

Title: Compilation and Analysis of Test Results for Hunt Valves
Engineering Evaluation No.: EV-C-814-03-003
ESO No.: Z66150

KEY WORDS: 1-inch UF6 Cylinder Valve, Hunt Valve

1.0 Summary

Independent testing by USEC and contract laboratory services has determined there is no conclusive evidence to support that 1-inch UF6 cylinder valves manufactured by Hunt Valve Company deviate from the USEC specification and ANSI N14.1 requirements.

2.0 Detailed Problem Statement

USEC committed to the NRC to develop a plan to perform independent testing of 1-inch UF6 cylinder valves to demonstrate acceptability of the valves without reliance on information supplied by Hunt Valve Company (Reference 4.1). A portion of the plan was to confirm the valves complied with ANSI N14.1. A sample of valves was pressure tested per ANSI N14.1 requirements and also analyzed using hardness, tensile and chemical composition testing to ensure compliance with ANSI. This evaluation provides a compilation and analysis of test results.

3.0 Assumptions

None

4.0 References

- 4.1 Letter to NRC from USEC dated November 18, 2002 (GDP 02-0106), *Action Plan Summary-Evaluation of NRC Concerns with Hunt Valve Cylinder Valves*
- 4.2 ANSI N14.1-1990, *American National Standard for Nuclear Materials – Uranium Hexafluoride – Packaging for Transport*
- 4.3 PGDP Operability Evaluation OE-C-822-02-006, Rev. 1, *UF6 Cylinder Valve Failed Hydrostatic Pressure Test*, issued under EN-C-822-02-036, Rev. 1
- 4.4 PGDP Operability Evaluation OE-C-822-02-002, Rev. 0, *1" and 3/4" Hunt Cylinder Valve Stem Evaluation*, issued under EN-C-822-02-021, Rev. 0
- 4.5 PGDP Operability Evaluation OE-C-826-01-002, Rev. 0, *Potentially Defective UF6 Cylinder Valves*, issued under EN-C-826-01-043, Rev. 0
- 4.6 PGDP Engineering Evaluation EV-C-814-01-016, Rev. 0, *1 Inch UF6 Cylinder Valves*
- 4.7 PORTS Operability Evaluation OE-MC-2002-0246, Rev. 0, *Year 2000 UF6 Cylinder Valve Stem Issues*
- 4.8 PORTS Operability Evaluation OE-CO-2001-0079, Rev. 0, *UF6 Cylinder Valve Thread Engagement*
- 4.9 PGDP Operability Evaluation OE-C-822-02-005, Rev. 2, *Potentially Defective UF6 Cylinder Valve Packing Nuts*, issued under EN-C-822-03-001, Rev. 0
- 4.10 USEC JSP-532, Latest Revision, *Specification for One-Inch Angle Drum Valves for Uranium Hexafluoride Service*.
- 4.11 ASTM E8-01, *Standard Test Methods for Tension Testing of Metallic Materials*

REVIEWED FOR
CLASSIFICATION

SOH 4527 2/14/03
Initials Date

UNCLASSIFIED
NOT UCNI

5.0 Impact on Nuclear Safety

There are 2 functions of the cylinder valve: Q function is *liquid UF6 boundary and system integrity*, and AQ-NCS function is *liquid UF6 boundary and at C-360 Transfer Station process piping, designed to meet the maximum expected system pressure (100 psig)*

References 4.3 through 4.9 provide detailed descriptions of the safety function and impact on operations at PGDP. This Engineering Evaluation only addresses compliance with ANSI standards and does not introduce any additional nuclear safety issues not already reviewed and dispositioned by the reference documents.

6.0 Evaluation

6.1 ANSI N14.1

The following information is contained in ANSI N14.1-1990 and provides the specifications that must be met for 1-inch UF6 cylinder valves.

ANSI-N14.1-1990, Material Specifications

- Body, CDA alloy 636
- Packing Nut, Port Cap
 - Aluminum bronze, CDA 636
 - Stress relieve bar at 700°F for 1 hour min.
 - Hardness of Rockwell B70 to B85
 - UTS 45,000 psi min.
 - YS 25,000 psi min.
 - Elongation in 2 inches, 30% min.
 - Stress relieve after machining at 700°F for 1 hour min.
 - Nickel Copper (monel) ASTM B164, NO4400
 - Stress relieve bar at 1100°F for 1 hour min.
 - Mechanical properties for B164
 - Stress relieve after machining at 1100°F for 1 hour min.
 - Aluminum bronze, ASTM B150, C61300
 - Stress relieve bar at 800°F for 1 hour min.
 - Mechanical properties for B150
 - Stress relieve after machining at 800°F for 1 hour min.
- Packing Follower, Packing Ring
 - Aluminum bronze, CDA 636 or B150, C61300 as noted above
- Stem
 - Monel, ASTM B164, class A or B (Note: Although stated as class A and B in ANSI N14.1-90, ASTM B164 does not list alloys by class. The two alloys for the valve stem are N04400 or N04405)
 - Stress relieved at 1025°F for 1.5 hours min.
- Packing, Cap Gasket
 - Virgin TFE

Material Certification Requirements

- Aluminum bronze: chemical composition, tensile strength, yield strength and hardness (per ASTM B249)
- Certifications for each lot or size, report shall include heat number
- Monel: manufactured and tested per ASTM B164

Pneumatic pressure test at 400 psig, no leakage allowed

6.2 Components Evaluated

Components of concern for this evaluation are mainly the valve stems and packing nuts. The valve body, port cap, packing follower, packing ring, packing, cap gasket, solder and lubricant are not intended to be specifically analyzed since they are not suspect.

