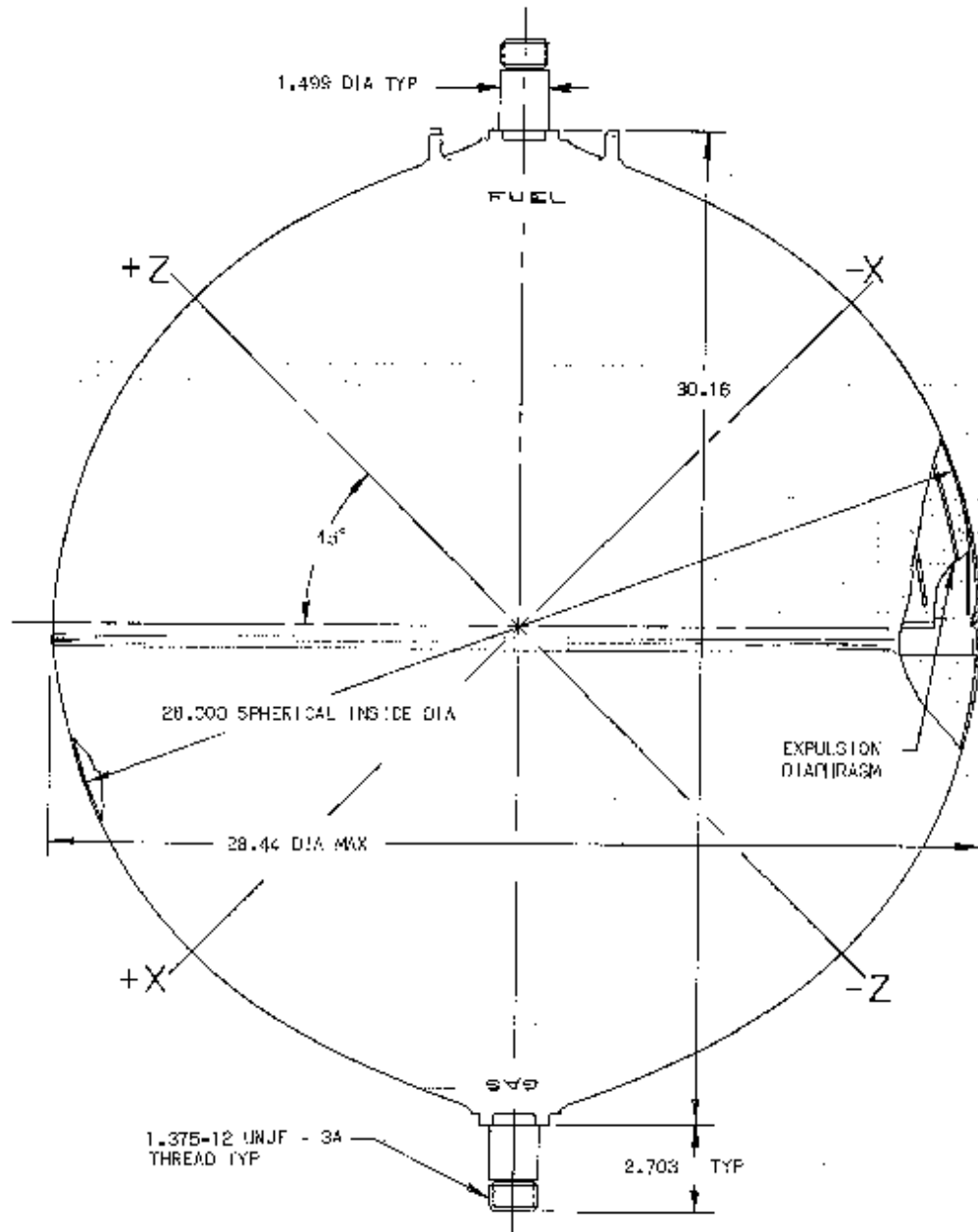


QUALIFICATION ENVIRONMENTS
FOR
APUS TANK, FUEL, DIAPHRAGM
ATK P/N 80228-1

Specimen Configuration

FIGURE 1
FUEL TANK CONFIGURATION



**Table 1: P/N 80228-1 APUS Tank, Fuel, Diaphragm
Specifications**

Parameters	Requirements
Operating Pressure	355 psig
Proof Pressure	970 psig, Actual Proof: 970 psig
Burst Pressure	1071 psig, Actual Burst: 1071 psig, Rupture @ 1321 psig
External Pressure	0.25 psia
Internal Vacuum	Not tested
Material of Construction	Spherical 6AL-4V titanium tank fabricated from closed die forgings and machine welded at the girth. Fluid connections are made with MS33649 Bosses located in the mounting bosses and two thermostat mounting lugs are provided adjacent to the fuel port boss.
Membrane Thickness	0.047"
Tank Mount(s)	Mounting is accomplished using polar bosses located normal to the plane of the girth weld.
Expulsion Efficiency	99.2 %
Design Fill Fraction	-
Tank Capacity	11371.9 in ³
Internal Dimensions	28.00" Ø spherical
Tank Weight	Maximum tank weight is 43.0 lbs, Actual tank weight is 41.63 lbs
Propellant Capacity	291 lbs N ₂ H ₄
Shell Leakage	<1x10 ⁻⁶ std cc/sec He max, Actual: none
Failure Mode	Burst
Natural Frequency	-
Temperature Environment	-
On Orbit Life	-

