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Rockwell International

TECHNICAL STUDY

Department 744-76XXX-645
Report No. 2573-62

TITLE: Energy Absorption by the size 14 Fig. 607 Valve Seat and Disk at Yankee Rowe

ABSTRACT

A preliminary investigation of the deformation damage expected to occur in the valve as a result of high energy impact of the disk on the seat was made. An elastic finite-element study of the valve body and disk showed that yielding will occur first in the valve body. A mathematical model of a postulated mode of plastic failure of the seat was developed and indicates that the valve body alone has adequate energy-absorbing capacity to absorb the necessary impact energy with a safe, functional terminal configuration. A scale model test of the valve body exhibited behavior similar the postulated failure mode, and indicated additional strength due to work hardening of the material. It is concluded that this valve can safely withstand the sudden closure which would result from an instantaneous release of pressure upstream of the valve.

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DISTRIBUTION

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OBJECTIVE

This study was undertaken at the request of the customer to determine whether the size 14 Figure 607 main steam isolation valves at the Yankee Rowe nuclear power plant are capable of safe and effective closure in the event of a catastrophic line break in the pipe adjacent to the valve inlet. Such a condition would cause these stop-check type valves to slam shut, the disks striking the seats at a velocity of 65.3 ft/sec (19.9 m/s) and with an energy of 139,250 in-lb (15.7 kJ) (1)[1].

Due to the limited time available, this study was to be limited to an elastic finite-element analysis, hand calculations, and simple model testing.

CONCLUSIONS

1. The disk impact energy due to the sudden flow reversel associated with a line break can be safely absorbed by the valve seat.

2. The type of deformation that will occur is a plastic flow of the seat shelf, downward and inward, causing a reduction in the inside diameter of the valve bore below the seat. Very little radial movement of the body shell will occur.

3. The valve disk is stronger than the seat by a factor of 2.23. Therefore most plastic deformation will occur in the valve seat. Any plastic deformation that might occur in the disk will provide further energy-absorbing capacity.

4. The deformed seat in the model was coined to an excellent finish. However, no stellite was deposited on this seat as is the case in the actual valve. Therefore, the sealing ability of the valve after this deformation has occurred cannot be predicted solely on the basis of the test. However, even though the stellite might crack, intimate contact between the disk and body seating peripheries is assured and any leakage should be negligible by comparison with the quantity of steam discharged by the line break.

DISCUSSION

This investigation included three principal activities: an elastic finite-element stress analysis of the disk and body, a simplified plastic analysis of the seat region, and an experimental study of the plastic deformation of the seat. Discussion of these activities will be presented in that order.

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[1] Numbers in parenthesis refer to references at end of paper.

ELASTIC FINITE-ELEMENT ANALYSIS

The lower portion of the disk and the seat region of the body were modeled using FINEL (2), an axisymmetric finite-element program having rectangular and triangular elements. This program has been used extensively within Rockwell and has been verified with closed-form analyses and by comparison to NASTRAN on identical models.

Since the body loading includes both the seat loading due to impact and the internal pressure loading above the seat, it was necessary to run two cases in order to identify the seat deflection due to the impact loading alone.

Exhibit One is the computer output for the combined pressure and impact loading of the body. For a pressure load of 1000 psi (69 bar) and an impact load of 1,000,000 lbs. (4.45 MN), the maximum stress intensity occurs just below the seat, and has a magnitude of 72.3 ksi (498 MPa).

Comparing this value to the yield strength of the body material at 500F (260C), which, from Section III of the ASME Code (4), is 29.1 ksi (200 MPa), shows that the actual seat loading at which yield will occur is:

$$1,000,000 \left(\frac{29.1}{72.3}\right) = 402,500 \text{ lb. } (1.79 \text{ MN})$$

And the corresponding pressure loading would be:

$$1000 \left(\frac{29.1}{72.3}\right) = 403 \text{ psi } (28 \text{ bar})$$

which fortunately compares well with the 424 psi (29 bar) obtained by extrapolating the inlet pressure in the simulation study to the time of impact.

