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WOODS HOLE OCEANOGRAPHIC INSTITUTION

TECHNICAL MEMORANDUM #DS-15
SUMMARY REPORT ON FABRICATION,
INSPECTION AND TEST OF ALVIN
FIXED AND VARIABLE BUOYANCY SPHERES

James W. Mavor, Jr.

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Woods Hole, Massachusetts

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SUMMARY REPORT ON FABRICATION,
INSPECTION AND TEST OF ALVIN
FIXED AND VARIABLE BUOYANCY SPHERES

by

James W. Mavor, Jr.

January 1965

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Introduction

Fifteen aluminum alloy spheres of approximately 2 ft. diameter are used in the research submarine ALVIN for fixed and variable buoyancy. Six of them (GM Dwg. 542019) are made from 6061-T6 alloy and are known as the variable buoyancy spheres (V.B.). The material of the other nine is 7178-T6 alloy. These are known as the fixed buoyancy spheres (F.B.) (GMI Dwg. 542019). This report describes the manufacture, inspection, test and predicted collapse pressure of these spheres. In addition, four additional spheres, two of each type, were tested to failure. Results are reported.

I. Manufacture

A. V.B. Spheres (GMI Dwg.542019)

Originating as 6061-T6 plate, sixteen hemispheres were die forged at the New Kensington, Pennsylvania plant of Aluminum Company of America. The as-forged hemispheres were specified $1.062 \pm .035$ inches thickness. Sufficient forging edge ring was provided to assure sufficient specimen stock. The forged hemispheres in the T6 condition were shipped to the World Tool and Engineering Company in Minneapolis, where they were machined inside and out. The machined hemispheres were then taken to the Northern Ordnance Division, Minneapolis, for welding. The hemispheres were annealed to the O condition, matched dimensionally and TIG welded per MIL W-22248, using a 356-T6 casting alloy filler metal. A back up ring was used and weld was machined outside. The welded spheres were finally solution treated at 1000° F for 10 hours, oil quenched and aged 350° F for 6 hours with air cooling. Final operation was a hard anodize followed by a seven coat application of Laminar X-500 polyurethane coating.

One of the spheres, designated V-1, was used as a trial medium for weld procedure. It was electron beam welded without attaining sufficient strength, heat treated 6 times and finally TIG welded by a procedure similar to the others. Sphere No.16-15 was TIG welded, cut apart, and rewelded because of porosity. It is presently in use in ALVIN. All other spheres were welded satisfactorily the first time and experienced the specified heat treatment cycle at Northern Ordnance T6 to O to T-4 to T-6.

Two of the eight spheres, No.V-1 and No.10-5, were selected on the basis of sphericity, thickness, flaws, and mechanical properties. They were considered the weakest and were tested to failure.

B. F.B. Spheres (GMI Dwg.542018)

Originating as 7178-T6 plate, twenty-two hemispheres were die forged at the New Kensington, Pennsylvania plant of Aluminum Company of America. The as-forged hemispheres were specified $.960 \pm .035$ inches thickness. Sufficient forging edge ring was provided to assure sufficient specimen stock. The forged hemispheres in the T-6 condition were shipped to the World Tool and Engineering Company in

Minneapolis where they were machined inside and out. The hemispheres were delivered to the Applied Science Division, Litton Systems, where they were iridited, then matched dimensionally and assembled metal to metal in a moderate, air atmosphere vacuum. Tests showed maintenance of vacuum for a minimum of 24 hours without sealing band. After assembly the joint was sealed with an equator band of epoxy resin bonded to the sphere and to a polysulfide rubber band. Final operation was a seven coat application of Laminar X-500 polyurethane coating with white finish coat.

Two spheres considered the weakest, B-1 and B-7, were selected and tested to failure.

II. Dimensional Measurement

A. V.B. Spheres (6061-T6)

Thickness measurements by micrometer caliper of each hemisphere before welding were made on two meridians of longitude 90° apart on 4 inch centers. Outside diameters of welded spheres prior to anodize and coating were measured on 4 inch centers around the equator and around two meridians of longitude 90° apart. The results are presented in Ref.4 and summarized in Table I.

B. F.B. Spheres (7178-T6)

Thickness measurements by micrometer caliper of each hemisphere before assembly and prior to iridite were made on two meridians of longitude 90° apart on 4 inch centers. Outside diameters of spheres after final assembly were measured on 4 inch centers around the equator and around two meridians of longitude 90° apart. The results are presented in Ref. 5 and summarized in Table II.

C. In addition to thickness and outside diameter measurements, templates were used to measure outside local radius of curvature. This technique was used with success on the ALVIN pressure hulls and is a quick and very accurate method for this most important measurement. All nineteen spheres were measured using templates manufactured in accordance with Fig. 1. Three templates were made for each type of sphere, one of nominal outside radius of 90° arc length. The other two of length approximately equal (8 inches) to the critical arc length L_C (Ref. 1, p7 and 8).

Of these two, one is of nominal radius and the other of 5% greater radius. If these two templates are placed on top of one another so that the end points coincide, the center of the arc of one will be displaced a distance 0.035 inches, of Ref. 1. The critical length L_c for the V.B. spheres is 7.70 inches and for the F.B. spheres 6.22 inches.

Measurements were made on closer than 1.5 inch centers by placing a template in two positions 90° to one another and gauging the gaps between template and sphere surface by eye. Experience has shown that this gap can be gauged by eye to better than $\pm .005$ inches. Accuracy of $\pm .010$ " was considered adequate for this test representing $\pm 1\%$ change in radius of curvature. It was specified that only measurements exceeding tolerance of 5% would be recorded. None were. The measurements were made by W. O. Rainnie and M.J. McCamis of WHOI and H. Froehlich of Litton.

D. Ultrasonic thickness measurements were made on 2 inch centers of all 19 spheres by WHOI people. Thickness was read to $\pm .005$ inches accuracy. It was specified that readings and location of out of tolerance measurements be recorded. Tolerance was $\pm .020$ inches and all readings were within tolerance.

III. Mechanical and Chemical Properties

A. 6061-T6 V.B. Spheres

1. Chemical properties of plate are certified in Ref.4 and are as follows:

	<u>Si</u>	<u>Fe</u>	<u>Cu</u>	<u>Mn</u>	<u>Mg</u>	<u>Cr</u>	<u>Zn</u>	<u>Ti</u>	<u>Other</u>	
									<u>Each</u>	<u>Total</u>
Max.	0.8	0.7	0.40	.15	1.2	.35	.25	.15	.05	.15
Min.	0.4		0.15		.8	.15				

2. Plate mechanical properties in the T-6 condition are reported in Ref. 4 as

	<u>Tensile Strength(psi)</u>	<u>Yield Strength(psi)</u>	<u>Elongation,%</u>
Max.	49,600	44,000	12
Min.	49,500	44,000	12

3. As forged (T-6) mechanical properties were measured with specimens taken from edge rings and tested at Custom Tool Company, Minneapolis (WHOI P.O.25989). Reports are on file at WHOI and results are as follows:

Compressive Properties from Stress-Strain Curves

<u>Sphere</u>	<u>Comp. 0.2% Y.S. (psi)</u>	<u>Comp. P.L. (psi)</u>
13-2	38,500	29,000
16-15	38,900	30,800
9-3	38,900	30,800
14-4	38,700	30,800
10-5	38,500	28,900
0-17	38,800	30,800
12-8	39,300	30,800

10 mm X 10 mm V-notch Charpy impact specimens tested as follows:

<u>Specimen</u>	<u>Temp.</u>	<u>Impact Energy, (ft.lbs.)</u>
16	-120° F	7.5, 10.0, 8.0
4	-120° F	10.0, 11.0, 10.0
5	-120° F	9.0, 9.5, 10.5
14	-120° F	11.0, 10.5, 9.0
15	-120° F	10.0, 10.5, 10.0

4. Pieces taken from forging end rings from two spheres, identification unknown, were welded using the same procedure and filler (356-T6) that were used in welding the spheres. One such weldment was taken through solution and aging heat treatment with each sphere to give an indication of sphere weld properties. Testing was performed at Northern Ordnance and results are as follows for specimens taken across weld.
(Reported in Ref. 4)

<u>File No.</u>	<u>Heat Treat with sphere</u>	<u>0.2% Comp.Y.S.</u>	<u>0.2% Tens.Y.S.</u>	<u>Tens. U.S.</u>	<u>% Elong. 2</u>	<u>Frac- ture</u>	<u>500 Kg BHN</u>
871	15-16	40,000	39,150	43,650	5	edge of weld	97
864	0-17	42,000	38,500	41,800	3.5	"	96
	12-8	42,500	37,250	41,600	3.5	"	98
863	10-5	42,000	39,500	43,500	4	weld	98
	9-3	41,500	40,600	43,900	5	"	96
859	13-2	41,500	37,750	43,800	6.5	"	97-98
858	14-4	42,000	39,500	44,200	8	"	97-98

The filler 356-T6 is not ordinarily used in welding 6061. It was used because Northern Ordnance experience has been that only this electrode is heat-treatable to full base metal strength. The 3.5% elongation reported is typical for this material. A comparison of compressive properties of the weld with the base metal shows that either the weldment is the stronger or else the heat treatment after welding resulted in higher strength than the original plate treatment.

5. For weld qualification, a weldment was made from a ring of 6061-T6 not taken from ALVIN sphere material. This is reported in Ref. 4. Results were:

<u>Specimen</u>	<u>0.2% Tens.Y.S.</u>	<u>Tens.U.S.</u>	<u>% Elong.2"</u>	<u>Fracture</u>
A	38,800	43,650	5.5	edge of weld
B	38,750	43,950	5.5	in weld

0.2% offset Y.S. was 42,500 psi.