80228-1 was subjected to the following qualification tests:

<u>TEST NUMBER</u>	<u>TITLE</u>
1	ACCEPTANCE TEST
2	PRESSURE HOLD
3	LOW TEMPERATURE TEST
4	INTERNAL VOLUME
5	EXTERNAL LEAKAGE
6	INTERNAL LEAKAGE
7	RADIOGRAPHIC INSPECTION
8	PENETRANT INSPECTION
9	EXPULSION CYCLE LIFE TEST
10	INTERNAL LEAKAGE
11	PRESSURE CYCLE LIFE TEST
12	EXTERNAL LEAKAGE
13	INTERNAL LEAKAGE
14	TRANSIENT VIBRATION
15	RANDOM VIBRATION TEST
16	EXTERNAL LEAKAGE
17	RADIOGRAPHIC INSPECTION
18	PENETRANT INSPECTION
19	DESIGN SHOCK
20	EXTERNAL LEAKAGE
21	ACCELERATION TEST
22	EXTERNAL LEAKAGE
23	DEPLETION PRESSURE TEST
24	INTERNAL LEAKAGE
25	SLOSH TEST
26	EXPULSION EFFICIENCY
27	INTERNAL LEAKAGE
28	RADIOGRAPHIC INSPECTION
29	PENETRANT INSPECTION
30	EXTERNAL PRESSURE TEST
31	BURST RUPTURE TEST

The following tests are listed in this document.

- 1) Proof Pressure Test
- 2) Pressure Hold Test
- 3) Low Temperature Test
- 4) Pressure Cycle Life Test
- 5) External Pressure Test
- 6) Transient/ random Vibration and Design Shock
- 7) Acceleration Test
- 8) Slosh Test
- 9) External Pressure Test
- 10) Burst Rupture Test

Proof Pressure Test
 Tank is pressurized to 970 psig.



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 APPENDIX C
 PAGE C29

DATA SHEET D
 PROOF PRESSURE TEST

DATE 5-21-1976
 PART NAME TANK, FUEL, DIAPHRAGM (APUS)
 PSI PART No. 80228-1 "D"
 PSI SERIAL No. 18229CLASS100.0.6

TEST EQUIPMENT: GAUGE 0978 CALIB DUE 11-20-76

TEST MEDIUM: DISTILLED AND DEIONIZED WATER					
				TEST VALUE	REQUIREMENT
PROOF PRESSURE				<u>970 PSIG</u>	970 OR .05% OFFSET, WHICHEVER IS LESS
PRESSURE PSIG	Δ VOLUME ML	PRESSURE PSIG	Δ VOLUME ML	PRESSURE PSIG	Δ VOLUME ML
500	4000	700	3369	880	2792
520	3929	720	3305	900	2724
540	3869	740	3241	910	2692
560	3810	760	3178	920	2660
580	3748	780	3110	930	2624
600	3684	800	3053	940	2593
620	3622	820	2985	950	2555
640	3558	840	2921	960	2521
660	3494	860	2858	970	2486
680	3429				

TIME TO DEPRESSURIZE (TO 500 PSI) 12 15 SEC MAX.
 TIME ABOVE 267 PSIG 11 MINUTES

Pressure Hold

The tank is loaded with 291 ± 4 lbs of hydrazine and pressurized to 355, +20/-0 psig with helium gas. The tank's temperature is raised to 125°F.

The tank is stabilized at this condition for a period of 90 days.



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APPENDIX D
PAGE D3



DATA SHEET C
PRESSURE HOLD TEST

TEST No. 2 PARA. 4.2



PSI PART No. 80228-L

PSI SERIAL No. 18229CL435100.06

TEST EQUIPMENT: SEE FIGURE #1 APPENDIX B

	TEST VALUE	TEST REQUIREMENT
A) WEIGHT SCALE READING AFTER TRAP OR LINE FILL	<u>530</u> LBS	N/A
B) WEIGHT SCALE READING AFTER SPECIMEN FILL	<u>235</u> LBS	N/A
C) PROPELLANT FILL WEIGHT (A) - (B)	<u>295</u> LBS	291 ± 4 LBS 
D) THERMOCOUPLE A	<u>127</u> °F	$125^{\circ}\text{F} +10$ -0
E) THERMOCOUPLE B	<u>128</u> °F	$125^{\circ}\text{F} +10$ -0
F) FILL PRESSURE	<u>363</u> PSIG	$355 +20$ -0 PSIG 
G) HISTORICAL RECORD P & T VS TIME	<u>SEE LOG SHEET</u>	N/A
H) WEIGHT SCALE READING AFTER TRAP FILL AND BEFORE EXPULSION	<u>235</u> LBS	N/A
I) WEIGHT SCALE READING AT FIRST BUBBLE	<u>530</u> LBS	N/A
J) FUEL REMAINING AT FIRST BUBBLE = C - (I - H)	<u>0</u> LBS	N/A
K) TOTAL GAS ACCUMULATION	<u>120</u> SCC	N/A

TEMPERATURE 75°F BEFORE EXPULSION

TESTED BY MO. HAA  DATE 9-29-76 SPECIMEN PASSED 

Low Temperature Test

The tank's temperature is decreased to -40°F, +0°F/-10°F and stabilized for 120, +10/-0 minutes.