Exhibit Two is the analysis of the body under impact loading only. This analysis shows that the outward deflection of the seat is .0061" (0.16 mm) due to impact. Applying the 0.403 yield adjustment factor as above, the adjusted deflection at a 402,500 lb. (1.79 MN) load would be .00245" (0.062 mm).

A calculation of the elastic energy absorbed by outward deflection of the seat yields:

$$W = \frac{1}{2} F x = \frac{1}{2} (402,500)(.00245) = 493 \text{ in-lb.}$$

or, in SI units,

$$\frac{1}{2} (1.79)(.062)\, 10^3 = 55.6 \text{ J}$$

which is, of course, insignificant compared to the 1,251,000 in.lb. (141.4 kJ) impact energy.

Exhibit Three is the finite-element model of the disk. This disk model is loaded in proportion to the mass at each section, in the manner used in the Leonard and O'Leary study of nuclear swing check valves (3). The FINEL program is also used in this analysis.

The seat load resulting from the arbitrarily-scaled inertial loading was 45,670 lb. (.203 MN). The maximum stress intensity was 1.59 ksi (11 MPa) compared to a yield stress (F11 material) of 31.2 ksi (215 MPa)(4), indicating that the disk can withstand a seat load of:

$$45{,}670 \left(\frac{31.2}{1.59}\right) = 898{,}000 \text{ lb. } (4.0 \text{ MN})$$

before yielding. Since the body will begin to yield at 402,500 lb. (1.79 MN), the disk is approximately 898,000/402,500 = 2.23 times as strong as the body.

By summing the products of one-half the applied forces times the deflection of the corresponding nodes, the elastic energy input to the disk was calculated to be 4.75 in-lb (.535 J) under the loading of the model. This must be scaled up by a factor of $(402{,}500/45670)^2 = 77.7$ to correspond to the body yield load, yielding an elastic energy of 369 in-lb (41.6 J).

The elastic energy also would include that energy absorbed by relative motion of the disk into the conical seat. Inward deflection of the disk, adjusted for the yield load of the body, would be:

$$.00005 \left(\frac{402{,}500}{45670}\right) = .00044" \ (0.011 \text{ mm})$$

Adding this to the outward deflection of the body and multiplying by half the applied force, the energy absorbed is:

$$W = \frac{1}{2}(402{,}500)(.00044 + .00245) = 582 \text{ in.lb.}$$

or, in SI units,

$$W = \frac{1}{2}(1.79)(.011 + .062)\, 10^3 = 65.6 \text{ J}$$

The total energy that is absorbed elastically, then, up to the point of incipient yielding, would be:

Description	Energy, in-lb (J)
Body Elastic Energy	493 (55.6)
Disk Elastic Energy	369 (41.6)
Disk-Body Relative Motion	583 (65.6)
Total Elastic Energy Capacity	1444 (162.8)

Thus, the elastic analysis bears out the initial opinion that the amount of energy that can be absorbed elastically is far less than that which would be supplied under the postulated line break conditions.

Nonetheless, the elastic analysis does identify the body as the likely site of plastic deformation and further, an examination of the maximum shear trajectories in the seat region (Exhibit Four) does suggest a mode of failure. One can visualize the seat deforming downward and inward due to the applied load, with material from behind the seat bulging out below the seat. This concept led to the plastic analysis described below.

PLASTIC SEAT ANALYSIS

Exhibit Five shows the derivation of a simple equation for the amount of energy required to plastically deform the seat in a manner suggested by the maximum-shear trajectories of Exhibit Four. This analysis makes use of three simplifying assumptions:

1. The effect of hoop stress is neglected since the radius of the seat is quite large compared to the local deformations. Therefore the problem is simplified to a two-dimensional plane.

2. Deformation occurs along parallel slip planes.

3. Loading occurs along the slip planes, that is, there is no effect of loading through the slip planes on the shear yield stress.