Hardness of weld metal 100 BHN - 500 Kg. Load
50-62 R "B"

Hardness of parent metal 104-109 BHN 500 Kg. Load
57-60 R "B"

B. 7178-T6 F.B.Spheres

1. Chemical properties of plate are certified in Ref.5 and are as follows:

<u>Of 2 tests</u>	<u>Si</u>	<u>Fe</u>	<u>Cu</u>	<u>Mn</u>	<u>Mg</u>	<u>Cr</u>	<u>Al</u>	<u>Ti</u>	<u>Other</u>	<u>Total</u>
Max	.50	0.7	2.4	.30	3.1	.40	7.3	.20	.05	.15
Min			1.6		2.4	.18	6.3			

2. Plate mechanical properties in the T-6 condition are reported in Ref.5 as:

(Hemispheres 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22)

	<u>Tens. U.S. (psi)</u>	<u>Tens.Y.S. (psi)</u>	<u>Elong.%</u>
Max	90,500	83,200	10.5
Min	90,300	82,800	10.0

(Hemispheres 23, 24, 25, 26, 27, 28, 29, 30, 31, 32)

<u>Of 4 tests</u>	<u>Tens.U.S.(psi)</u>	<u>Tens.Y.S.(psi)</u>	<u>Elong.%</u>
Max	87,100	81,100	13.0
Min	86,100	79,700	12.0

Correlation of sphere and hemisphere identification is as follows (Ref.5):

<u>Sphere</u>	<u>Hemispheres</u>	<u>Disposition</u>
B-1	18 & 19	Collapsed in test
B-2	X & 3	Currently in ALVIN
B-3	7 & 16	"
B-4	20 & 0	"
B-5	12 & 13	"
B-6	17 & 22	"
B-7	23 & 25	Collapsed in test
B-8	29 & 32	Currently in ALVIN
B-9	26 & 31	"
B-10	27 & 30	"
B-11	24 & 28	"

Those hemispheres listed under plate properties which do not appear in above correlation were rejected because of unacceptable flaws or dimensional out-of-tolerance.

3. As forged mechanical properties were measured with specimens taken from edge rings and tested at Custom Tool Company, Minneapolis, (WHOI P.O.25989). Reports are on file at WHOI and results are as follows:

Longitudinal and transverse compression specimens
1 in. long by 1/2 in. diam. were tested and
stress-strain curves recorded

<u>C.T.Spec.No.</u> (trans) (longl)	<u>Sphere</u> <u>No.</u>	<u>Hemi-</u> <u>sphere No.</u>	<u>Comp. Y.S.</u> <u>0.2% trans.</u>	<u>Comp.P.L.</u> <u>(trans.)</u>	<u>Comp.Y.S.</u> <u>0.2%</u> <u>(longl)</u>	<u>Comp.</u> <u>P.L.</u> <u>(longl)</u>	
8/29	5/17	B-6	17	84,800	71,300	83,200	68,600
	5/12	B-5	12	84,800	70,000	81,000	68,600
	2/29	B-8	29	84,200	71,400	83,200	72,400
	3/30	B-10	30	85,000	69,400	83,200	72,400
	4/31	B-9	31	83,500	71,400	83,200	72,400
6/22	8/7	B-3	7	82,800	69,000	83,200	72,400
	22	B-6	22	82,500	69,000	83,200	72,400
	7/X	B-2	X	80,300	69,600	78,100	65,200
	2/3	B-2	3	83,000	69,400	79,800	68,600
1/24	7/24	B-11	24	84,300	73,400	82,000	68,600
7/27	2/27	B-10	27	85,200	73,400	81,900	71,000
2/20	1/28	B-11	28	86,100	69,400	83,400	72,400
	1/5			81,800	66,000	79,600	66,000
	8/20	B-4	20	84,300	68,000	79,500	66,000
	3/26	B-9	26	85,000	73,400	81,000	68,600
	9/13	B-5	13	83,300	69,400	79,500	68,600
	7/16	B-3	16	81,500	69,400	79,500	68,600
	3/8			82,100	67,000	77,800	65,200
	1/25	B-7	25	86,300	71,400	81,800	72,400
	3/23	B-7	23	85,000	73,400	87,500	86,000?
	2/32	B-8	32	85,000	71,400	84,300	72,400
4/0	B-4	0	82,300	69,400	78,000	65,200	
6/18	B-1	18	80,600	69,000	79,500	68,600	
7/19	B-1	19	82,000	69,500	79,500	68,600	

4. 10 mm X 10 mm Charpy V-notch specimens were machined from forging edge rings from the hemispheres and tested at -120° F at Custom Tool Company, Minneapolis. The report is on file at WHOI. Results were as follows:

<u>Spec.No.</u>	<u>Impact Energy</u> ft.lbs.
8-1,2,3	1.1, 1.2, 1.1
5-1,2,3	1.2, 2.0, 1.0
24-1,2,3	1.2, 1.2, 1.2
28-1,2,3	1.0, 1.2, 1.0
29-1,2,3	1.1, 1.2, 1.0
32-1,2,3	0.8, 1.2, 1.0
23-1,2,3	1.1, 1.1, 1.2
25-1,2,3	1.2, 1.1, 1.6
27-1,2,3	1.1, 1.0, 1.0
30-1,2,3	1.2, 1.8, 1.3
31-1,2,3	1.1, 1.2, 1.1

<u>Spec. No.</u>	<u>Impact Energy</u> ft lbs.
26-1,2,3	1.0, 1.8, 1.0
17-1,2,3	1.3, 1.2, 1.0
22-1,2,3	1.1, 1.2, 1.2
12-1,2,3	1.4, 1.1, 1.2
13-1,2,3	1.2, 1.3, 1.2
20-1,2,3	1.0, 1.0, 1.0
0-1,2,3	1.0, 1.1, 1.2
7-1,2,3	1.0, 1.0, 1.0
16-1,2,3	1.1, 1.2, 1.0
X-1,2,3	1.0, 1.5, 1.0
3-1,2,3	1.1, 1.1, 1.0
18-1,2,3	1.3, 1.1, 1.1
19-1,2,3	1.7, 1.0, 1.0

Correlation between Charpy specimen numbers and hemisphere numbers has not been made as yet. However, the numbers are essentially all the same.

IV. Nondestructive Testing (excluding physical dimensions)

A. 6061-T6 V.B. Spheres

1. Ultrasonic Inspection

- a. ALCOA conducted U/S inspection (Ref.4) of each as-forged hemisphere. Acceptance standard was Class "B" plate. Readings were taken in each of 8 segments. Vidagage thickness readings were made at three points on a meridian.
- b. At Litton, 100% coverage using Sonoray Model 50 was performed. A combination of longitudinal and shear wave inspection was used. No cracks, significant porosity or significant inclusions were detected. A reference block with known flaws was used. (Ref. WHOI Log-Litton 4/17/64). This inspection was performed jointly by WHOI and Litton inspectors.

2. X-ray Inspection of all welds on the spheres was performed at Northern Ordnance Division. Final x-rays showed slight but acceptable indications. X-rays were examined by WHOI inspectors and are on file at Northern Ordnance (Ref.WHOI Log-4/27/64). Weld metal was used to build up penetration reenforcement as well as at the equator.

3. Dye penetrant inspection of all welds was performed at Northern Ordnance Division. No cracks were detected. Procedure was witnessed by WHOI and Litton inspectors.

B. 7178-T6 F.B. Spheres

1. Ultrasonic Inspection

- a. ALCOA conducted U/S inspection similar to that on V.B. spheres.
- b. At Litton 100% U/S coverage similar to that performed on V.B. spheres was made by WHOI and Litton inspectors.

V. Proof Tests of V.B. and F.B. Spheres

The V.B. spheres include a stainless steel fitting at each polar penetration. These fittings with the 7/8 in. dia. threaded hole plugged were installed on all spheres before test and have remained on through test to the present time, with the exception that the plug was removed from one end of each sphere and replaced by a Lenz fitting adapted to 5/8" tubing.

Sphere V-1 was tested to 5200 psi without failure. All V.B. and F.B. spheres were proof tested to 3300 psi and weighed accurately before and after test to determine leakage. The procedure and result are presented in Ref.3.

In addition F.B. Sphere No.B-1, later collapsed at SWRI; was cycled 10 times at Litton to 3350 psi, Ref.5.

VI. Experimental Stress Analysis

Two 6061-T6 V.B. spheres, V-1 and 10-5 and two 7178-T6 F.B. spheres, B-1 and B-7, were judged the weakest representatives of the two types and selected for test to collapse.

Of the other F.B. Spheres, B-1 had the largest difference in diameters (0.035 in.), and its total mismatch is large (0.030). In addition, this sphere had been cycled 10 times and held at 3300 psi for sixteen hours. It was the first sphere put together and, as a result, the techniques used with the remaining spheres were developed during its assembly. It was assembled, disassembled and handled considerably more than any other sphere. Sphere B-7 had the thinnest wall (.540), a large mismatch (.024) and a large difference in diameters (.021).

Of the V.B. spheres, V-1 was selected first because the joint had been welded 3 times and heat treated six times. Also, it had the most eccentric equator and a large pole to pole eccentricity. Sphere 10-5 was selected because it was the thinnest by a substantial margin.

A. Instrumentation

A total of 12 locations were strain gaged, all on the outside with two-gage, 90° rosettes, micromasurement EA-06-12-STA-120. Gages were loaded with Eastman 910 Cement and waterproofed. Strains were recorded by 100 channel Baldwin-Lima-Hamilton Strain Recorder. Fig. 2 presents the gage locations and numbers

B. Procedure

The spheres were tested in the thirty inch inside diameter tank at Southwest Research Institute. They were tested to collapse as follows: Spheres B-7, V-1 and 10-5 were mounted in a rack and together cycled 1500 times in salt water 0-2700 psi. Sphere B-1 was then cycled 1500 times in oil 0-2700 psi.