ANSI N14.1 contains optional materials for the packing nut and stem. Hunt Valves currently specified by USEC contain packing nuts manufactured from aluminum bronze, ASTM B150, C61300 and stems made from ASTM B164, N04400.

6.3 Hardness Testing

6.3.1 Valve Stems

Per ASTM B164-98, Mechanical Properties, a hardness measurement of B60 to B75 is expected for annealed bar with a tensile strength of 70,000 psi (minimum). For cold worked material (stress relieved) the tensile strength is 87,000 psi (minimum). USEC equipment specification JSP-532 requires a minimum stem hardness of 81 Rockwell B which has a tensile strength of approximately 90,000 psi. The increased hardness reduces the probability of twisting the valve stem during operation of the valve.

Two monel valve stems were selected for testing, one was from a suspect lot and the other is a control.

Table 1
Hardness Test Summary

Component	Measured Values	Average
HV-30 stem (top) Non-suspect heat code control item	94.2, 94.1, 93.1, 92.4, 93.1	93.4
HV-10 stem (top) Suspect heat code	94.2, 93.7, 94.2, 93.6, 93.3	93.8
HV-10 stem (inside)	94.0, 92.8, 92.9, 93.0, 94.5	93.4

Note: Laboratory notes are located in Appendix 1 to this document.

Based on the testing summarized in this section, HV-10 and HV-30 valve stems meet the USEC specification and thus the ANSI N14.1 requirement for hardness.

6.3.2 Packing Nuts

ASTM B150-98 does not specifically list a hardness requirement for CDA C61300 material. Since no conclusions could be drawn from hardness information the tests were not made. Tensile properties discussed in the next section will determine compliance with ANSI.

6.4 Tensile Testing

6.4.1 Valve Stems

ASTM B164-98 provides a relationship between hardness and tensile strength for N04400 material. No further tensile measurements were required to determine compliance with ANSI.

6.4.2 Packing Nuts

Table 2 of ASTM B150-98 provides tensile strength requirements for Alloy UNS C61300. For drawn and stress relieved hexagonal rod and bar the minimum tensile strength for material over 1" to 2" inclusive (distance between parallel surfaces) is 70,000 psi. It is important to note that packing nuts for 1-inch UF6 cylinder valves have a dimension across the flats of 2-1/16" which is outside the specified range in ASTM B150. Minimum tensile strength requirements listed in Table 2 of ASTM B150-98 decrease in value as the distance between parallel surfaces increases. For 1/2" and under stock the tensile strength minimum is 80,000 psi and for over 1/2" to 1" inclusive the minimum is 75,000 psi.

Appendix 2 contains actual lab reports for tensile testing. Five tensile specimens were machined from each selected packing nut. Table 2 below shows the resulting average for each packing nut. A sample of bar stock from Ansonia Brass was also tested and is designated as A-1. During initial testing of HV-19 a specimen failed in a brittle laminar mode perpendicular to the specimen width, another specimen was included in the results and is noted as HV-19X.

Table 2
Tensile Test Summary

Valve ID	Tensile Strength Average, psi
HV-2	74,920
HV-4	73,685
HV-6	75,010
HV-10	70,084
HV-12	78,308
HV-18	78,193
HV-19	77,663
HV-20	72,744
HV-30	71,627
HV-44	68,949
HV-19X (Retest)	79,724
A-1	78,080

As shown above all the packing nut tensile values meet the ASTM requirement for 1" to 2" stock except HV-44. The average of tested values for HV-44 is only 1-1/2 percent less than the minimum of 70,000 psi. One tensile specimen from HV-44 (44-2, tensile strength of 70,101 psi) actually met the minimum requirement.

ASTM E8-01, Appendix X1, *Factors Affecting Tension Test Results*, discusses factors that may have an adverse effect on tension test results. It is stated that the precision and bias depend on strict adherence to the stated test procedure and are influenced by instrumental and material factors, specimen preparation, and measurement/testing errors.

The packing nut bar stock for HV-44 was manufactured by Ampco Metal, Inc. This company provided a Certification of Chemical and Mechanical Tests report (Appendix 3) stating tensile test values of 79,500 and 78,500 psi in accordance with ASTM E8. These values are based on tensile testing performed on the bar stock, not the machined nut. Tensile specimens taken from bar stock are

typically machined with the long axis parallel to the direction of the extrusion. When performing tensile testing after a component is machined it is sometime not possible to machine the specimen to obtain the preferred orientation parallel to the direction of extrusion. This was the case for the packing nut. The specimen had to be oriented perpendicular to the extrusion direction. There is no data available that shows a comparison of tensile values versus grain direction for CDA 61300 material.