The resulting equation for the plastic energy absorbed by the seat in the deformation defined is:

$$W_p = 7.5844\, d\, \tau_{yp}\, (a^2 - b^2)$$

For the case of the size 14 Figure 607 valve, this results in a seat energy absorption of:

$$W_p = 271{,}181 \text{ in-lb } (30.6 \text{ kJ})$$

Since the disk is subject to a steam pressure acting in the direction of travel, the total energy required to be absorbed is the sum of the kinetic energy of the disk due to its velocity at impact and the products of the pressure force and the distance the disk travels after impact. This steam pressure energy is equal to the product of the pressure and the volume change, or

$$W_e = P_b \Delta v_b, \text{ where:}$$

W_e = expansion work,
P_b = bonnet chamber pressure, and
Δv_b = bonnet chamber volume change

The bonnet chamber volume change is the product of the bonnet area, 14.8 in^2 (0.0954 m^2) and the seat deflection, 0.190 in. (4.83 mm), or 28.2 in^3 (.00046 m^3).

The bonnet chamber pressure can be obtained by extrapolation of the simulation data, and is:

$$P_2 = \frac{V_1 P_1}{V_2} = \frac{480.8\ (264.23)}{896.3} = 142 \text{ psi } (9.8 \text{ bar})$$

The yields an expansion work of 4004 in.lb. (452 J).

Therefore, the total energy input is 139,250 + 4004 = 143,254 in-lb (16.2 kJ), which compares favorably with the 271,181 in.lb. (30.6 kJ) seat energy absorption as calculated. Therefore, on the basis of these calculations, the seat design can safely absorb all the energy of the disk within the deformation limits described.

EXPERIMENTAL SEAT STUDY

In order to demonstrate the credibility of the calculation method as a means for estimating energy absorption capabilities, a scale model of the size 24 Fig. 4007 valve seat was made up and an actual deformation test was performed, with the relationship between loading and deflection recorded over the full travel of the simulated disk into the seat. The size 24 valve seat is similar in shape to that of the size 14.

Exhibit Six shows the test model dimensions. The linear scale factor of 0.1875, referred to the size 24 valve, was chosen in order to permit use of the 200,000 lb. (889 kN) test machine in the Rockwell materials laboratory. Clay impressions were made of the seat in the model and viewed on an optical comparator to verify that the geometry was correct.

A tensile specimen was made of the same piece of material that was used for the body, and was pulled to determine the yield strength of the material. Its yield strength (0.2% offset) was 43.3 ksi (298 MPa). This is typical of the 1018 material used, and is higher than the minimum specified yield strength of the valve body material. Knowing the actual yield strength provides a basis for comparison of the energy absorbed in the test model to that which would be absorbed in a valve with minimum material properties. The ratio of yield strengths is:

$$\frac{43.3}{29.1} = 1.49$$

Exhibit Seven shows the test data plotted as a load-deflection curve. In addition, a family of theoretical curves is shown, since the theoretical force is a function of the coefficient of friction between the disk and seat. The theoretical curve for $\mu = 0.25$ matches the data well, and since this is a reasonable coefficient of friction, the experimental data do seem to confirm the theory.

The theoretical amount of deflection in the model that would be required to frictionlessly absorb the scaled equivalent of the energy of the disk is 0.088" (2.2 mm). However, the test data indicate that, due to the large energy absorption by friction between the disk and seat, only 0.058" (1.5 mm) of deflection would be required to accomplish the same amount of energy absorption. Since the frictionless assumption is more conservative, a maximum seat deformation of 0.19" (4.83 mm) would be expected to occur in the size 14 valve, out of a total 0.31" (7.9 mm) seat shoulder width.

Exhibit Eight shows the shape of the deformed model bore after the test. The flow of material is not exactly as predicted by the mathematical model. The difference can be explained by two factors. First, the contribution of the circumferential, or hoop, strengths of the material tends to resist radial material movement more than in the ideal model. And second, strain hardening along the 22-1/2° slip planes would terd to cause the material to seek new slip directions of lesser resistance after yielding has begun.

Exhibit Nine shows the derivation of the theoretical curves of Exhibit Seven, based on the strength and dimensions of the model.