Strain gages were mounted and sphere B-1 was cycled 500 times more in oil 0-2700 psi, and taken to collapse at 7800 psi. Since the result of this test indicated linearity of all gages to greater than 6000 psi, it was decided to cycle sphere B-7 an additional 500 cycles 0-4000 psi in salt water. Strains were read on the first cycle to 4000 psi. On the 2000th cycle pressure was run up to collapse at 8200 psi. Sphere V-1 was cycled an additional 500 cycles making a total of 2000 cycles in salt water 0-2700 psi. It was pressurized to collapse, reading strains, at 5200 psi. On the basis of the V-1 test, sphere 10-5 was pressurized to 3750 on cycle 1501 with strains read. No yielding was indicated so it was cycled 500 times in oil 0-3750 psi making a total of 2000 cycles, 1500 in salt water and 500 in oil. It was collapse at 5400 psi. The following table summarizes the procedure.

<u>Sphere</u>	<u>Medium</u>	<u>No. of Cycles</u>	<u>Pressure Range (psi)</u>	<u>Collapse Pressure</u>
B-1	Oil	2000	0-2700	7800
B-7	Salt water	1500	0-2700	
B-7	Salt water	500	0-4000	8200
V-1	Salt water	2000	0-2700	5200
10-5	Salt water	1500	0-2700	
10-5	Oil	500	0-3750	5400

All strains were recorded in increments of 500 psi until near collapse when the increment was reduced to 100 psi.

C. Presentation of Data

Data is presented in Appendices 1 - 5 in two forms. First as received from the computer. It is assumed that Leg. 1 or Leg. 2 is on the principal strain line. Sigma 1 is the principal stress in the Leg. 1 direction and Sigma 2 the principal stress in the Leg. 2 direction. Sens 1 and Sens 2 are respectively $\text{Sigma 1} \div E$ and $\text{Sigma 2} \div E$. They have no physical meaning. The plot below the reduced data is Sigma as abscissa vs pressure as ordinate.

The second form of presentation is notes made during examination of the original strain recordings.

VII. Analysis of Results

A. Spheres B-1 and B-7 collapsed suddenly and violently resulting in many pieces varying in size from sand particles to a maximum of 40 sq. in. (Fig.5). A lamination type fracture surface resulted, indicating very rapid change from compression to tension (Fig.6). The location of failure initiation could not be determined.

Spheres V-1 and 10-5 failed in a local and ductile manner. Snap through buckling occurred approximately half way between pole and equator in one hemisphere of each sphere (Fig.3,4,6, and 7). The snapped through piece of shell remained attached by a tongue on sphere 10-5 shown in Fig. 4. On sphere V-1, the tongue, which became detached, involved the polar penetration which appeared to be a secondary failure as was the cracking of the equator weld, Fig. 7. The equator weld of sphere 10-5 failed completely, also a secondary failure.

B. Dimensions and mechanical properties of collapsed spheres are tabulated below:

Sphere	Mean thick- ness <u>inches</u>	Mean Radius <u>Inches</u>	Mean Outside Radius <u>Inches</u>	0.2% offset (Forged edge rings) Comp.Y.S. (psi)	
B-1	.560	11.475	11.755	*80,050	
B-7	.546	11.472	11.745	*84,050	
10-5	.797	11.447	11.862	38,500	(One coupon per (sphere no data (available
V-1	.849	11.510	11.935	38,700	(Mean of 7 spheres

*Mean of trans. and long₁ coupons from weaker of 2 hemispheres.

C. The actual collapse pressures and hoop stress levels of the four spheres B-1, B-7, V-1 and 10-5 are presented below:

<u>Sphere</u>	<u>Actual collapse pressure(psi)</u>	<u>Stress at collapse(psi)</u>
B-1	7850	81,700
B-7	8200	88,200
10-5	5400	38,900
V-1	5200	35,300

Calculations of predicted collapse using the methods of Ref. 1 compare favorably with the actual collapse pressure.

The strain gage results showed that in the case of the spheres B-1 and B-7, all strains were linear to more than 5000 psi pressure. Strains were uniform with no non-uniformities at the joint. Sphere 10-5 show linear strains to 4000 psi. The weld region did not show conditions different from nonweld regions. Sphere V-1 showed non-linearity adjacent to the weld at one location at 3500 psi. However 5 other locations adjacent to the weld showed behavior no different from regions away from the weld. On each sphere 6 locations were gaged adjacent to weld, 2 locations at polar discontinuity and 4 locations on uniform position of sphere.

The four spheres were selected for collapse before all mechanical properties data from edge rings was available. A review of the selection in the light of this shows 10-5 sphere had the lowest strength of base metal of the V.B. spheres. Spheres B-1 and B-7 were apparently not those of lowest strength but the difference is small.

VIII. Buoyancy and V.B. Sphere Weight Analysis

7178-T6 Spheres O.D. = 23.499 in av. of 9 max.23.530 in.
(9 in vehicle) min.23.475 in.
thickness = .553 av. of 9 max. .574 in.
min. .543 in.
weight . 95.17 lbs. av.
of 9 max. 97 1/4 lb.
min. 94 lbs.
 $\Delta = 6800(.037) = 252\#$ av.of 9
Internal vol. = 3.40 cu.ft.

6061-T6 O.D. = 23.789 av. of 6 max.23.896
(6 in vehicle) min.23.600
thickness = .843 av. of 6 max. .858
min. .804
weight = 1396(.098) = 137# av. of 6
displ. = 7050(.037) = 261# av. of 6
Internal vol. = 3.27 cu.ft.

SUMMARY DATA SHEET FOR
"ALVIN" VARIABLE BALLAST SPHERES
MATERIAL 6061-T6

Hemisphere No. & Weight	Wall Thickness Based on Min Hem		X-ray of Weld	Sonoray Results	Compressive Yield & Hardness	Max. Out of Round (Girth)	Max. Out of Round (Pole to Girth)	Av. of 8 Girth Dia. Minus Av. of 4 Pole Girth Dia.	Weld Shrinkage (Pole to Girth)	Surface Defects	His- tory
	Min.	Max.									
9 & 3 143#	.850	.858	Slight Spots	1 Indi- cation Very Small	41,500 96 BHN	.020	.040	.022	.017	Tool Groove on Boss	None
17 & 0 140-1/2#	.822	.840	Clean	None	42,000 96 BHN	.013	.143	.130	.099	Cavities on Boss Surface	None
12 & 8 143-1/2#	.842	.850	Slight Spots	None	42,500 98 BHN	.022	.042	.025	.040	None	None
13 & 2 138#	.804	.832	Clean	None	41,500 97 BHN	.023	.183	.166	.055	None	None
V-1 143-1/2#	.843	.855	Clean	7 or 8 Very Small In- dications	42,500 100 BHN	.065	+.110	+.052	NO Prior Read- ing	Exten- sive	E-B Heat Treated 6 Times then re- welded TIG
16 & 15 147-3/4#	.858	.877	One Spot on No.1 Shot	Slight Indica- tions in One Area	40,000 97 BHN	.035	.072	.053	.064	Exten-	Welded & cut apart be- cause of porosity rewelded
10 & 5 134-1/2#	.790	.800	2 or 3 Slight Spots	None	42,000 98 BHN	.020	.065	.047	.039	Cavity on Boss Surface	None
14 & 4 143-1/2#	.830	.853	Clean	None	42,000 97 BHN	.017	.092	.077	.070	None	None

Capacity 25 Gallons

TABLE I

Spheres V-1, 10 & 5 were selected for collapse

Sphere No.	Diameter			Wall Thickness (of Min. Hemisphere)		Total Mis-match	Weight in lbs.	Comments
	Min.	Average (24 Readings)	Max.	Min.	Max.			
B-1	23.495	23.510	23.530	.550	.567	.030	94-1/2	Selected for Collapse
B-2	23.494	23.505	23.523	.546	.547	.015	94-1/4	Ultrasonic Test of Hemisphere "X" at Litton
B-3	23.495	23.508	23.525	.560	.565	.011	96-1/2	
B-4	23.483	23.502	23.517	.567	.574	.013	97-1/4	Ultrasonic Test of Hemisphere "O" at Litton
B-5	23.504	23.509	23.517	.550	.554	.007	96	
B-6	23.500	23.507	23.514	.551	.555	.019	95-1/4	
B-7	23.480	23.490	23.501	.540	.550	.024	93-3/4	Selected for Collapse
B-8	23.480	23.492	23.508	.543	.554	.023	94	
B-9	23.475	23.485	23.493	.544	.548	.024	94-1/4	
B-10	23.480	23.490	23.500	.545	.553	.011	94-1/2	
B-11	23.478	23.490	23.498	.545	.553	.031	94-1/2	

TABLE II

FIXED BOUYANCY SPHERES

7178 - T6

O.D. = $23.500 \pm .020$ SPEC.

THICKNESS = $.550 \pm .020$ SPEC.

VARIABLE BOUYANCY SPHERES

6061 - T6

O.D. = $23.770 - 23.870$ FROM MEASUREMENT
AS OF 12/6/63

THICKNESS = $.890 \pm .020$ SPEC.

TEMPLATE DESIGN "A"

TEMPLATE DESIGN "B"

	TEMPLATE NO.	RADIUS R	CHORD C
7178 SPHERES	1 A	11.750	90° ARC
	2 B	11.750	8"
	3 B	12.350"	8"
6061 SPHERES	4 A	11.910"	90° ARC
	5 B	11.910"	8"
	6 B	12.510"	8"

Fig. 1 Template for Local Sphericity

NOTE : GAGES 1, 2, 15, 16 ARE AT THE REINFORCEMENT - SHELL DISCONTINUITY OF SPHERES V-1 AND 10 - 5 AND AT THE POLES OF SPHERES B-1 AND B-7.

Fig. 2 Strain Gage Locations

Figure 3. Spheres B-7, V-1, and 10-5 Mounted in Test Rack.

Figure 4. Sphere B-1 Mounted in Test Rack.

Figure 5. Close-up of Delaminated 7178-T6 Shell Fragment.

Figure 6. Many Fragments of Collapsed 7178-T6 Sphere.