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APPENDIX D
PAGE D4

DATA SHEET D LOW TEMPERATURE TEST

DATE 9-29-76

PART NAME TANK, FUEL, DIAPHRAGM (APUS)

TEST No. 3 PARA. 4.3

PSI PART No. 80228-L

PSI SERIAL No. 18229CLASS100 06

TEST EQUIPMENT: SEE EQUIPMENT LIST - APPENDIX B

SPECIMEN GAS PRESSURE	<u>9</u> PSIG	<u>5</u> PSIG MIN
SPECIMEN TEMPERATURE	<u>-42</u> °F	<u>-40</u> ⁺⁰ <u>-10</u> °F
TIME AT TEMPERATURE	<u>125</u> MINUTES	<u>120</u> ⁺¹⁰ <u>-0</u> MINUTES

TESTED BY M. J. HAM DATE 9-29-76 SPECIMEN PASSED ✓ Yes

Pressure Cycle Life Test

The tank is filled with hydrazine, and the tank is pressurized from 0 psig to 355, +20/-0 psig to 0 psig. Number of cycles is 600.

Tank's temperature is also stabilized at 125°F.



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APPENDIX D
PAGE 011

DATA SHEET 1

PRESSURE CYCLE LIFE TEST

DATE 10-25-76

PART NAME TANK, FUEL, DIAPHRAGM (APUS)

PSI PART No. 80223-L

PSI SERIAL No. 13229CLASS10006

TEST No. 11 PARA. 4.5

TEST EQUIPMENT: SEE EQUIPMENT LIST - APPENDIX B

	<u>TEST VALUE</u>		<u>REQUIREMENT</u>				
A) HIGH PRESSURE LIMIT	<u>(RECORD IN TABLE) PSIG</u>		<u>355 +20 -0 PSIG</u>				
B) LOW PRESSURE LIMIT	<u>(RECORD IN TABLE) PSIG</u>		<u>0 +40 -0 PSIG</u>				
C) CHAMBER TEMPERATURE	<u>(RECORD IN TABLE) °F</u>		<u>125 +10 -0 °F</u>				
D) NUMBER OF CYCLES	<u>600</u> CYCLES		<u>600</u> MINIMUM				
E) TOTAL CYCLES FROM DATA SHEET H	<u>200</u> CYCLES						
F) TOTAL PRESSURE CYCLES (D+E)	<u>800</u>		<u>800</u> CYCLES MIN				
CYCLE No.	<u>1</u>	<u>100</u>	<u>200</u>	<u>300</u>	<u>400</u>	<u>500</u>	<u>600</u>
HIGH PRESSURE	<u>370 PSIG</u>	<u>370 PSIG</u>	<u>370 PSIG</u>	<u>370 PSIG</u>	<u>370 PSIG</u>	<u>370 PSIG</u>	<u>370 PSIG</u>
LOW PRESSURE	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
TEMPERATURE	<u>130°F</u>	<u>130°F</u>	<u>130°F</u>	<u>130°F</u>	<u>130°F</u>	<u>130°F</u>	<u>130°F</u>

TESTED BY M. Q. H. A. DATE 10-25-76 SPECIMEN PASSED YES



External Pressure Test

An external pressure difference of .25 psia is applied to the tank for five minutes
No visual damage is observed.



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APPENDIX D
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DATA SHEET N
EXTERNAL PRESSURE TEST

TEST No. 30, PARA. 4.10

TEST EQUIPMENT GAUGE ST0363 DUE 11-21-76


TE 11-9-76

RT NAME TANK, FUEL, DIAPHRAGM (APUS)