REFERENCES

1. Disk Velocity of Impact with Seat for Line Break at Upstream Side of Size 14 Fig. 607 Non-Return Valve, E. B. Pool, Rockwell International, Report 2573-48.

2. FINEL - A Stress Analysis Program Using Axisymmetric Finite Elements, J. H. Fowler, Rockwell International, Report 2573-01-21-14.

3. Verification of a Qusai-Static Elastic-Plastic Impact Analysis for a Check Valve Used on a Nuclear Piping System, J. W. Leonard and J. R. O'Leary, ASME Paper No. 74-WA/PVP-8.

4. ASME Boiler and Pressure Vessel Code, Sect'on III Division 1, Subsection NA, Table I-2.1, 1974 edition, ASME, New York, pp. 88-93.

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SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

NT	NOREGT	NR	NZ	NPR	NPZ	NF	NSUPP	IBP1	MAXITS	NPLOT	NTRI	NCOUP
96	69	6	22	2	2	0	5	16	1000	13	3	0

NGRIDS
3

CC	BETA	E	MU
.10000E-07	.0	.30000E+08	.30000

GRID 1 -- 4 X 9 -- 1 5 50 46

GRID 2 -- 3 X 1 -- 47 50 56 53

GRID 3 -- 3 X 10 -- 53 56 96 93

RECTANGULAR ELEMENTS

1	2	7	6	2	3	8	7	3	4	9	8	4	5	10	9	6	7	12	11
7	8	13	12	8	9	14	13	9	10	15	14	11	12	17	16	12	13	18	17
13	14	19	18	14	15	20	19	16	17	22	21	17	18	23	22	18	19	24	23
19	20	25	24	21	22	27	26	22	23	28	27	23	24	29	28	24	25	30	29
26	27	32	31	27	28	33	32	28	29	34	33	29	30	35	34	31	32	37	36
32	33	38	37	33	34	39	38	34	35	40	39	36	37	42	41	37	38	43	42
38	39	44	43	39	40	45	44	41	42	47	46	42	43	48	47	43	44	49	48
44	45	50	49	47	48	54	53	48	49	55	54	49	50	56	55	53	54	58	57
54	55	59	58	55	56	60	59	57	58	62	61	58	59	63	62	59	60	64	63
61	62	66	65	62	63	67	66	63	64	68	67	65	66	70	69	66	67	71	70
67	68	72	71	69	70	74	73	70	71	75	74	71	72	76	75	73	74	78	77
74	75	79	78	75	76	80	79	77	78	82	81	78	79	83	82	79	80	84	83
81	82	86	85	82	83	87	86	83	84	88	87	85	86	90	89	86	87	91	90
87	88	92	91	89	90	94	93	90	91	95	94	91	92	96	95				

TRIANGULAR ELEMENTS

47	53	52	0	47	52	51	0	47	51	46	0

R LATTICE

6.4400	6.5600	6.8800	7.3300	7.7800	8.2500

Z LATTICE

.0	.60000	1.2000	1.8000	2.4000	3.0000
3.6000	4.2000	4.8000	5.4000	5.9000	6.0200
6.6400	7.2400	7.8400	8.4400	9.0400	9.6400
10.240	10.840	11.440	12.040		

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SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

NODAL LATTICE POSITIONS

1	1	1
2	3	1
3	4	1
4	5	1
5	6	1
6	1	2
7	3	2
8	4	2
9	5	2
10	6	2
11	1	3
12	3	3
13	4	3
14	5	3
15	6	3
16	1	4
17	3	4
18	4	4
19	5	4
20	6	4
21	1	5
22	3	5
23	4	5
24	5	5
25	6	5
26	1	6
27	3	6
28	4	6
29	5	6
30	6	6
31	1	7
32	3	7
33	4	7
34	5	7
35	6	7
36	1	8
37	3	8
38	4	8
39	5	8
40	6	8
41	1	9
42	3	9
43	4	9
44	5	9
45	6	9
46	1	10
47	3	10
48	4	10
49	5	10
50	6	10

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SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