Figure 7. Sphere 10-5 after Failure.

Figure 8. Sphere 10-5 after Failure Showing Snapped through Fragment.

References

1. "Predictions of the Collapse Strength of Three HY-100 Steel Spherical Hulls Fabricated for the Oceanographic Research Vessel ALVIN", by T. J. Kiernan, DTMB Report 1792 of March 1964.
2. "Experimental Stress Analysis of ALVIN Buoyancy Spheres", E. M. Briggs and R. C. Dehart, SWRI, October 1964.
3. "ALVIN High Pressure Test Report", Applied Science Division, Litton Systems, July 24, 1964.
4. Quality Assurance Report for ALVIN Project 6061 Aluminum Spheres, Applied Science Division, Litton Systems, June 9, 1964.
5. Quality Assurance Report for ALVIN Project 7178 Aluminum Spheres, Applied Science Division, Litton Systems, June 9, 1964.

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	1	0	0	0
7.3076923+03	6.6923077+03	1	1000	7.3076923+02	6.6923077+02
1.4571429+04	1.3571429+04	1	2000	1.4571429+03	1.3571429+03
2.0516484+04	2.0054945+04	1	3000	2.0516484+03	2.0054945+03
2.6679121+04	2.7263736+04	1	4000	2.6679121+03	2.7263736+03
3.6714286+04	4.0714286+04	1	5000	3.6714286+03	4.0714286+03
MIN SCALE	MAX SCALE				
1000	90000				
-----10-----20-----30-----40-----50-----60-----70-----800-----90					
POINT IS LEFT OF SCALE					
1	*				
2	*				
3	*				
4	*				
5	*				
				PRES.	STRESS
				0	0
				1000	7.3076923+03
				2000	1.4571429+04
				3000	2.0516484+04
				4000	2.6679121+04
				5000	3.6714286+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	2	0	0	0
6.4285714+03	6.4285714+03	2	1000	6.4285714+02	6.4285714+02
1.3142857+04	1.3142857+04	2	2000	1.3142857+03	1.3142857+03
1.9285714+04	1.9285714+04	2	3000	1.9285714+03	1.9285714+03
2.5714286+04	2.5714286+04	2	4000	2.5714286+03	2.5714286+03
4.2571429+04	4.2571429+04	2	5000	4.2571429+03	4.2571429+03
MIN SCALE	MAX SCALE				
1000	90000				
-----10-----20-----30-----40-----50-----60-----70-----800-----90					
POINT IS LEFT OF SCALE					
7	*				
8	*				
9	*				
0	*				
1	*				
				PRES.	STRESS
				0	0
				1000	6.4285714+03
				2000	1.3142857+04
				3000	1.9285714+04
				4000	2.5714286+04
				5000	4.2571429+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	3	0	0	0
6.5274725+03	6.7582418+03	3	1000	6.5274725+02	6.7582417+02
1.3417582+04	1.3725275+04	3	2000	1.3417582+03	1.3725275+03
1.9802198+04	2.0340659+04	3	3000	1.9802198+03	2.0340659+03
2.6439560+04	2.7131868+04	3	4000	2.6439560+03	2.7131868+03
3.7373626+04	3.7912088+04	3	5000	3.7373626+03	3.7912088+03
MIN SCALE	MAX SCALE				
1000	90000				
-----10-----20-----30-----40-----50-----60-----70-----800-----90					
POINT IS LEFT OF SCALE					
3	*				
4	*				
5	*				
6	*				
7	*				
				PRES.	STRESS
				0	0
				1000	6.5274725+03
				2000	1.3417582+04
				3000	1.9802198+04
				4000	2.6439560+04
				5000	3.7373626+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	4	0	0	0
5.9340659+03	5.7802198+03	4	1000	5.9340659+02	5.7802198+02
1.1978022+04	1.1593407+04	4	2000	1.1978022+03	1.1593407+03
1.7670330+04	1.6901099+04	4	3000	1.7670330+03	1.6901099+03
2.3824176+04	2.2747253+04	4	4000	2.3824176+03	2.2747253+03
3.1670330+04	2.9901099+04	4	5000	3.1670330+03	2.9901099+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE					
9	*				
0	*				
1	*				
2	*				
3	*				
				PRES.	STRESS
				0	0
				1000	5.9340659+03
				2000	1.1978022+04
				3000	1.7670330+04
				4000	2.3824176+04
				5000	3.1670330+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	5	0	0	0
6.2197802+03	6.0659341+03	5	1000	6.2197802+02	6.0659341+02
1.2439560+04	1.2131868+04	5	2000	1.2439560+03	1.2131868+03
1.8692308+04	1.8307692+04	5	3000	1.8692308+03	1.8307692+03
2.4879121+04	2.4263736+04	5	4000	2.4879121+03	2.4263736+03
3.3824176+04	3.1747253+04	5	5000	3.3824176+03	3.1747253+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE					
5	*				
6	*				
7	*				
8	*				
9	*				
				PRES.	STRESS
				0	0
				1000	6.2197802+03
				2000	1.2439560+04
				3000	1.8692308+04
				4000	2.4879121+04
				5000	3.3824176+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	6	0	0	0
6.6043956+03	6.6813187+03	6	1000	6.6043956+02	6.6813187+02
1.3241758+04	1.3472527+04	6	2000	1.3241758+03	1.3472527+03
1.9670330+04	1.9901099+04	6	3000	1.9670330+03	1.9901099+03
2.6384615+04	2.6615385+04	6	4000	2.6384615+03	2.6615385+03
3.6318681+04	3.6395604+04	6	5000	3.6318681+03	3.6395604+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE					
1	*				
2	*				
3	*				
4	*				
5	*				
				PRES.	STRESS
				0	0
				1000	6.6043956+03
				2000	1.3241758+04
				3000	1.9670330+04
				4000	2.6384615+04
				5000	3.6318681+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	7	0	0	0
6.6813187+03	6.6043956+03	7	1000	6.6813187+02	6.6043956+02
1.3395604+04	1.3318681+04	7	2000	1.3395604+03	1.3318681+03
1.9604396+04	1.9681319+04	7	3000	1.9604396+03	1.9681319+03
2.6351648+04	2.6505495+04	7	4000	2.6351648+03	2.6505494+03
3.7901099+04	4.0670330+04	7	5000	3.7901099+03	4.0670330+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE					
7	*				
8	*				
9	*				
0	*				
1	*				
				PRES.	STRESS
				0	0
				1000	6.6813187+03
				2000	1.3395604+04
				3000	1.9604396+04
				4000	2.6351648+04
				5000	3.7901099+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	8	0	0	0
6.5274725+03	6.7582418+03	8	1000	6.5274725+02	6.7582417+02
1.3307692+04	1.3692308+04	8	2000	1.3307692+03	1.3692308+03
2.0164835+04	2.0549451+04	8	3000	2.0164835+03	2.0549451+03
2.7043956+04	2.7813187+04	8	4000	2.7043956+03	2.7813187+03
3.4659341+04	3.7197802+04	8	5000	3.4659341+03	3.7197802+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE					
3	*				
4	*				
5	*				
6	*				
7	*				
				PRES.	STRESS
				0	0
				1000	6.5274725+03
				2000	1.3307692+04
				3000	2.0164835+04
				4000	2.7043956+04
				5000	3.4659341+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	9	0	0	0
5.5934066+03	4.9780220+03	9	1000	5.5934066+02	4.9780220+02
1.1296703+04	9.9890110+03	9	2000	1.1296703+03	9.9890110+02
1.7032967+04	1.5109890+04	9	3000	1.7032967+03	1.5109890+03
2.2989011+04	2.0296703+04	9	4000	2.2989011+03	2.0296703+03
3.0846154+04	2.6153846+04	9	5000	3.0846154+03	2.6153846+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE					
9	*				
0	*				
1	*				
2	*				
3	*				
				PRES.	STRESS
				0	0
				1000	5.5934066+03
				2000	1.1296703+04
				3000	1.7032967+04
				4000	2.2989011+04
				5000	3.0846154+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	10	0	0	0
6.1868132+03	5.9560439+03	10	1000	6.1868132+02	5.9560439+02
1.2296703+04	1.1989011+04	10	2000	1.2296703+03	1.1989011+03
1.8406593+04	1.8021978+04	10	3000	1.8406593+03	1.8021978+03
2.4769231+04	2.4230769+04	10	4000	2.4769231+03	2.4230769+03
3.3340659+04	3.1802198+04	10	5000	3.3340659+03	3.1802198+03
MIN SCALE	MAX SCALE				
1000	90000				
-----10-----20-----30-----40-----50-----60-----170-----800----- 90					
POINT IS LEFT OF SCALE					
5	*				
6	*				
7		*			
8		*			
9		*			
				PRES.	STRESS
				0	0
				1000	6.1868132+03
				2000	1.2296703+04
				3000	1.8406593+04
				4000	2.4769231+04
				5000	3.3340659+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	11	0	0	0
5.6483516+03	5.4945055+03	11	1000	5.6483516+02	5.4945055+02
1.1263736+04	1.0879121+04	11	2000	1.1263736+03	1.0879121+03
1.6813187+04	1.6043956+04	11	3000	1.6813187+03	1.6043956+03
2.2395604+04	2.1318681+04	11	4000	2.2395604+03	2.1318681+03
2.9076923+04	2.7923077+04	11	5000	2.9076923+03	2.7923077+03
MIN SCALE	MAX SCALE				
1000	90000				
-----10-----20-----30-----40-----50-----60-----170-----800----- 90					
POINT IS LEFT OF SCALE					
1	*				
2	*				
3		*			
4		*			
5		*			
				PRES.	STRESS
				0	0
				1000	5.6483516+03
				2000	1.1263736+04
				3000	1.6813187+04
				4000	2.2395604+04
				5000	2.9076923+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	12	0	0	0
5.9670330+03	5.8901099+03	12	1000	5.9670329+02	5.8901099+02
1.2043956+04	1.1813187+04	12	2000	1.2043956+03	1.1813187+03
1.8120879+04	1.7736264+04	12	3000	1.8120879+03	1.7736264+03
2.4340659+04	2.3802198+04	12	4000	2.4340659+03	2.3802198+03
3.3076923+04	3.1923077+04	12	5000	3.3076923+03	3.1923077+03
MIN SCALE	MAX SCALE				
1000	90000				
-----10-----20-----30-----40-----50-----60-----170-----800----- 90					
POINT IS LEFT OF SCALE					
7	*				
8	*				
9		*			
0		*			
1		*			
				PRES.	STRESS
				0	0
				1000	5.9670330+03
				2000	1.2043956+04
				3000	1.8120879+04
				4000	2.4340659+04
				5000	3.3076923+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	1	0	0	0
3.2527473+03	3.6758242+03	1	500	3.2527472+02	3.6758242+02
6.3846154+03	7.1153846+03	1	1000	6.3846154+02	7.1153846+02
9.6813187+03	1.0604396+04	1	1500	9.6813187+02	1.0604396+03
1.2791209+04	1.3637363+04	1	2000	1.2791209+03	1.3637363+03
1.5945055+04	1.6483516+04	1	2500	1.5945055+03	1.6483516+03
1.9285714+04	1.9285714+04	1	3000	1.9285714+03	1.9285714+03
2.2406593+04	2.2021978+04	1	3500	2.2406593+03	2.2021978+03
2.6065934+04	2.5219780+04	1	4000	2.6065934+03	2.5219780+03
2.9164835+04	2.7549451+04	1	4500	2.9164835+03	2.7549451+03