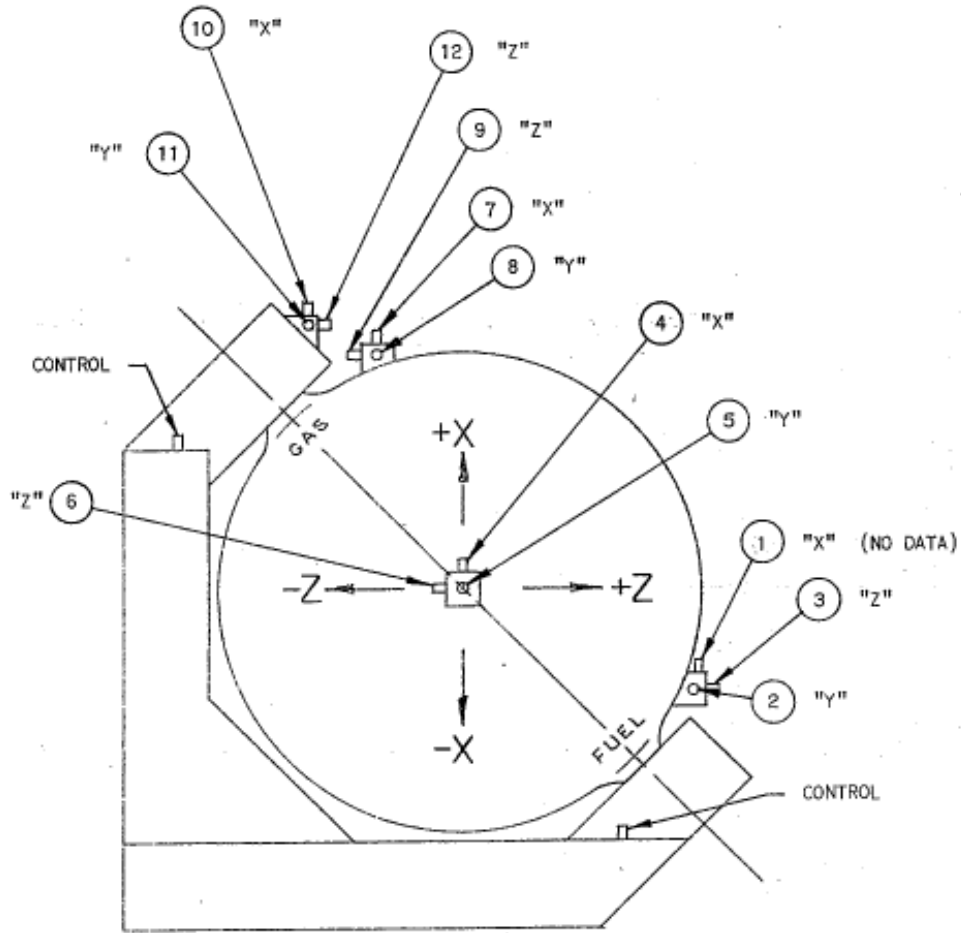
PSI PART No. 80228-1

PSI SERIAL No. 18229CLASS100 06

	TEST RESULTS	REQUIREMENT
SPECIMEN DIFF. PRESSURE	<u>0.25</u> PSIA	0.5 PSIA MAXIMUM
TEST DURATION	<u>5</u> MINUTES	5.0 ^{+0.5} / ₀ MINUTES
OBSERVATIONS:	<u>NONE</u>	

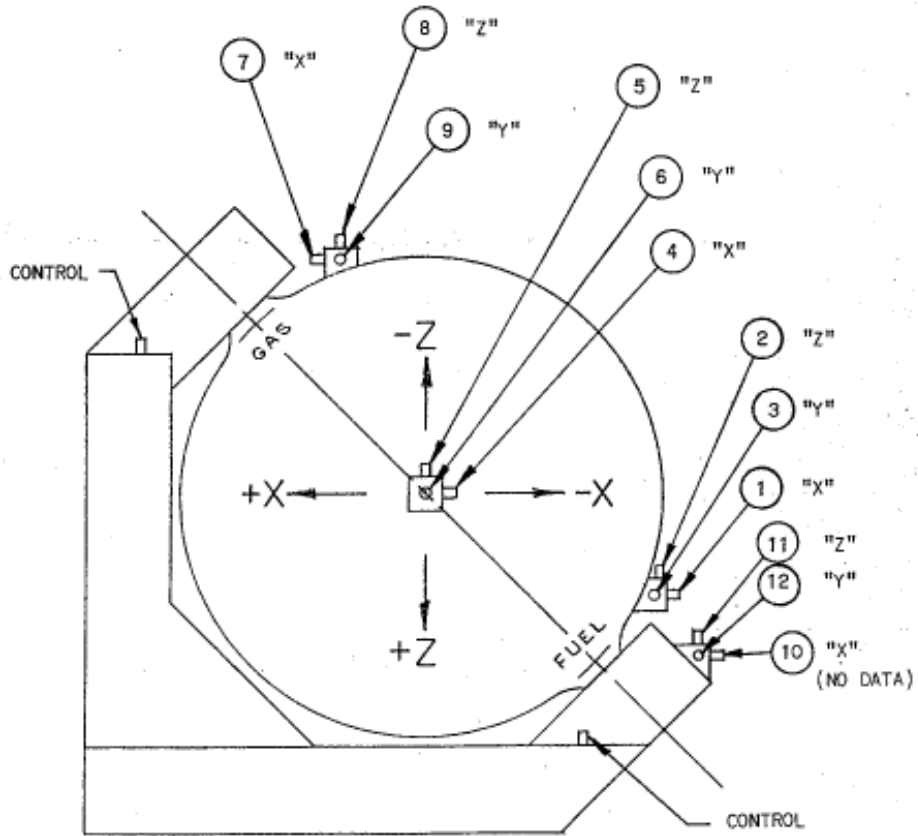
TESTED BY Lee Rose  DATE 11-9-76 SPECIMEN PASSED YES

