM-65B

Certification Date: 03/04/98

Certificate No.: 65B-030498-ARM-P

INTERPRETATION OF DATA

1. Certified values listed below reflect analysis results submitted by qualified analytical laboratories using a combination of methods and instrumentation that emulate actual methods and instrumental techniques currently utilized in the analytical community.
2. Any data reported and enclosed by a parentheses () is a "best estimate", and is NOT CERTIFIED. This data could not be quantified sufficiently for certification. It was however, reported by enough laboratories to be considered as potentially present in the matrix of the material being examined.
3. The "Interlaboratory Analysis Program" (ILAP) utilized in the establishment of the data is an ongoing program with permanent membership. Certain elements may be selected by a consensus of the members for more extensive testing. Therefore the data in brackets [] indicates further testing is in process.
4. Second number represents the 95% Confidence Interval.

IMPORTANT: A "USER REGISTRATION CARD" ACCOMPANIES ALL SHIPMENTS. THIS CARD SHOULD BE COMPLETED IMMEDIATELY UPON RECEIPT OF MATERIALS WITH THE APPROPRIATE USER INFORMATION. THIS IS THE ONLY WAY IN WHICH ARMI CAN GUARANTEE CUSTOMERS UPDATES OR POSSIBLE DATA MODIFICATIONS!

<u>NICKEL</u> [3.73]	<u>IRON</u> [3.73]	<u>COBALT</u> [0.60]	<u>MANGANESE</u> [0.29]	<u>SULFUR</u> [0.001]	<u>COPPER</u> [0.053]
<u>CHROMIUM</u> [21.31]	<u>TUNGSTEN</u> [2.85]	<u>VANADIUM</u> [0.15]	<u>ALUMINUM</u> [0.28]	<u>TITANIUM</u> [0.006]	<u>LEAD</u> [0.006]
<u>BORON</u> [0.005]	<u>CARBON</u> [0.005]	<u>PHOSPHORUS</u> [0.006]	<u>MAGNESIUM</u> [0.005]	<u>SILICON</u> [0.025]	<u>MOLYBDENUM</u> [13.11]
<u>NIOBIUM</u> [0.03]	<u>ZIRCONIUM</u> [0.03]	<u>TANTALUM</u> [0.03]	<u>TIN</u> [0.045]	<u>NITROGEN</u> [0.045]	<u>OXYGEN</u> [0.045]

The laboratories participating in the "Interlaboratory Analysis Program" (ILAP) and certification of this material are as follows:

Allegheny Ladium Corporation, Brackenridge, PA
Allegheny Ladium Corporation, Lockport, NY
Chicago Spectro Service Laboratory, Inc., Chicago, IL
Cannon Muskegon, Muskegon, MI
Teledyne AStar, Monroe, NC
Howmet Alloy Division, Dover, NJ
Metals Analysis Incorporated, Huntington Beach, CA

Inco Alloys International, Inc., Huntington, WV
Haynes International, Inc., Kokomo, IN
Anderson Laboratories, Inc., Greendale, WI
Lockheed-Martin Astronautics, Littleton, CO
Laboratory Testing, Inc., Dublin, PA
Howmet Corp., Metals Controls Lab, Whitehall, MI

TRACEABILITY TO NIST: Members of the "Interlaboratory Analysis Program" (ILAP) listed above validate test methods and instrument performance utilizing SRMs produced by the National Institute of Standards & Technology, (NIST). Validation may be in the form of one or both of two independent methods described as follows:

1. Selected laboratories from the above listing are furnished SRMs that have been chosen as the best available "Type Standards" in relation to the matrix composition of the test materials being analyzed. These SRMs are provided by and at the expense of Analytical Reference Materials International, Inc. The data resulting from these examinations therefore becomes the common "point of reference" for all testing and subsequent data results for all IARMSTM certified by Analytical Reference Materials International, Inc. thereby establishing a specific line of "Traceability" to the U.S. Department of Commerce, National Institute of Standards & Technology, (NIST).
2. At the option of ARMI and/or in the absence of currently available SRMs that are matrix compatible with ARMI program materials, other NIST/NBS materials classically resident in the ILAP member lab may be used for the characterization of ILAP materials. Validation by this method requires that the ILAP member have on file with ARMI an affidavit verifying the use of the SRMs accompanied by a copy of the NIST/NBS Certificates of Analysis as they apply to that matrix group.

Either one or both of these methods establishes a specific line of traceability to NIST for those elements that are noted as "certified values" on the NIST Certificates of Analysis applicable to the SRMs referenced on the ARMI Certificate of Analysis.

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FIGURE 3

LDUA MATERIALS VERIFICATION TESTING

XRF Spectra Collected at LDUA Verification Test Locations
LDUA-01 through LDUA-15

Consisting of 16 Pages

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LDUA15

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