3.1373626+04	2.8912088+04	1	5000	3.1373626+03	2.8912088+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE				PRES.	STRESS
1	*			0	0
2	*			500	3.2527473+03
3	*			1000	6.3846154+03
4	*			1500	9.6813187+03
5	*			2000	1.2791209+04
6	*			2500	1.5945055+04
7	*			3000	1.9285714+04
8	*			3500	2.2406593+04
9	*			4000	2.6065934+04
0	*			4500	2.9164835+04
	*			5000	3.1373626+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	2	0	0	0
2.9560440+03	3.1868132+03	2	500	2.9560439+02	3.1868132+02
6.1318681+03	6.4395604+03	2	1000	6.1318681+02	6.4395604+02
9.3406593+03	9.8021978+03	2	1500	9.3406593+02	9.8021978+02
1.2307692+04	1.2692308+04	2	2000	1.2307692+03	1.2692308+03
1.5472527+04	1.6241758+04	2	2500	1.5472527+03	1.6241758+03
1.8406593+04	1.9021978+04	2	3000	1.8406593+03	1.9021978+03
2.1791209+04	2.2637363+04	2	3500	2.1791209+03	2.2637363+03
2.4945055+04	2.5483516+04	2	4000	2.4945055+03	2.5483516+03
2.8736264+04	2.9120879+04	2	4500	2.8736264+03	2.9120879+03
3.5098901+04	3.4329670+04	2	5000	3.5098901+03	3.4329670+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE				PRES.	STRESS
2	*			0	0
3	*			500	2.9560440+03
4	*			1000	6.1318681+03
5	*			1500	9.3406593+03
6	*			2000	1.2307692+04
7	*			2500	1.5472527+04
8	*			3000	1.8406593+04
9	*			3500	2.1791209+04
0	*			4000	2.4945055+04
	*			4500	2.8736264+04
1	*			5000	3.5098901+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	3	0	0	0
3.2197802+03	3.0659341+03	3	500	3.2197802+02	3.0659341+02
6.3956044+03	6.3186813+03	3	1000	6.3956044+02	6.3186813+02
9.5384615+03	9.4615385+03	3	1500	9.5384615+02	9.4615384+02
1.2241758+04	1.2472527+04	3	2000	1.2241758+03	1.2472527+03
1.5384615+04	1.5615385+04	3	2500	1.5384615+03	1.5615385+03
1.8307692+04	1.8692308+04	3	3000	1.8307692+03	1.8692308+03
2.1230769+04	2.1769231+04	3	3500	2.1230769+03	2.1769231+03
2.4450549+04	2.4835165+04	3	4000	2.4450549+03	2.4835165+03
2.7340659+04	2.7802198+04	3	4500	2.7340659+03	2.7802198+03
3.0769231+04	3.1230769+04	3	5000	3.0769231+03	3.1230769+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE				PRES.	STRESS
3	*			0	0
4	*			500	3.2197802+03
5	*			1000	6.3956044+03
6	*			1500	9.5384615+03
7	*			2000	1.2241758+04
8	*			2500	1.5384615+04
9	*			3000	1.8307692+04
0	*			3500	2.1230769+04
1	*			4000	2.4450549+04
2	*			4500	2.7340659+04
	*			5000	3.0769231+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	4	0	0	0
3.1098901+03	3.0329670+03	4	500	3.1098901+02	3.0329670+02
6.3956044+03	6.3186813+03	4	1000	6.3956044+02	6.3186813+02
9.4615385+03	9.5384615+03	4	1500	9.4615384+02	9.5384615+02
1.2604396+04	1.2681319+04	4	2000	1.2604396+03	1.2681319+03
1.5780220+04	1.5934066+04	4	2500	1.5780220+03	1.5934066+03
1.8890110+04	1.8967033+04	4	3000	1.8890110+03	1.8967033+03
2.2142857+04	2.2142857+04	4	3500	2.2142857+03	2.2142857+03
2.4956044+04	2.5186813+04	4	4000	2.4956044+03	2.5186813+03
2.8307692+04	2.8692308+04	4	4500	2.8307692+03	2.8692308+03
3.3461538+04	3.3538462+04	4	5000	3.3461538+03	3.3538462+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	5	0	0	0
3.2087912+03	3.3626374+03	5	500	3.2087912+02	3.3626374+02
6.4945055+03	6.6483516+03	5	1000	6.4945055+02	6.6483516+02
9.7802198+03	9.9340659+03	5	1500	9.7802198+02	9.9340659+02
1.3175824+04	1.3252747+04	5	2000	1.3175824+03	1.3252747+03
1.6428571+04	1.6428571+04	5	2500	1.6428571+03	1.6428571+03
1.9604396+04	1.9681319+04	5	3000	1.9604396+03	1.9681319+03
2.3000000+04	2.3000000+04	5	3500	2.3000000+03	2.3000000+03
2.6109890+04	2.6032967+04	5	4000	2.6109890+03	2.6032967+03
2.9681319+04	2.9604396+04	5	4500	2.9681319+03	2.9604396+03
3.6417582+04	3.4725275+04	5	5000	3.6417582+03	3.4725275+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	6	0	0	0
2.8901099+03	2.9670330+03	6	500	2.8901099+02	2.9670330+02
6.0000000+03	6.0000000+03	6	1000	6.0000000+02	6.0000000+02
8.8901099+03	8.9670330+03	6	1500	8.8901099+02	8.9670329+02
1.1934066+04	1.1780220+04	6	2000	1.1934066+03	1.1780220+03
1.4857143+04	1.4857143+04	6	2500	1.4857143+03	1.4857143+03
1.7714286+04	1.7714286+04	6	3000	1.7714286+03	1.7714286+03
2.0681319+04	2.0604396+04	6	3500	2.0681319+03	2.0604396+03
2.3538462+04	2.3461538+04	6	4000	2.3538462+03	2.3461538+03
2.6395604+04	2.6318681+04	6	4500	2.6395604+03	2.6318681+03
2.9285714+04	2.9285714+04	6	5000	2.9285714+03	2.9285714+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	10	0	0	0
2.9230769+03	3.0769231+03	10	500	2.9230769+02	3.0769231+02
6.0329670+03	6.1098901+03	10	1000	6.0329670+02	6.1098901+02
9.1318681+03	9.4395604+03	10	1500	9.1318681+02	9.4395604+02
1.2131868+04	1.2439560+04	10	2000	1.2131868+03	1.2439560+03
1.5450549+04	1.5835165+04	10	2500	1.5450549+03	1.5835165+03
1.8230769+04	1.8769231+04	10	3000	1.8230769+03	1.8769231+03
2.1692308+04	2.2307692+04	10	3500	2.1692308+03	2.2307692+03
2.5010989+04	2.5703297+04	10	4000	2.5010989+03	2.5703297+03
3.0065934+04	3.0219780+04	10	4500	3.0065934+03	3.0219780+03
3.6560440+04	3.6868132+04	10	5000	3.6560440+03	3.6868132+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	11	0	0	0
3.1098901+03	3.0329670+03	11	500	3.1098901+02	3.0329670+02
6.1098901+03	6.0329670+03	11	1000	6.1098901+02	6.0329670+02
9.1428571+03	9.1428571+03	11	1500	9.1428572+02	9.1428572+02
1.2032967+04	1.2109890+04	11	2000	1.2032967+03	1.2109890+03
1.5065934+04	1.5219780+04	11	2500	1.5065934+03	1.5219780+03
1.7923077+04	1.8076923+04	11	3000	1.7923077+03	1.8076923+03
2.1208791+04	2.1362637+04	11	3500	2.1208791+03	2.1362637+03
2.4054945+04	2.4516484+04	11	4000	2.4054945+03	2.4516484+03
2.7747253+04	2.7824176+04	11	4500	2.7747253+03	2.7824176+03
3.2978022+04	3.2593407+04	11	5000	3.2978022+03	3.2593407+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	1	0	0	0
5.0000000+03	5.0000000+03	1	500	5.0000000+02	5.0000000+02
9.2857143+03	9.2857143+03	1	1000	9.2857143+02	9.2857143+02
1.5000000+04	1.5000000+04	1	1500	1.5000000+03	1.5000000+03
1.9285714+04	1.9285714+04	1	2000	1.9285714+03	1.9285714+03
2.3736264+04	2.4120879+04	1	2500	2.3736264+03	2.4120879+03
2.8571429+04	2.8571429+04	1	3000	2.8571429+03	2.8571429+03
3.3571429+04	3.3571429+04	1	3500	3.3571429+03	3.3571429+03
3.7857143+04	3.7857143+04	1	4000	3.7857143+03	3.7857143+03
4.2692308+04	4.2307692+04	1	4500	4.2692308+03	4.2307692+03
4.7142857+04	4.7142857+04	1	5000	4.7142857+03	4.7142857+03
5.2142857+04	5.2142857+04	1	5500	5.2142857+03	5.2142857+03
5.6978022+04	5.6593407+04	1	6000	5.6978022+03	5.6593407+03
6.2527473+04	6.1758242+04	1	6500	6.2527473+03	6.1758242+03
6.7142857+04	6.7142857+04	1	7000	6.7142857+03	6.7142857+03
7.9285714+04	7.9285714+04	1	7500	7.9285714+03	7.9285714+03
8.8571428+04	8.8571428+04	1	7750	8.8571429+03	8.8571429+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	2	0	0	0
4.2857143+03	4.2857143+03	2	500	4.2857143+02	4.2857143+02
9.1208791+03	8.7362637+03	2	1000	9.1208791+02	8.7362637+02
1.4285714+04	1.4285714+04	2	1500	1.4285714+03	1.4285714+03
1.8571429+04	1.8571429+04	2	2000	1.8571429+03	1.8571429+03
2.2857143+04	2.2857143+04	2	2500	2.2857143+03	2.2857143+03
2.7857143+04	2.7857143+04	2	3000	2.7857143+03	2.7857143+03
3.2692308+04	3.2307692+04	2	3500	3.2692308+03	3.2307692+03
3.6978022+04	3.6593407+04	2	4000	3.6978022+03	3.6593407+03
4.1428571+04	4.1428571+04	2	4500	4.1428571+03	4.1428571+03
4.5714286+04	4.5714286+04	2	5000	4.5714286+03	4.5714286+03
5.0549451+04	5.0164835+04	2	5500	5.0549451+03	5.0164835+03
5.5714286+04	5.5714286+04	2	6000	5.5714286+03	5.5714286+03
6.0714286+04	6.0714286+04	2	6500	6.0714286+03	6.0714286+03
6.5714286+04	6.5714286+04	2	7000	6.5714286+03	6.5714286+03
7.5164835+04	7.5549450+04	2	7500	7.5164835+03	7.5549450+03
8.0384615+04	7.9615385+04	2	7750	8.0384615+03	7.9615385+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	3	0	0	0
4.2857143+03	4.2857143+03	3	500	4.2857143+02	4.2857143+02
9.2857143+03	9.2857143+03	3	1000	9.2857143+02	9.2857143+02
1.4285714+04	1.4285714+04	3	1500	1.4285714+03	1.4285714+03
1.8571429+04	1.8571429+04	3	2000	1.8571429+03	1.8571429+03
2.2857143+04	2.2857143+04	3	2500	2.2857143+03	2.2857143+03
2.7307692+04	2.7692308+04	3	3000	2.7307692+03	2.7692308+03
3.2142857+04	3.2142857+04	3	3500	3.2142857+03	3.2142857+03
3.693407+04	3.6978022+04	3	4000	3.693407+03	3.6978022+03
4.0879121+04	4.1263736+04	3	4500	4.0879121+03	4.1263736+03
4.5714286+04	4.5714286+04	3	5000	4.5714286+03	4.5714286+03
5.0164835+04	5.0549451+04	3	5500	5.0164835+03	5.0549451+03
5.5879121+04	5.6263736+04	3	6000	5.5879121+03	5.6263736+03
6.1043956+04	6.1813187+04	3	6500	6.1043956+03	6.1813187+03
6.6373626+04	6.7912088+04	3	7000	6.6373626+03	6.7912088+03
7.2857143+04	7.2857143+04	3	7500	7.2857143+03	7.2857143+03
7.4285714+04	7.4285714+04	3	7730	7.4285714+03	7.4285714+03
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE			PRES.	STRESS	
5	*		500	4.2857143+03	0
6	*		1000	9.2857143+03	
7			1500	1.4285714+04	
8	*		2000	1.8571429+04	
9			2500	2.2857143+04	
0			3000	2.7307692+04	
1			3500	3.2142857+04	
2			4000	3.693407+04	
3			4500	4.0879121+04	
4			5000	4.5714286+04	
5			5500	5.0164835+04	
6			6000	5.5879121+04	
7			6500	6.1043956+04	
8			7000	6.6373626+04	
9			7500	7.2857143+04	
0			7730	7.4285714+04	