Vibration Test Set-Up

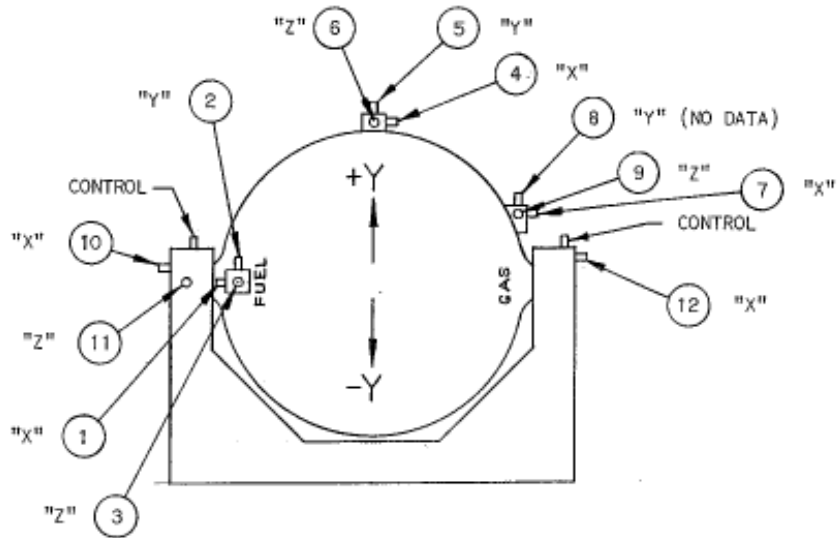
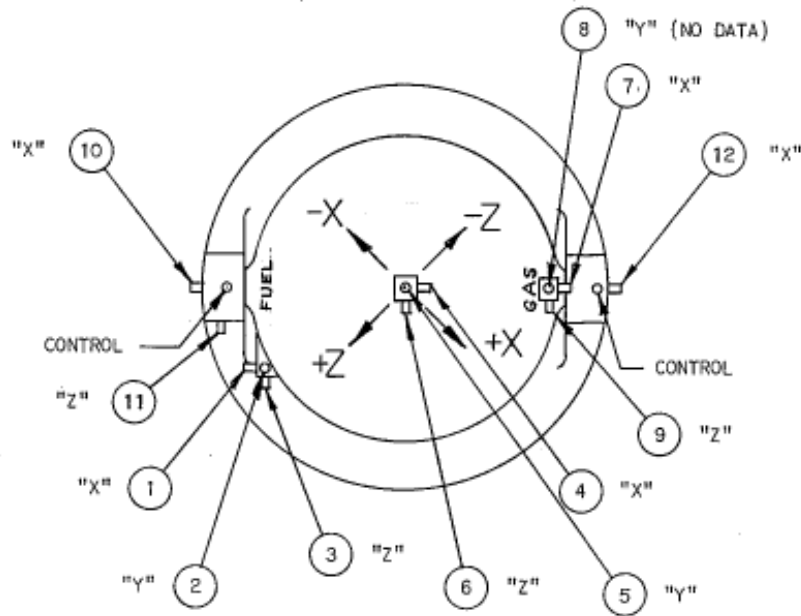


TRANSIENT VIBRATION

"X" AXIS ACCELEROMETER LOCATIONS



TRANSIENT VIBRATION
"Z" AXIS ACCELEROMETER LOCATIONS



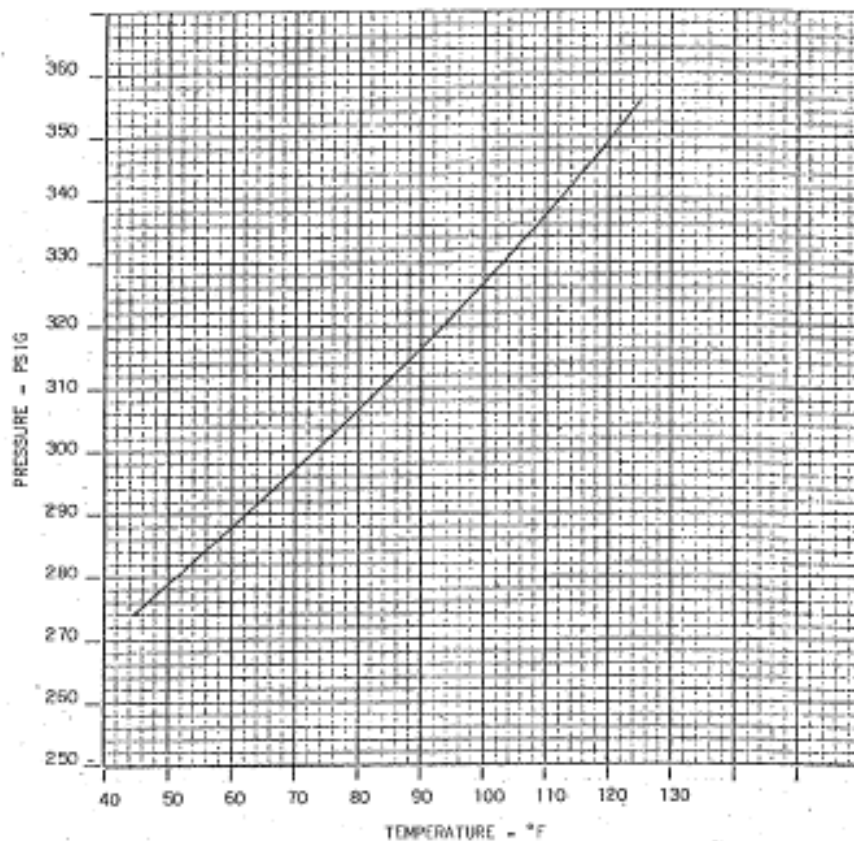
TRANSIENT VIBRATION
 "Y" AXIS ACCELEROMETER LOCATIONS

Transient Vibration (Wet)

A sinusoidal sweep is made from 5 to 2000 Hz.