The size of the PGDP test specimens also was not an industry standard. Due to the packing nut configuration the maximum gage length obtainable was 0.625 inches. Typical industry gage length for tensile specimens is 2 inches. Reducing the specimen size increases the bias.

The information introduced above is provided to show possible errors that may be encountered for comparison of PGDP tensile testing results versus information provided by Hunt Valve Company. For HV-44 the average value for PGDP tensile results fall below the minimum requirement of 70,000 psi. However, since the value is only 1-1/2% less it is not conclusively a non-compliance with ANSI N14.1 based on these results. All other packing nuts met ANSI N14.1.

Based on the information summarized in this section there is no conclusive evidence to support a deviation from USEC specification and ANSI N14.1 requirements for packing nut tensile strength.

6.5 Chemical Composition Testing

A contract was initiated with an independent testing laboratory to perform chemical analysis of valve stems and packing nuts to confirm compliance with ANSI N14.1 and ASTM standards. Two valve stems and ten packing nuts were analyzed. A sample matrix was developed and is provided in Appendix 4 showing the correlation between the valve ID number and the heat code.

6.5.1 Valve Stems

Appendix 4 contains the lab test reports from Dirats Laboratories. For the valve stems a quantitative analysis by X-Ray Fluorescence and Combustion was used. The results for HV-10 and HV-30 meet ANSI N14.1 and ASTM chemical composition requirements.

6.5.2 Packing Nuts

Appendix 4 contains the lab test reports from Dirats Laboratories. For the packing nuts a quantitative analysis by Inductively Coupled Plasma-Optical Emission was used. The results for packing nuts meet ANSI N14.1 and ASTM chemical composition requirements.

Based on the testing summarized in this section, valve stems and packing nuts meet USEC specification and ANSI N14.1 requirements for chemical composition.

6.6 Pressure Testing

Pressure testing of a sample of cylinder valves was performed at PGDP. The testing duplicated to the maximum extent possible the method in ANSI N14.1, Section 6.15.8. The intent of the testing and sampling method chosen was to

ensure a 95/95 confidence level that valves would pass the pressure test. The test is performed at 400 psig and the valve passes if there is no leakage. One valve (HV-40) in the sample population of 129 valves failed the seat leakage test. Another valve (HV-41) leaked by the seat initially but passed the test after cleaning the seat and retesting.

There were no valve body failures, packing leakage or packing nut cracking evident at the conclusion of testing. The cause of the seat leakage failure is apparently debris imbedded in the seating surface. The debris may be a result of thread machining/deburring practices resulting in aluminum bronze filings being generated from the valve body threaded area as the valve is operated. Final root cause determination of the valve leakage is pending USEC laboratory analysis of additional leaking valve samples and will not be available prior to finalizing this evaluation. Based on results to date and USEC Operability Evaluations the valves are considered degraded but remain operable.

7.0 Conclusions and Recommendations

Independent testing by USEC and contract laboratory services has determined there is no conclusive evidence to support a material deviation from the USEC specification and ANSI N14.1 requirements for 1-inch UF6 cylinder valves manufactured by Hunt Valve Company.

Prepared By: TL Fletcher / [Signature] Date: 2/14/03
 (Printed Name) (Signed Name)

Reviewed By: D. C. Mason / [Signature] Date: 02/14/03
 (Printed Name) (Signed Name)

Approved By: E. K. Voci / [Signature] Date: 2/14/2003
 (Printed Name) (Signed Name)
 MANAGER, DESIGN ENGINEERING

Subject Hardness Measurement on HV-10 and HV-30 Valve Stems

Date 1 15 15 2003
Month Day Year

Continued from Page No. _____

Hardness - Standard - 96.4 ± 0.7 (96.3, 96.3, 96.8, 97.1, 96.8) No A

HV-30 Stem 94.2, 94.1, 93.1, 92.4, 93.1 $\Rightarrow 93.4 \pm 0.8$

S-1 Stem ~~83.8, 81.6~~ in constant readings on end -

(6) center of threads - insertion 76.5, 78.2, 78.6, 77.4, 79.5 $\Rightarrow 78.0 \pm 1.1$

HV-10 94.2, 93.7, 94.2, 93.6, 93.3 - 93.8 ± 0.9 Stem top

94.0, 92.8, 92.9, 93.0, 94.5 - 93.4 ± 1.1 Stem inside

hardness measurements taken 1/1/03

Per ASTM Standards B-164-98
 "Nickel - Copper Alloy Rod, Bar and Wire"
 Table 1 Mechanical Properties of
 Rod and Bar a hardness measurement
 of B60 to B75 is expected for annealed Bar
 tensile 70,000 psi (minimum)
 for Cold Worked (stress relieved) - tensile 87,000 min

ASTM 14.1 States: "Stem, Part 2, Bar material
 ASTM B164, Class A or B, cold drawn and
 stress relieved to 1025°F for 1/2 hour min."