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	4	0	0	0
5.5494505+03	5.1648352+03	4	500	5.5494506+02	5.1648351+02
1.1098901+04	1.0329670+04	4	1000	1.1098901+03	1.0329670+03
1.5714286+04	1.5714286+04	4	1500	1.5714286+03	1.5714286+03
2.0549451+04	2.0164835+04	4	2000	2.0549451+03	2.0164835+03
2.5934066+04	2.4780220+04	4	2500	2.5934066+03	2.4780220+03
3.0934066+04	2.9780220+04	4	3000	3.0934066+03	2.9780220+03
3.5934066+04	3.4780220+04	4	3500	3.5934066+03	3.4780220+03
4.0934066+04	3.9780220+04	4	4000	4.0934066+03	3.9780220+03
4.5384615+04	4.4615385+04	4	4500	4.5384615+03	4.4615385+03
5.0219780+04	4.9085934+04	4	5000	5.0219780+03	4.9085934+03
5.5054945+04	5.3516484+04	4	5500	5.5054945+03	5.3516483+03
6.0934066+04	5.9780220+04	4	6000	6.0934066+03	5.9780220+03
6.6241758+04	6.7472527+04	4	6500	6.6241758+03	6.7472527+03
7.6648352+04	7.5494505+04	4	7000	7.6648352+03	7.5494505+03
9.9340659+04	9.7802198+04	4	7500	9.9340659+03	9.7802198+03
1.2181319+05	1.2104396+05	4	7790	1.2181319+04	1.2104396+04
MIN SCALE	MAX SCALE				
1000	90000				
POINT IS LEFT OF SCALE			PRES.	STRESS	
9	*		500	5.5494505+03	0
0			1000	1.1098901+04	
1	*		1500	1.5714286+04	
2	*		2000	2.0549451+04	
3			2500	2.5934066+04	
4			3000	3.0934066+04	
5			3500	3.5934066+04	
6			4000	4.0934066+04	
7			4500	4.5384615+04	
8			5000	5.0219780+04	
9			5500	5.5054945+04	
0			6000	6.0934066+04	
1			6500	6.6241758+04	
2			7000	7.6648352+04	
POINT IS RIGHT OF SCALE			7500	9.9340659+04	
POINT IS RIGHT OF SCALE			7790	1.2181319+05	

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	5	0	0	0
4.4505495+03	4.8351648+03	5	500	4.4505494+02	4.8351648+02
9.4505494+03	9.8351648+03	5	1000	9.4505494+02	9.8351648+02
1.4615385+04	1.5384615+04	5	1500	1.4615385+03	1.5384615+03
1.8736264+04	1.9120879+04	5	2000	1.8736264+03	1.9120879+03
2.3736264+04	2.4120879+04	5	2500	2.3736264+03	2.4120879+03
2.8736264+04	2.9120879+04	5	3000	2.8736264+03	2.9120879+03
3.3186813+04	3.3956044+04	5	3500	3.3186813+03	3.3956044+03
3.8021978+04	3.8406593+04	5	4000	3.8021978+03	3.8406593+03
4.3021978+04	4.3406593+04	5	4500	4.3021978+03	4.3406593+03
4.7307692+04	4.7692308+04	5	5000	4.7307692+03	4.7692308+03
5.1758242+04	5.2527473+04	5	5500	5.1758242+03	5.2527473+03
5.7472527+04	5.8241758+04	5	6000	5.7472527+03	5.8241758+03
6.2802198+04	6.4340659+04	5	6500	6.2802198+03	6.4340659+03
6.9010989+04	7.1703297+04	5	7000	6.9010989+03	7.1703297+03
8.4285714+04	8.9285714+04	5	7500	8.4285714+03	8.9285714+03
1.0120879+05	1.0736264+05	5	7750	1.0120879+04	1.0736264+04
MIN SCALE		MAX SCALE			
1000		90000			
-----10-----20-----30-----40-----50-----60-----170-----800-----90					
POINT IS LEFT OF SCALE					
2	*				
3	*				
4		*			
5		*			
6			*		
7			*		
8				*	
9				*	
0				*	
1				*	
2				*	
3				*	
4				*	
5				*	
6				*	
POINT IS RIGHT OF SCALE					

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	6	0	0	0
4.8351648+03	4.4505495+03	6	500	4.8351648+02	4.4505494+02
9.8351648+03	9.4505494+03	6	1000	9.8351648+02	9.4505494+02
1.4285714+04	1.4285714+04	6	1500	1.4285714+03	1.4285714+03
1.9120879+04	1.8736264+04	6	2000	1.9120879+03	1.8736264+03
2.4120879+04	2.3736264+04	6	2500	2.4120879+03	2.3736264+03
2.8571429+04	2.8571429+04	6	3000	2.8571429+03	2.8571429+03
3.3406593+04	3.3021978+04	6	3500	3.3406593+03	3.3021978+03
3.7692308+04	3.7307692+04	6	4000	3.7692308+03	3.7307692+03
4.2527473+04	4.1758242+04	6	4500	4.2527473+03	4.1758242+03
4.6978022+04	4.6593407+04	6	5000	4.6978022+03	4.6593407+03
5.1813187+04	5.1043956+04	6	5500	5.1813187+03	5.1043956+03
5.5549451+04	5.5164835+04	6	6000	5.5549451+03	5.5164835+03
6.0714286+04	6.0714286+04	6	6500	6.0714286+03	6.0714286+03
6.6428571+04	6.6428571+04	6	7000	6.6428571+03	6.6428571+03
7.4230769+04	7.5769231+04	6	7500	7.4230769+03	7.5769231+03
7.8461538+04	8.1538461+04	6	7750	7.8461538+03	8.1538461+03
MIN SCALE		MAX SCALE			
1000		90000			
-----10-----20-----30-----40-----50-----60-----170-----800-----90					
POINT IS LEFT OF SCALE					
6	*				
7		*			
8			*		
9				*	
0					*
1					*
2					*
3					*
4					*
5					*
6					*
7					*
8					*
9					*
0					*
1					*