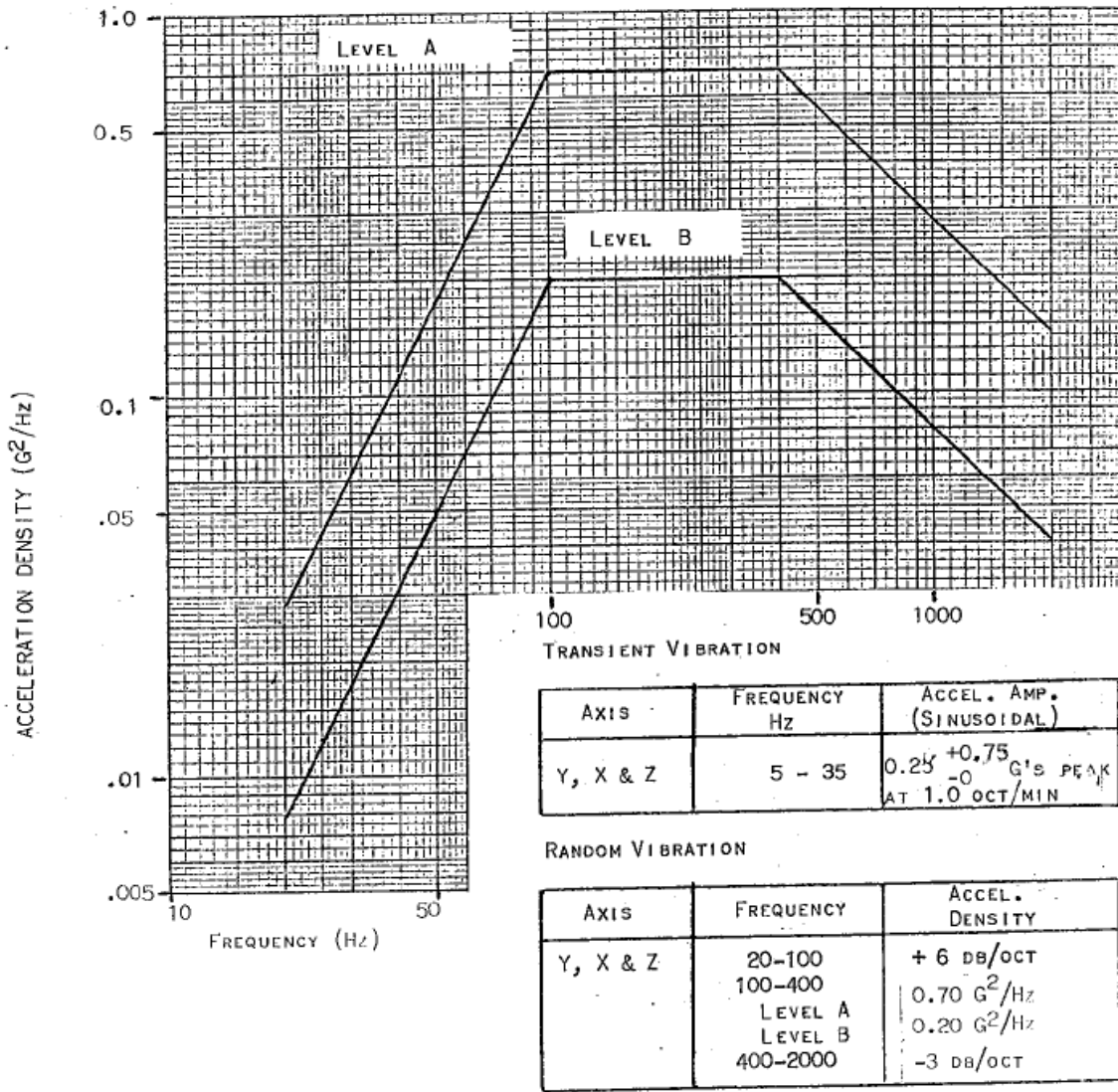
Sweep rate is 1 octave/minute at an acceleration amplitude of 0.25, +0.75/-0 g zero-to-peak.

The tank is loaded with 288 ± 4 lbs of distilled, deionized water and pressurized according to the graph below. Water temperature was 74° , thus the pressure was 300 psig.



FILL PRESSURE VS. TEMPERATURE RELATIONSHIP
FOR A 291 LB. HYDRAZINE OR A 288 LB. WATER LOAD

Random Vibration (Wet)



B

VIBRATION SPECTRUM DIAGRAM

FIGURE 5

Design Shock

The tank is subjected to three 20 ± 2 g terminal sawtooth shock pulses of 11 ± 1 milliseconds duration.

Test is conducted in each direction in each of the three mutually perpendicular axes.

DATA SHEET J
TRANSIENT/RANDOM VIBRATION
AND DESIGN SHOCK

DATE 11/30/76 thru 12/10/76 v.br.
12-8-76 shock

PART NAME TANK, FUEL, DIAPHRAGM (APUS)

TEST No. 14, 15 & 19
PARA. 4.6.2, 4.6.3 & 4.6.7

PSI PART No. 60228-1

PSI SERIAL No. 13229CLASS100.0.6

TEST EQUIPMENT: See Attached data sheet

VIBRATION TESTS	TEST RESULTS			TEST REQUIREMENTS
	Y AXIS	X AXIS	Z AXIS	
LOADED WATER WEIGHT	<u>288 LBS</u>	<u>288 LBS</u>	<u>288 LBS</u>	<u>288 ± 4 LBS</u>
WATER TEMPERATURE	<u>74 °F</u>	<u>74 °F</u>	<u>74 °F</u>	<u>FIGURE 2 +20</u>
FILL PRESSURE	<u>300 PSIG</u>	<u>300 PSIG</u>	<u>300 PSIG</u>	<u>-0 PSIG</u>
EXPELLED WATER WEIGHT		<u>70 LBS.</u>	<u>70 LBS.</u>	<u>70 ± 5 LBS</u>
FINAL PRESSURE		<u>175 PSIG</u>	<u>190 PSIG</u>	
DESIGN SHOCK				
RAMP AMPLITUDE	<u>+Y 20 G's</u>	<u>-Y 20 G's</u>	}	<u>20 ± 2 G's</u>
	<u>+X 20 G's</u>	<u>-X 20 G's</u>		
	<u>+Z 20 G's</u>	<u>-Z 20 G's</u>		
PULSE DURATION	<u>+Y 11 MS</u>	<u>-Y 11 MS</u>	}	<u>11 ± 1 MS</u>
	<u>+X 11 MS</u>	<u>-X 11 MS</u>		
	<u>+Z 11 MS</u>	<u>-Z 11 MS</u>		
<i>Specimen unloaded and unpressurized during shock test.</i>				