JSP-532 over rides ANSI and states
 "Maximum hardness after machining
 81 RB" \rightarrow

HV-30 "Control" (not suspect) and HV-10
 (suspect lot) both meet the JSP-532
 Requirement, Hardness $> 81 RB$ on the Stem.

HV-30 93.4 ± 0.8 , HV-10 93.8 ± 0.4

Continued on page _____

Bryan F. D'Arcy 1/15/03
Recorded by Date

Read and understood by Date

APPENDIX 2

Valve	Specimen	Thick (in)	Width (in)	Area (sq in)	Load at Failure (lbs)	Tensile Strength (psi)	Tested Length (in)	Elong. (%)
44	1	0.099	0.050	0.004950	340	68686.9	0.875	40.0
44	2	0.099	0.050	0.004950	347	70101.0	0.875	40.0
44	3	0.099	0.051	0.005049	343	67934.2	0.843	34.9
44	4	0.099	0.050	0.004950	344	69494.9	0.875	40.0
44	5	0.099	0.051	0.005049	346	68528.4	0.875	40.0
					Average	68949.1		39.0
4	1	0.100	0.050	0.005000	369	73800.0	0.890	42.4
4	2	0.099	0.050	0.004950	367	74141.4	0.906	45.0
4	3	0.100	0.050	0.005000	370	74000.0	0.906	45.0
4	4	0.099	0.051	0.005049	369	73083.8	0.875	40.0
4	5	0.100	0.050	0.005000	367	73400.0	0.875	40.0
					Average	73685.0		42.5
19	1	0.099	0.050	0.004950	346	69899.0	0.825	0.0
19	2	0.099	0.050	0.004950	395	79798.0	0.765	22.4
19	3	0.099	0.050	0.004950	390	78787.9	0.781	25.0
19	4	0.099	0.051	0.005049	400	79223.6	0.765	22.4
19	5	0.099	0.050	0.004950	399	80606.1	0.781	25.0
					Average	77662.9		18.9
30	1	0.101	0.050	0.005050	355	70297.0	0.843	34.9
30	2	0.100	0.051	0.005100	366	71764.7	0.859	37.4
30	3	0.100	0.050	0.005000	361	72200.0	0.843	34.9
30	4	0.100	0.051	0.005100	368	72156.9	0.828	32.5
30	5	0.099	0.050	0.004950	355	71717.2	0.843	34.9
					Average	71627.2		34.9
10	1	0.100	0.051	0.005100	355	69607.8	0.859	37.4
10	2	0.100	0.050	0.005000	352	70400.0	0.875	40.0
10	3	0.100	0.051	0.005100	354	69411.8	0.859	37.4
10	4	0.100	0.050	0.005000	352	70400.0	0.875	40.0
10	5	0.100	0.050	0.005000	353	70600.0	0.875	40.0
					Average	70083.9		39.0
12	1	0.102	0.050	0.005100	389	76274.5	0.828	32.5
12	2	0.102	0.050	0.005100	397	77843.1	0.828	32.5
12	3	0.100	0.050	0.005000	393	78600.0	0.828	32.5
12	4	0.101	0.050	0.005050	404	80000.0	0.796	27.4
12	5	0.100	0.051	0.005100	402	78823.5	0.812	29.9
					Average	78308.2		30.9
18	1	0.100	0.051	0.005100	399	78235.3	0.796	27.4
18	2	0.100	0.051	0.005100	402	78823.5	0.828	32.5
18	3	0.100	0.052	0.005200	407	78269.2	0.796	27.4
18	4	0.100	0.050	0.005000	387	77400.0	0.796	27.4
18	5	0.100	0.051	0.005100	399	78235.3	0.828	32.5
					Average	78192.7		29.4

APPENDIX 2
(cont.)