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	7	0	0	0
5.000000+03	5.000000+03	7	500	5.000000+02	5.000000+02
1.000000+04	1.000000+04	7	1000	1.000000+03	1.000000+03
1.500000+04	1.500000+04	7	1500	1.500000+03	1.500000+03
1.983516+04	1.945054+04	7	2000	1.983516+03	1.945054+03
2.500000+04	2.500000+04	7	2500	2.500000+03	2.500000+03
2.912087+04	2.873626+04	7	3000	2.912087+03	2.873626+03
3.412087+04	3.373626+04	7	3500	3.412087+03	3.373626+03
3.824175+04	3.747252+04	7	4000	3.824175+03	3.747252+03
4.340659+04	4.302197+04	7	4500	4.340659+03	4.302197+03
4.840659+04	4.802197+04	7	5000	4.840659+03	4.802197+03
5.252747+04	5.175824+04	7	5500	5.252747+03	5.175824+03
5.824175+04	5.747252+04	7	6000	5.824175+03	5.747252+03
6.395604+04	6.318681+04	7	6500	6.395604+03	6.318681+03
6.785714+04	6.785714+04	7	7000	6.785714+03	6.785714+03
7.857142+04	7.857142+04	7	7500	7.857142+03	7.857142+03
8.214285+04	8.214285+04	7	7750	8.214285+03	8.214285+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	8	0	0	0
5.000000+03	5.000000+03	8	500	5.000000+02	5.000000+02
1.000000+04	1.000000+04	8	1000	1.000000+03	1.000000+03
1.500000+04	1.500000+04	8	1500	1.500000+03	1.500000+03
1.983516+04	1.945054+04	8	2000	1.983516+03	1.945054+03
2.483516+04	2.445054+04	8	2500	2.483516+03	2.445054+03
2.912087+04	2.873626+04	8	3000	2.912087+03	2.873626+03
3.412087+04	3.373626+04	8	3500	3.412087+03	3.373626+03
3.840659+04	3.802197+04	8	4000	3.840659+03	3.802197+03
4.269230+04	4.230769+04	8	4500	4.269230+03	4.230769+03
4.824175+04	4.747252+04	8	5000	4.824175+03	4.747252+03
5.285714+04	5.285714+04	8	5500	5.285714+03	5.285714+03
5.807692+04	5.692307+04	8	6000	5.807692+03	5.692307+03
6.434065+04	6.280219+04	8	6500	6.434065+03	6.280219+03
7.043956+04	6.813186+04	8	7000	7.043956+03	6.813186+03
8.049450+04	7.664835+04	8	7500	8.049450+03	7.664835+03
8.912087+04	8.373626+04	8	7750	8.912087+03	8.373626+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
U	0	1	0	0	0
4.5714286+03	4.5714286+03	1	500	4.5714286+02	4.5714286+02
8.8571429+03	8.8571429+03	1	1000	8.8571428+02	8.8571428+02
1.4285714+04	1.4285714+04	1	1500	1.4285714+03	1.4285714+03
1.8571429+04	1.8571429+04	1	2000	1.8571429+03	1.8571429+03
2.2500000+04	2.2500000+04	1	2500	2.2500000+03	2.2500000+03
2.7142857+04	2.7142857+04	1	3000	2.7142857+03	2.7142857+03
3.2142857+04	3.2142857+04	1	3500	3.2142857+03	3.2142857+03
3.7142857+04	3.7142857+04	1	4000	3.7142857+03	3.7142857+03
4.0714286+04	4.0714286+04	1	4500	4.0714286+03	4.0714286+03
4.5357143+04	4.5357143+04	1	5000	4.5357143+03	4.5357143+03
5.1428571+04	5.1428571+04	1	5500	5.1428571+03	5.1428571+03
5.5714286+04	5.5714286+04	1	6000	5.5714286+03	5.5714286+03
5.7142857+04	5.7142857+04	1	6500	5.7142857+03	5.7142857+03
6.7142857+04	6.7142857+04	1	7000	6.7142857+03	6.7142857+03
7.7142857+04	7.7142857+04	1	7500	7.7142857+03	7.7142857+03
8.2857143+04	8.2857143+04	1	8000	8.2857143+03	8.2857143+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	2	0	0	0
3.5714286+03	3.5714286+03	2	500	3.5714286+02	3.5714286+02
8.5714286+03	8.5714286+03	2	1000	8.5714285+02	8.5714285+02
1.3571429+04	1.3571429+04	2	1500	1.3571429+03	1.3571429+03
1.8571429+04	1.8571429+04	2	2000	1.8571429+03	1.8571429+03
2.2142857+04	2.2142857+04	2	2500	2.2142857+03	2.2142857+03
2.7142857+04	2.7142857+04	2	3000	2.7142857+03	2.7142857+03
3.2142857+04	3.2142857+04	2	3500	3.2142857+03	3.2142857+03
3.6785714+04	3.6785714+04	2	4000	3.6785714+03	3.6785714+03
4.0714286+04	4.0714286+04	2	4500	4.0714286+03	4.0714286+03
4.5714286+04	4.5714286+04	2	5000	4.5714286+03	4.5714286+03
5.2857143+04	5.2857143+04	2	5500	5.2857143+03	5.2857143+03
6.0000000+04	6.0000000+04	2	6000	6.0000000+03	6.0000000+03
6.5714286+04	6.5714286+04	2	6500	6.5714286+03	6.5714286+03
7.2142857+04	7.2142857+04	2	7000	7.2142857+03	7.2142857+03
7.6428571+04	7.6428571+04	2	7500	7.6428571+03	7.6428571+03
8.2857143+04	8.2857143+04	2	8000	8.2857143+03	8.2857143+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	3	0	0	0
4.4505495+03	4.8351648+03	3	500	4.4505494+02	4.8351648+02
9.2857143+03	9.2857143+03	3	1000	9.2857143+02	9.2857143+02
1.2637363+04	1.3791209+04	3	1500	1.2637363+03	1.3791209+03
1.5439560+04	1.8131868+04	3	2000	1.5439560+03	1.8131868+03
2.0274725+04	2.2582418+04	3	2500	2.0274725+03	2.2582418+03
2.5824176+04	2.7747253+04	3	3000	2.5824176+03	2.7747253+03
3.0274725+04	3.2582418+04	3	3500	3.0274725+03	3.2582418+03
3.4560440+04	3.6868132+04	3	4000	3.4560440+03	3.6868132+03
3.8846154+04	4.1153846+04	3	4500	3.8846154+03	4.1153846+03
4.4230769+04	4.5769231+04	3	5000	4.4230769+03	4.5769231+03
4.8351648+04	4.9505495+04	3	5500	4.8351648+03	4.9505495+03
5.3406593+04	5.3021978+04	3	6000	5.3406593+03	5.3021978+03
6.0879121+04	6.1263736+04	3	6500	6.0879121+03	6.1263736+03
6.6868132+04	6.9560439+04	3	7000	6.6868132+03	6.9560439+03
2.3626374+04	6.2087912+04	3	7500	2.3626374+03	6.2087912+03
8.3076923+04	8.6923077+04	3	8000	8.3076923+03	8.6923077+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	4	0	0	0
5.3846154+03	4.6153846+03	4	500	5.3846154+02	4.6153846+02
1.0219780+04	9.0659341+03	4	1000	1.0219780+03	9.0659340+02
1.4505495+04	1.3351648+04	4	1500	1.4505494+03	1.3351648+03
1.9120879+04	1.8736264+04	4	2000	1.9120879+03	1.8736264+03
2.2307692+04	2.2692308+04	4	2500	2.2307692+03	2.2692308+03
2.6923077+04	2.8076923+04	4	3000	2.6923077+03	2.8076923+03
3.2307692+04	3.2692308+04	4	3500	3.2307692+03	3.2692308+03
3.6978022+04	3.6593407+04	4	4000	3.6978022+03	3.6593407+03
4.1813187+04	4.1043956+04	4	4500	4.1813187+03	4.1043956+03
4.7362637+04	4.6208791+04	4	5000	4.7362637+03	4.6208791+03
5.6208791+04	5.2362637+04	4	5500	5.6208791+03	5.2362637+03
5.9010989+04	5.6703297+04	4	6000	5.9010989+03	5.6703297+03
6.2197802+04	6.0659341+04	4	6500	6.2197802+03	6.0659341+03
6.9340659+04	6.7802198+04	4	7000	6.9340659+03	6.7802198+03
7.9340659+04	7.7802198+04	4	7500	7.9340659+03	7.7802198+03
1.1000000+05	1.0500000+05	4	8000	1.1000000+04	1.0500000+04