TESTED BY Daniel Edlester DATE 12-8-76 SPECIMEN PASSED



Acceleration Test

The tank was loaded with 288 ± 4 lbs of water.

Water temperature was 55°F, so the tank was pressurized to 290 psig.

The tank is subjected to an acceleration of 5, +1/-0 g's in each of the six axes corresponding to the three orthogonal planes.

Test duration is a minimum of 5 minutes in each direction.

DATA SHEET K

ACCELERATION TEST

TEST No. 21 PARA. 4.7

DATE 12-20-1976

PART NAME TANK, FUEL, DIAPHRAGM (APUS)

PSI PART No. 80228-1

PSI SERIAL No. 18229CLASS10006

TEST EQUIPMENT: SEE EQUIPMENT LIST

	TEST VALUE	REQUIREMENTS
LOADED WATER WT.	<u>292</u> LBS	288 ±4 LBS
WATER TEMPERATURE	<u>55</u> °F	
FILL PRESSURE	<u>290</u> PSIG	FIG. 2 ⁺²⁰ ₋₀ PSIG
ARM LENGTH	<u>18.5 ± 16.25</u> FT	NA
AXIS ROTATION +Y <u>28.2</u> RPM	ACCEL. = <u>5 (222)²</u> G's	5 +1, -0 G's
-Y <u>30</u> RPM	ACCEL. = <u>5 (195)²</u> G's	5 +1, -0 G's
+X <u>28.2</u> RPM	ACCEL. = <u>5 (222)²</u> G's	5 +1, -0 G's
-Z <u>30</u> RPM	ACCEL. = <u>5 (195)²</u> G's	5 +1, -0 G's
+Z <u>28.2</u> RPM	ACCEL. = <u>5 (222)²</u> G's	5 +1, -0 G's
-X <u>30</u> RPM	ACCEL. = <u>5 (195)²</u> G's	5 +1, -0 G's
$\text{ACCELERATION} = \frac{(\text{RPM} \times \frac{2\pi}{60})^2 \times \text{ARM LENGTH (FT)}}{32.2} = \text{G's}$		

TESTED BY Walter Williams DATE 12-20/76 SPECIMEN PASSED POST TEST. P4

Slosh Test

The tank was loaded with 288 ± 4 lbs of water.

Water temperature was 62°F , so the tank was pressurized to 290 psig.

TEST SEQUENCE	TEST AXIS	SPECIMEN LOAD LBS. H ₂ O (% RATED LOAD)		TEST REQUIREMENT		
				DOUBLE AMPLITUDE INCHES	FREQUENCY Hz	(1) IMPULSES
1	Y	260	(90)	3.0	0.5	4000
2	Y	BLOWDOWN TO EXPELL 116 LBS. WATER (2)				
3	Y	144	(50)	10.0	1.0	2000
4	Y	144	(50)	10.0	0.6	8000
5	Z	260	(90)	3.0	0.5	4000
6	Z	BLOWDOWN TO EXPELL 116 LBS. WATER (2)				
7	Z	144	(50)	10.0	1.0	2000
8	Z	144	(50)	10.0	0.6	8000

NOTES:

- (1) EACH IMPULSE IS DEFINED AS A HALF CYCLE OF THE RECIPROCATING DRIVING MECHANISM.
- (2) THE PRESSURE IN THE SPECIMEN GAS COMPARTMENT SHALL BE ALLOWED TO DECAY AS THE SPECIMEN WATER LOAD IS EXPELLED. (NO REPRESSURIZATION).

DATA SHEET M

SLOSH TEST

DATE 23 DEC 76
 PART NAME TANK, FUEL, DIAPHRAGM (APUS)
 TEST No. 25, PARA. 4.9
 PSI PART No. 80228-
 TEST AXIS Z
 PSI SERIAL No. 18229CLASS100
 TEST EQUIPMENT: SEE EQUIPMENT LIST

	TEST RESULTS	REQUIREMENT
A) SPECIMEN DRY WEIGHT	<u>63</u> LBS	
B) LOADED WATER WEIGHT	<u>290</u> LBS	<u>288 ± 4</u> LBS
C) WATER TEMPERATURE	<u>62</u> °F	
D) GAS COMPARTMENT PRESSURE	<u>290</u> PSIG	PER FIG 2
E) WATER EXPELLED TO ACHIEVE 90% LOAD	<u>30</u> LBS	<u>28 ± 2</u> LBS
F) WATER EXPELLED TO ACHIEVE 50% LOAD	<u>116</u> LBS	<u>116 ± 2</u> LBS
G) SPECIMEN WEIGHT, AFTER BLOWDOWN TO DEPLETION	<u>63.2</u> LBS	
EXPULSION EFFICIENCY: $\left[1 - \frac{G-A}{B} \right] \times 100$	<u>99.93</u> %	<u>98.7</u> %
No. OF 0.5 H ₂ IMPULSES	<u>4200</u>	4000 MIN
No. OF 1.0 H ₂ IMPULSES	<u>2100</u>	2000 MIN
No. OF 0.6 H ₂ IMPULSES	<u>8136</u>	8000 MIN