2	1	0.100	0.050	0.005000	373	74600.0	0.843	34.9
2	2	0.100	0.050	0.005000	373	74600.0	0.843	34.9
2	3	0.100	0.050	0.005000	377	75400.0	0.843	34.9
2	4	0.100	0.050	0.005000	380	76000.0	0.859	37.4
2	5	0.100	0.050	0.005000	370	74000.0	0.859	37.4
					Average	74920.0		35.9
6	1	0.099	0.050	0.004950	373	75353.5	0.843	34.9
6	2	0.099	0.050	0.004950	369	74545.5	0.843	34.9
6	3	0.100	0.050	0.005000	375	75000.0	0.843	34.9
6	4	0.099	0.050	0.004950	372	75151.5	0.859	37.4
6	5	0.100	0.050	0.005000	375	75000.0	0.843	34.9
					Average	75010.1		35.4
20	1	0.099	0.050	0.004950	362	73131.3	0.828	32.5
20	2	0.099	0.050	0.004950	356	71919.2	0.828	32.5
20	3	0.099	0.050	0.004950	363	73333.3	0.843	34.9
20	4	0.100	0.050	0.005000	359	71800.0	0.843	34.9
20	5	0.099	0.050	0.004950	364	73535.4	0.843	34.9
					Average	72743.8		33.9
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19	X	0.099	0.050	0.004950	397	80202.0	0.796	27.4
19	2	0.099	0.050	0.004950	395	79798.0	0.765	22.4
19	3	0.099	0.050	0.004950	390	78787.9	0.781	25.0
19	4	0.099	0.051	0.005049	400	79223.6	0.765	22.4
19	5	0.099	0.050	0.004950	399	80606.1	0.781	25.0
					Average	79723.5		24.4
A1	1	0.100	0.050	0.005000	387	77400.0	0.843	34.9
A1	2	0.100	0.050	0.005000	394	78800.0	0.859	37.4
A1	3	0.100	0.050	0.005000	390	78000.0	0.843	34.9
A1	4	0.100	0.050	0.005000	390	78000.0	0.828	32.5
A1	5	0.100	0.050	0.005000	391	78200.0	0.843	34.9
					Average	78080.0		34.9

TENSION TESTING OF MATERIALS DATA SHEET

Test HU 44

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
44-1	0.099	0.050	0.00495	68686.9	NA	40.0	NA
44-2	0.099	0.050	0.00495	70101.0	NA	40.0	NA
44-3	0.099	0.051	0.005049	67934.2	NA	34.9	NA
44-4	0.099	0.050	0.00495	69494.9	NA	40.0	NA
44-5	0.099	0.051	0.005049	68528.4	NA	40.0	NA
			Average of 5	68949.1	NA	39.0	NA

Test Notes: GL = 0.625

Test HU 2

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
2-1	0.100	0.050	0.0050	74600.0	NA	34.9	NA
2-2	0.100	0.050	0.0050	74600.0	NA	34.9	NA
2-3	0.100	0.050	0.0050	75400.0	NA	34.9	NA
2-4	0.100	0.050	0.0050	76000.0	NA	37.4	NA
2-5	0.100	0.050	0.0050	74000.0	NA	37.4	NA
			Average of 5	74920.0	NA	35.9	NA

Test Notes: GL = 0.625

Performed By: D. J. Anderson 1-27-03 Reviewed By: D. J. Anderson 2/4/03

TENSION TESTING OF MATERIALS DATA SHEET

Test HV 4

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
4-1	0.100	0.050	0.0050	73800.0	NA	42.4	NA
4-2	0.099	0.050	0.00495	74141.4	NA	45.0	NA
4-3	0.100	0.050	0.0050	74000.0	NA	45.0	NA
4-4	0.099	0.051	0.005049	73053.8	NA	40.0	NA
4-5	0.100	0.050	0.0050	73400.0	NA	40.0	NA
			Average of 5	73685.0	NA	42.5	NA

Test Notes: GL = 0.625

Test HV 19

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
19-1	0.099	0.050	0.00495	69899.0	NA	0	NA
19-2	0.099	0.050	0.00495	79798.0	NA	22.4	NA
19-3	0.099	0.050	0.00495	78787.9	NA	25.0	NA
19-4	0.099	0.051	0.005049	79223.6	NA	22.4	NA
19-5	0.099	0.050	0.00495	80606.1	NA	25.0	NA
			Average of 5	77662.9	NA	18.9	NA

Test Notes: GL = 0.625
19-1 FAILED in a Brittle Laminate Mode
Perpendicular to the Specimen Width

Performed By: DE Wood 1-27-03 Reviewed By: Byrd D. Mc 2/4/03

TENSION TESTING OF MATERIALS DATA SHEET

Test HV 19

Material Description Packaging Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
19-X	0.099	0.050	0.004950	80202.0	NA	27.4	NA
			Average of 5				

Test Notes: GL - 0.625"

Test A1

Material Description Bar stock - ANSONIA BRASS

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
A1-1	0.100	0.050	0.0050	77400.0	NA	34.9	NA
A1-2	0.100	0.050	0.0050	78800.0	NA	37.4	NA
A1-3	0.100	0.050	0.0050	78000.0	NA	34.9	NA
A1-4	0.100	0.050	0.0050	78000.0	NA	32.5	NA
A1-5	0.100	0.050	0.0050	78200.0	NA	34.9	NA
			Average of 5	78080.0	NA	34.9	NA

Test Notes: GL = 0.625"

Performed By: DE Underwood 1-27-03 Reviewed By: Bryant D. Dene 2/4/03

TENSION TESTING OF MATERIALS DATA SHEET

Test HU 30

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
30-1	0.101	0.050	0.00505	70297.0	NA	34.9	NA
30-2	0.100	0.051	0.0051	71764.7	NA	37.4	NA
30-3	0.100	0.050	0.0050	72200.0	NA	34.9	NA
30-4	0.100	0.051	0.0051	72156.9	NA	32.5	NA
30-5	0.099	0.050	0.00495	71717.2	NA	34.9	NA
			Average of 5	71627.2	NA	34.9	NA