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
U	N	5	0	0	0
3.5714286+03	3.5714286+03	5	500	3.5714286+02	3.5714286+02
7.1428571+03	7.1428571+03	5	1000	7.1428571+02	7.1428571+02
1.1428571+04	1.1428571+04	5	1500	1.1428571+03	1.1428571+03
1.6428571+04	1.6428571+04	5	2000	1.6428571+03	1.6428571+03
2.0714286+04	2.0714286+04	5	2500	2.0714286+03	2.0714286+03
2.5000000+04	2.5000000+04	5	3000	2.5000000+03	2.5000000+03
2.8571429+04	2.8571429+04	5	3500	2.8571429+03	2.8571429+03
3.3571429+04	3.3571429+04	5	4000	3.3571429+03	3.3571429+03
3.7857143+04	3.7857143+04	5	4500	3.7857143+03	3.7857143+03
4.2142857+04	4.2142857+04	5	5000	4.2142857+03	4.2142857+03
4.5714286+04	4.5714286+04	5	5500	4.5714286+03	4.5714286+03
4.9285714+04	4.9285714+04	5	6000	4.9285714+03	4.9285714+03
5.7142857+04	5.7142857+04	5	6500	5.7142857+03	5.7142857+03
6.2142857+04	6.2142857+04	5	7000	6.2142857+03	6.2142857+03
6.8571428+04	6.8571428+04	5	7500	6.8571428+03	6.8571428+03
8.5000000+04	8.5000000+04	5	8000	8.5000000+03	8.5000000+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	6	0	0	0
5.0000000+03	5.0000000+03	6	500	5.0000000+02	5.0000000+02
9.1208791+03	8.7362637+03	6	1000	9.1208791+02	8.7362637+02
1.4120879+04	1.3736264+04	6	1500	1.4120879+03	1.3736264+03
1.8406593+04	1.8021978+04	6	2000	1.8406593+03	1.8021978+03
2.2692308+04	2.2307692+04	6	2500	2.2692308+03	2.2307692+03
2.7692308+04	2.7307692+04	6	3000	2.7692308+03	2.7307692+03
3.2142857+04	3.2142857+04	6	3500	3.2142857+03	3.2142857+03
3.6813187+04	3.6043956+04	6	4000	3.6813187+03	3.6043956+03
4.1098901+04	4.0329670+04	6	4500	4.1098901+03	4.0329670+03
4.5384615+04	4.4615385+04	6	5000	4.5384615+03	4.4615385+03
4.9835165+04	4.9450549+04	6	5500	4.9835165+03	4.9450549+03
5.4670330+04	5.3901099+04	6	6000	5.4670330+03	5.3901099+03
6.5714286+04	6.5714286+04	6	6500	6.5714286+03	6.5714286+03
7.1208791+04	7.2362637+04	6	7000	7.1208791+03	7.2362637+03
7.8901099+04	7.9670330+04	6	7500	7.8901099+03	7.9670330+03
8.7032967+04	9.0109890+04	6	8000	8.7032967+03	9.0109890+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	7	0	0	0
4.1208791+03	3.7362637+03	7	500	4.1208791+02	3.7362637+02
8.4065934+03	8.0219780+03	7	1000	8.4065934+02	8.0219780+02
1.3791209+04	1.2637363+04	7	1500	1.3791209+03	1.2637363+03
1.8076923+04	1.6923077+04	7	2000	1.8076923+03	1.6923077+03
2.2527473+04	2.1758242+04	7	2500	2.2527473+03	2.1758242+03
2.7362637+04	2.6208791+04	7	3000	2.7362637+03	2.6208791+03
3.1978022+04	3.1593407+04	7	3500	3.1978022+03	3.1593407+03
3.6263736+04	3.5879121+04	7	4000	3.6263736+03	3.5879121+03
4.0549451+04	4.0164835+04	7	4500	4.0549451+03	4.0164835+03
4.5549451+04	4.5164835+04	7	5000	4.5549451+03	4.5164835+03
5.0164835+04	5.0549451+04	7	5500	5.0164835+03	5.0549451+03
5.4945055+04	5.6483516+04	7	6000	5.4945055+03	5.6483516+03
5.9945055+04	6.1483516+04	7	6500	5.9945055+03	6.1483516+03
6.3516484+04	6.5054945+04	7	7000	6.3516483+03	6.5054945+03
7.1538461+04	7.3461538+04	7	7500	7.1538461+03	7.3461538+03
7.7802198+04	7.9340659+04	7	8000	7.7802198+03	7.9340659+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	8	0	0	0
4.2857143+03	4.2857143+03	8	500	4.2857143+02	4.2857143+02
8.4065934+03	8.0219780+03	8	1000	8.4065934+02	8.0219780+02
1.3406593+04	1.3021978+04	8	1500	1.3406593+03	1.3021978+03
1.7692308+04	1.7307692+04	8	2000	1.7692308+03	1.7307692+03
2.2692308+04	2.2307692+04	8	2500	2.2692308+03	2.2307692+03
2.7142857+04	2.7142857+04	8	3000	2.7142857+03	2.7142857+03
3.1978022+04	3.1593407+04	8	3500	3.1978022+03	3.1593407+03
3.5934066+04	3.4780220+04	8	4000	3.5934066+03	3.4780220+03
4.0384615+04	3.9615385+04	8	4500	4.0384615+03	3.9615385+03
4.5219780+04	4.4065934+04	8	5000	4.5219780+03	4.4065934+03
4.7142857+04	4.7142857+04	8	5500	4.7142857+03	4.7142857+03
4.9065934+04	5.0219780+04	8	6000	4.9065934+03	5.0219780+03
5.2252747+04	5.4175824+04	8	6500	5.2252747+03	5.4175824+03
6.4945055+04	6.6483516+04	8	7000	6.4945055+03	6.6483516+03
7.1428571+04	7.1428571+04	8	7500	7.1428571+03	7.1428571+03
7.8571428+04	7.8571428+04	8	8000	7.8571428+03	7.8571428+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	9	0	0	0
4.8351648+03	4.4505494+03	9	500	4.8351648+02	4.4505494+02
9.2857143+03	9.2857143+03	9	1000	9.2857143+02	9.2857143+02
1.3406593+04	1.3021978+04	9	1500	1.3406593+03	1.3021978+03
1.7307692+04	1.7692308+04	9	2000	1.7307692+03	1.7692308+03
2.1593407+04	2.1978022+04	9	2500	2.1593407+03	2.1978022+03
2.5329670+04	2.6098901+04	9	3000	2.5329670+03	2.6098901+03
2.8516484+04	3.0054945+04	9	3500	2.8516484+03	3.0054945+03
3.2417582+04	3.4725275+04	9	4000	3.2417582+03	3.4725275+03
3.6153846+04	3.8846154+04	9	4500	3.6153846+03	3.8846154+03
4.0439560+04	4.3131868+04	9	5000	4.0439560+03	4.3131868+03
4.4120879+04	4.8736264+04	9	5500	4.4120879+03	4.8736264+03
4.8186813+04	5.3956044+04	9	6000	4.8186813+03	5.3956044+03
5.0879121+04	5.6263736+04	9	6500	5.0879121+03	5.6263736+03
5.3351648+04	5.9505495+04	9	7000	5.3351648+03	5.9505495+03
5.6593407+04	6.6978022+04	9	7500	5.6593407+03	6.6978022+03
6.0000000+04	7.5000000+04	9	8000	6.0000000+03	7.5000000+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	10	0	0	0
4.6703297+03	3.9010989+03	10	500	4.6703297+02	3.9010989+02
1.0604396+04	8.6813187+03	10	1000	1.0604396+03	8.6813187+02
1.5989011+04	1.3296703+04	10	1500	1.5989011+03	1.3296703+03
2.0439560+04	1.8131868+04	10	2000	2.0439560+03	1.8131868+03
2.5274725+04	2.2582418+04	10	2500	2.5274725+03	2.2582418+03
3.0109890+04	2.7032967+04	10	3000	3.0109890+03	2.7032967+03
3.5109890+04	3.2032967+04	10	3500	3.5109890+03	3.2032967+03
4.0109890+04	3.7032967+04	10	4000	4.0109890+03	3.7032967+03
4.5109890+04	4.2032967+04	10	4500	4.5109890+03	4.2032967+03
5.0439560+04	4.8131868+04	10	5000	5.0439560+03	4.8131868+03
5.6923077+04	5.3076923+04	10	5500	5.6923077+03	5.3076923+03
6.2472527+04	5.8241758+04	10	6000	6.2472527+03	5.8241758+03
1.1192308+05	7.8076923+04	10	6500	1.1192308+04	7.8076923+03
7.4725275+04	7.2417582+04	10	7000	7.4725275+03	7.2417582+03
8.3461538+04	8.1538461+04	10	7500	8.3461538+03	8.1538461+03
9.4945055+04	9.1483516+04	10	8000	9.4945055+03	9.1483516+03

SIGMA1	SIGMA2	GAGE NO.	PRESSURE	SENS1	SENS2
0	0	11	0	0	0
6.4835165+03	4.9450549+03	11	500	6.4835165+02	4.9450549+02
1.1318681+04	9.3956044+03	11	1000	1.1318681+03	9.3956044+02
1.6153846+04	1.3846154+04	11	1500	1.6153846+03	1.3846154+03
2.0604396+04	1.8681319+04	11	2000	2.0604396+03	1.8681319+03
2.4725275+04	2.2417582+04	11	2500	2.4725275+03	2.2417582+03
2.9175824+04	2.7252747+04	11	3000	2.9175824+03	2.7252747+03
3.3626374+04	3.2087912+04	11	3500	3.3626374+03	3.2087912+03
3.7912088+04	3.6373626+04	11	4000	3.7912088+03	3.6373626+03
4.2032967+04	4.0109890+04	11	4500	4.2032967+03	4.0109890+03
4.7032967+04	4.5109890+04	11	5000	4.7032967+03	4.5109890+03
5.2582418+04	5.0274725+04	11	5500	5.2582418+03	5.0274725+03
5.8681319+04	5.5604396+04	11	6000	5.8681319+03	5.5604396+03
6.2967033+04	5.9890110+04	11	6500	6.2967033+03	5.9890110+03
6.9450549+04	6.4835165+04	11	7000	6.9450549+03	6.4835165+03
7.2362637+04	7.1208791+04	11	7500	7.2362637+03	7.1208791+03
8.1868132+04	7.9560439+04	11	8000	8.1868132+03	7.9560439+03