TESTED BY J. Richard DATE 12-29-76 SPECIMEN PASSED YES

DATA SHEET M

SLUSH TEST

DATE 24 Dec 76
 PART NAME TANK, FUEL, DIAPHRAGM (APUS)
 TEST No. 25, PARA. 4.9
 PSI PART No. 80228-1
 TEST AXIS Y
 PSI SERIAL No. 18229CLASS100
 TEST EQUIPMENT: SEE EQUIPMENT LIST

	TEST RESULTS	REQUIREMENT
A) SPECIMEN DRY WEIGHT	<u>63.2</u> LBS	
B) LOADED WATER WEIGHT	<u>290</u> LBS	<u>288 ± 4 LBS</u>
C) WATER TEMPERATURE	<u>50</u> °F	
D) GAS COMPARTMENT PRESSURE	<u>279</u> PSIG	<u>PER FIG 2</u>
E) WATER EXPELLED TO ACHIEVE 90% LOAD	<u>30</u> LBS	<u>28 ± 2 LBS</u>
F) WATER EXPELLED TO ACHIEVE 50% LOAD	<u>116</u> LBS	<u>116 ± 2 LBS</u>
G) SPECIMEN WEIGHT AFTER BLOWDOWN TO DEPLETION	<u>63</u> LBS	
EXPULSION EFFICIENCY: $\left[1 - \frac{G-A}{B} \right] \times 100$	<u>100</u> %	<u>98.7 %</u>
No. of 0.5 H ₂ IMPULSES	<u>4200</u>	<u>4000 MIN</u>
No. of 1.0 H ₂ IMPULSES	<u>2100</u>	<u>2000 MIN</u>
No. of 0.6 H ₂ IMPULSES	<u>8136</u>	<u>8000 MIN</u>

TESTED BY I. Richard DATE 12-29-76 SPECIMEN PASSED YES

External Pressure Test

The tank is evacuated to a pressure of 0.5 psia, or less, for a duration of 5, +0.5/-0 minutes.



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DATA SHEET M

SLUGH TEST

DATE 24 Dec 76

PART NAME TANK, FUEL, DIAPHRAGM (AFUS)

TEST No. 26
TEST No. 25, PARA. 4.9

PSI PART No. 80228-L

TEST AXIS Y

PSI SERIAL No. 18229CLASS100

TEST EQUIPMENT: SEE EQUIPMENT LIST

	TEST RESULTS	REQUIREMENT
A) SPECIMEN DRY WEIGHT	<u>63.2</u> LBS	
B) LOADED WATER WEIGHT	<u>290</u> LBS	288 ± 4 LBS
C) WATER TEMPERATURE	<u>50</u> °F	
D) GAS COMPARTMENT PRESSURE	<u>279</u> PSIG	PER FIG 2
E) WATER EXPELLED TO ACHIEVE 90% LOAD	<u>30</u> LBS	28 ± 2 LBS
F) WATER EXPELLED TO ACHIEVE 50% LOAD	<u>116</u> LBS	116 ± 2 LBS
G) SPECIMEN WEIGHT AFTER BLOWDOWN TO DEPLETION	<u>63</u> LBS	
EXPULSION EFFICIENCY: $\left[1 - \frac{G-A}{B} \right] \times 100$	<u>100</u> %	98.7 %
No. of 0.5 H ₂ IMPULSES	<u>4200</u>	4000 MIN
No. of 1.0 H ₂ IMPULSES	<u>2100</u>	2000 MIN
No. of 0.6 H ₂ IMPULSES	<u>8136</u>	8000 MIN

TESTED BY I. Richard DATE 12-29-76 SPECIMEN PASSED YES

Burst Rupture Test

The design burst pressure is 1070 psig.

The actual burst pressure was 1321 psig.




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DATA SHEET 0
BURST/RUPTURE PRESSURE TEST

DATE 1-7-77
PART NAME TANK, FUEL, DIAPHRAGM (APUS)
TEST No. 31 PARA. 4.11
PSI PART No. 80228-1
PSI SERIAL No. 18229CLASS100.06
TEST EQUIPMENT: GAUGE L-0978 DUE 7-4-77

	TEST RESULTS	TEST REQUIREMENT
SPECIMEN TEMPERATURE	<u>68</u> °F	80°F MAX.
PRESSURIZATION RATE	<u>100</u> PSI/MINUTE	100 PSI/MINUTE MAX
DESIGN BURST LEVEL		
PRESSURE	<u>1070</u> PSIG	1070 [±] 10 PSIG
DWELL TIME	<u>127</u> SEC.	120 ^{±5} / ₀ SECONDS
RUPTURE PRESSURE	<u>1321</u> PSIG	
OBSERVATIONS:	_____ _____ _____	

TESTED BY [Signature]  DATE 1-7-77 SPECIMEN PASSED Yes