Test Notes: GL = 0.625

Test HU 10

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
10-1	0.100	0.051	0.0051	69600	NA	37.4	NA
10-2	0.100	0.050	0.0050	70400.0	NA	40.0	NA
10-3	0.100	0.051	0.0051	69411.8	NA	37.4	NA
10-4	0.100	0.050	0.0050	70400.0	NA	40.0	NA
10-5	0.100	0.050	0.0050	70600.0	NA	40.0	NA
			Average of 5	70083.9	NA	39.0	NA

Test Notes: GL = 0.625

Performed By: DE Caldwell 1-27-03 Reviewed By: James J. Jones 2/4/03

TENSION TESTING OF MATERIALS DATA SHEET

Test HV6

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
6-1	0.099	0.050	0.00495	75353.5	NA	34.9	NA
6-2	0.099	0.050	0.00495	74575.5	NA	34.9	NA
6-3	0.100	0.050	0.0050	75000.0	NA	34.9	NA
6-4	0.099	0.050	0.00495	75151.5	NA	37.4	NA
6-5	0.100	0.050	0.0050	75000.0	NA	34.9	NA
			Average of 5	75010.1	NA	35.4	NA

Test Notes: GL = 0.625

Test HV20

Material Description Packing Nut CDA 613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
20-1	0.099	0.050	0.00495	73131.3	NA	32.5	NA
20-2	0.099	0.050	0.00495	71919.2	NA	32.5	NA
20-3	0.099	0.050	0.00495	73333.3	NA	34.9	NA
20-4	0.100	0.050	0.0050	71800.0	NA	34.9	NA
20-5	0.099	0.050	0.00495	73535.4	NA	34.9	NA
			Average of 5	72743.8	NA	33.9	NA

Test Notes: GL = 0.625

Performed By: D. G. [Signature] 1-27-03 Reviewed By: [Signature] 2/4/03

TENSION TESTING OF MATERIALS DATA SHEET

Test HV 12

Material Description Packing Unit CDA-613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
12-1	0.102	0.050	0.0051	76274.5	NA	32.5	NA
12-2	0.102	0.050	0.0051	77843.1	NA	32.5	NA
12-3	0.100	0.050	0.0050	75600.0	NA	32.5	NA
12-4	0.101	0.050	0.00508	80000.0	NA	27.4	NA
12-5	0.100	0.051	0.0051	78823.5	NA	29.9	NA
			Average of 5	78308.2	NA	30.9	NA

Test Notes: GL = 0.625"

Test HV 10

Material Description Packing Unit CDA-613

Specimen Designation	Width (in)	Thick (in)	Area (in ²)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Reduction of Area (%)
18-1	0.100	0.051	0.0051	78235.3	NA	27.4	NA
18-2	0.100	0.051	0.0051	78823.5	NA	32.5	NA
18-3	0.100	0.052	0.0052	78269.2	NA	27.4	NA
18-4	0.100	0.050	0.0050	77400.0	NA	27.4	NA
18-5	0.100	0.051	0.0051	78235.3	NA	32.5	NA
			Average of 5	78192.7	NA	29.4	NA

Test Notes: GL = 0.625"

Performed By: DE Odgerswood 1-27-03 Reviewed By: Byron F. DeNune 9/4/03

Certification of Chemical and Mechanical Tests

Unclassified

ISO 9002 Certified

HUNT VALVE CO INC - SALEM, OH
 Date Signed 31-Aug-00

Ampco Metal

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Ampco Metal certifies that all items, including this report and the results of tests and values listed hereon are in full conformance with all purchase order and specification requirements. Further, the values shown represent the actual values obtained during testing, using the sample selection and test methods specified in the applicable material specification. It is also understood that knowingly and willfully falsifying or concealing a material fact on this form, or making false, fictitious or fraudulent statements or representations hereon could constitute a felony punishable under Federal Statutes. All material supplied is also free from mercury alpha or radium contamination and was melted in the U.S.A.

INCORPORATED

1745 South 38th Street
 P.O. Box 2004, Milwaukee, WI 53201
 414/645-3750
 FAX 414/645-3225

Your P.O. 2935	Date Shipped 08/31/00
Our Order No. 18599	Quantity 498#, 875 PCS
Your Part No. Item 1	Specification Ampco 8 Extruded, Drawn & Stress Relieved Hex
UF6-503-3	Finish Machined
UF6-503-X REV B DATED 12-1-93	ASTM-B150-95a, 98 C61300 HR50
PACKING NUT	Navy Level 1
Produced from 2-1/16" Hex stock	Special Annealing Instructions:
LOT AXN PRODUCED FROM HEAT# C24608	Stress Relieve at 800-820 Degrees F.
	For 1 Hour at Temp.

Nil=Less than .01%

CHEMICAL ANALYSIS

Lot Number	AXN	AXN			
No. Pieces					
✓ Copper Incl. Silver	90.68	90.72			
✓ Aluminum	6.53	6.53			
✓ Iron	2.47	2.42			
✓ Nickel incl Cobalt	0.03	0.03			
✓ Manganese	0.01	0.01			
✓ Tin	0.26	0.27			
✓ Lead	Nil	Nil			
✓ Zinc	0.01	0.01			
✓ Silicon	0.01	0.01			
✓ Phosphorus	0.003	0.001			
✓ Others	Nil	Nil			

TRACEABILITY
 CODE: AXN

MECHANICAL PROPERTIES

✓ Tensile ksi.	79.5	78.5			
✓ Yield ksi. at .5% Ext.	43.0	43.3			
✓ Elong. %, 4D	41.0	41.0			

OTHER TESTS

Visual & Dimensional	OK				
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CHEMICAL ANALYSIS PER FED-STD-151 UNLESS OTHERWISE NOTED.
 MECHANICAL TESTING PERFORMED IN ACCORDANCE WITH ASTM-E8.

Issued by Ampco Metal, Milwaukee, WI
 Unless indicated otherwise.

Unless otherwise noted all tests performed by Ampco

AMPCO METAL
 Mary E. Kulas

Mary E. Kulas

Authorized Representative
 Material Control
 Material Certification Analyst

ASTM B150 REV. 95A GR. C61300
 AXN CODE AXN
 CWY 9/6/00

Unclassified

P/N: 07-999-8175 REV.A
 P/O: 566948
 I.OT # 200027-70

APPENDIX 4

Dirats Laboratory Sample Matrix

Per the NRC Information Notice the suspect lots are:

AXP, AFD, AFM, ATE, AFB, AFC, AXN, BXN, BXP, CCF, CCG for packing nuts

PEN and PFV for stems

Hunt Valve	Packing Nut	Suspect	Stem	Suspect	Valve Lot	Heat
HV-2	AXP*	yes	PFV	Yes	200027-61	FAU
HV-4	AFC*	yes	PFX	No	200027-61	DZD
HV-6	AFB*	yes	PGE	No	200027-86	JUE
HV-10	AFD*	yes	PFV*	Yes	200027-70	JSO
HV-12	BXP*	yes	PFV	Yes	200027-70	JSO
HV-18	CCF*	yes	PFV	Yes	200027-71	JTQ
HV-19	CCG*	yes	PGE	No	200027-84	KDS
HV-20	BXN*	yes	PGE	No	200027-84	JTD
HV-30	BXM*	No	PGE*	No	200027-82	KDT
HV-44	AXN*	yes	PFX	No	200027-20	DZD
S-1	614	No	∞*	No	7805-6	06
A-1	613*	No	NA	No	Na	Na
* Samples to Test	11		3			

HV-40 (failed pressure test)	CCF	yes	PGE	No	200027-85	JDN
---------------------------------	-----	-----	-----	----	-----------	-----

S-1 Superior Valve – over 10 years old stem from previous vendor.

A-1 Ansonia bar stock from different supplier

HV-10 Both packing nut and stem are from suspect lots

HV-30 Neither packing nut nor stem are from suspect lots (CONTROL SAMPLE).

APPENDIX 4

(cont.)



DIRATS
LABORATORIES

TEST REPORT

Bryan DeNeve
United States Enrichment Corp.
5600 Hobbs Road
MS-7210
Paducah, KY 42202-1410

Report Number 380393
Report Date 23-JAN-03
Page 1 of 2
Client Number 865400
Client Order 636737
Release Item #1

RECEIVED 1 Section Bar Stock Approx. 1 1/2"lg. and 10 Nuts
IDENT AS Follows For Work Number 549571 Rev. O
MATERIAL C61300
TEST TO ASTM B150-98 Alloy C61300
FAX 270-441-5941

PROPERTIES AS SUPPLIEDQUANTITATIVE ANALYSIS BY ICP-OE

Sample	Required	A-1	HV-2	HV-4	HV-6
%					
Ag	Report	<0.002	<0.002	<0.002	<0.002
Al	6.0-7.5	6.84	6.61	6.54	6.57
Co	Report	<0.01	<0.01	<0.01	<0.01
Cu	Report	90.18	90.59	90.74	90.76
Fe	2.0-3.0	2.62	2.53	2.47	2.43
Mn	0.20 max.	0.01	0.01	0.01	0.01
Ni	Report	<0.01	<0.01	<0.01	<0.01
P	0.015 max.	<0.002	<0.002	<0.002	<0.002
Pb	0.01 max.	<0.002	<0.01	<0.002	<0.002
Si	0.10 max.	0.02	0.01	<0.01	<0.01
Sn	0.20-0.50	0.32	0.24	0.23	0.22
Zn	0.10 max.	<0.01	<0.01	<0.01	<0.01
Cu + Ag	REM	REM	REM	REM	REM
Ni + Co	0.15 max.	<0.01	<0.01	<0.01	<0.01
Disp:		In Spec	In Spec	In Spec	In Spec

The symbol < signifies not detected at the detectability limit indicated.

APPENDIX 4
(cont.)



TEST REPORT

United States Enrichment Corp.
Paducah, KY 42202-1410

Report Number
Report Date
Page

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23-JAN-03
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Sample	Required	HV-10	HV-12	HV-18	HV-19
%					
Ag	Report	<0.002	<0.002	0.004	0.005
Al	6.0-7.5	6.64	6.34	6.41	6.34
Co	Report	<0.01	<0.01	<0.01	<0.01
Cu	Report	90.62	91.04	90.76	91.00
Fe	2.0-3.0	2.49	2.37	2.54	2.38
Mn	0.20 max.	0.01	0.01	0.01	0.01
Ni	Report	<0.01	<0.01	0.01	0.01
P	0.015 max.	<0.002	<0.002	0.003	0.007
Pb	0.01 max.	<0.002	<0.002	0.009	0.007
Si	0.10 max.	<0.01	0.01	0.01	0.02
Sn	0.20-0.50	0.23	0.22	0.23	0.21
Zn	0.10 max.	<0.01	<0.01	<0.01	<0.01
Cu + Ag	REM	REM	REM	REM	REM
Ni + Co	0.15 max.	<0.01	<0.01	0.01	0.01

Disp: In Spec In Spec In Spec In Spec

Sample	Required	HV-20	HV-30	HV-44
%				
Ag	Report	<0.002	0.003	<0.002
Al	6.0-7.5	6.40	6.37	6.34
Co	Report	<0.01	<0.01	<0.01
Cu	Report	90.91	91.07	90.96
Fe	2.0-3.0	2.43	2.29	2.41
Mn	0.20 max.	0.01	0.01	0.01
Ni	Report	<0.01	0.01	<0.01
P	0.015 max.	<0.002	<0.002	<0.002
Pb	0.01 max.	<0.002	<0.002	<0.002
Si	0.10 max.	0.01	0.01	0.01
Sn	0.20-0.50	0.23	0.23	0.26
Zn	0.10 max.	<0.01	<0.01	<0.01
Cu + Ag	REM	REM	REM	REM
Ni + Co	0.15 max.	<0.01	0.01	<0.01

Disp: In Spec In Spec In Spec

The symbol < signifies not detected at the detectability limit indicated.



WE CERTIFY THIS IS A TRUE COPY OF OUR RECORDS
Signed for J. Dirats and Co. by Eric E. Dirats, Audit Manager

NOTE: The recording of false, fictitious or fraudulent statements or entries on this document may be punished as a felony under federal law.

APPENDIX 4
(cont.)



TEST REPORT

Bryan DeNeve
United States Enrichment Corp.
5600 Hobbs Road
MS-7210
Paducah, KY 42202-1410

Report Number 380394
Report Date 23-JAN-03
Page 1 of 2
Client Number 865400
Client Order 636737
Release ITEM #2

RECEIVED 3 Sections Machined Parts
IDENT AS Follows For Work Number 549571 Rev. O
MATERIAL Monel 400/Monel 405
CONDITION *
TEST TO ASTM B164-98 Alloy N04400 and ASTM B164-98 Alloy N04405
TEST PER *
PURPOSE *

FAX 270-441-5941

PROPERTIES AS SUPPLIED

ASTM B164-98 ALLOY N04400

QUANTITATIVE ANALYSIS BY XRF, COMB.

Sample	S-1	HV-10	HV-30
%			
Cu	28.0-34.0	32.05	31.64
Fe	2.5 max.	1.42	1.76
Mn	2.0 max.	0.96	1.01
Ni	63.0 min.	64.69	64.75
Si	0.5 max.	0.25	0.15
C	0.3 max.	0.12	0.14
S	0.024 max.	0.001	<0.001
Others,			
Cr	0.24	0.37	0.14
Disp:	In Spec	In Spec	In Spec

APPENDIX 4
(cont.)



TEST REPORT

United States Enrichment Corp.
Paducah, KY 42202-1410

Report Number
Report Date
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23-JAN-03
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ASTM B164-98 ALLOY N04405

QUANTITATIVE ANALYSIS BY XRF, COMB.

Sample	S-1		HV-10	HV-30
%				
Cu	28.0-34.0	32.05	31.64	32.26
Fe	2.5 max.	1.42	1.76	2.30
Mn	2.0 max.	0.96	1.01	0.99
Ni	63.0 min.	64.69	64.75	63.92
Si	0.5 max.	0.25	0.15	0.15
C	0.3 max.	0.12	0.14	0.14
S	0.025-0.060	0.001*	<0.001*	<0.001*
Others,				
Cr		0.24	0.37	0.14
Disp:		Off Spec	Off Spec	Off Spec

The symbol < signifies not detected at the detectability limit indicated.



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Signed for J. Dirats and Co. by Eric E. Dirats, Audit Manager

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