NODAL LATTICE POSITIONS

51	1	11
52	2	12
53	3	12
54	4	12
55	5	12
56	6	12
57	3	13
58	4	13
59	5	13
60	6	13
61	3	14
62	4	14
63	5	14
64	6	14
65	3	15
66	4	15
67	5	15
68	6	15
69	3	16
70	4	16
71	5	16
72	6	16
73	3	17
74	4	17
75	5	17
76	6	17
77	3	18
78	4	18
79	5	18
80	6	18
81	3	19
82	4	19
83	5	19
84	6	19
85	3	20
86	4	20
87	5	20
88	6	20
89	3	21
90	4	21
91	5	21
92	6	21
93	3	22
94	4	22
95	5	22
96	6	22

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07/24/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

PICTORIAL REPRESENTATION

0	0	93	94	95	96
0	0	89	90	91	92
0	0	85	86	87	88
0	0	81	82	83	84
0	0	77	78	79	80
0	0	73	74	75	76
0	0	69	70	71	72
0	0	65	66	67	68
0	0	61	62	63	64
0	0	57	58	59	60
0	52	53	54	55	56
51	0	0	0	0	0
46	0	47	48	49	50
41	0	42	43	44	45
36	0	37	38	39	40
31	0	32	33	34	35
26	0	27	28	29	30
21	0	22	23	24	25
16	0	17	18	19	20
11	0	12	13	14	15
6	0	7	8	9	10
1	0	2	3	4	5

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SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

RADIAL PRESSURE, TYPE, NODES

1000.0	1	53	57	61	65	69	73	77	81	85	
	89	93									
.10000E+07	2	51	52								

AXIAL PRESSURE, TYPE, NODES

-1000.0	1	52	53
-.10000E+07	2	51	52

DEFLECTION	NODE	DIRECTION
.0	1	2
.0	2	2
.0	3	2
.0	4	2
.0	5	2

NODES, COORDINATES, AND FORCES

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

1	6.440	0.0	0.	0.
2	6.880	0.0	0.	0.
3	7.330	0.0	0.	0.
4	7.780	0.0	0.	0.
5	8.250	0.0	0.	0.
6	6.440	0.600	0.	0.
7	6.880	0.600	0.	0.
8	7.330	0.600	0.	0.
9	7.780	0.600	0.	0.
10	8.250	0.600	0.	0.
11	6.440	1.200	0.	0.
12	6.880	1.200	0.	0.
13	7.330	1.200	0.	0.
14	7.780	1.200	0.	0.
15	8.250	1.200	0.	0.
16	6.440	1.800	0.	0.
17	6.880	1.800	0.	0.
18	7.330	1.800	0.	0.
19	7.780	1.800	0.	0.
20	8.250	1.800	0.	0.
21	6.440	2.400	0.	0.
22	6.880	2.400	0.	0.
23	7.330	2.400	0.	0.
24	7.780	2.400	0.	0.
25	8.250	2.400	0.	0.
26	6.440	3.000	0.	0.
27	6.880	3.000	0.	0.
28	7.330	3.000	0.	0.
29	7.780	3.000	0.	0.
30	8.250	3.000	0.	0.
31	6.440	3.600	0.	0.
32	6.880	3.600	0.	0.
33	7.330	3.600	0.	0.
34	7.780	3.600	0.	0.
35	8.250	3.600	0.	0.
36	6.440	4.200	0.	0.
37	6.880	4.200	0.	0.
38	7.330	4.200	0.	0.
39	7.780	4.200	0.	0.
40	8.250	4.200	0.	0.
41	6.440	4.800	0.	0.
42	6.880	4.800	0.	0.
43	7.330	4.800	0.	0.
44	7.780	4.800	0.	0.
45	8.250	4.800	0.	0.
46	6.440	5.400	0.	0.
47	6.880	5.400	0.	0.
48	7.330	5.400	0.	0.
49	7.780	5.400	0.	0.
50	8.250	5.400	0.	0.

.ODES, COORDINATES, AND FORCES

.IZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

51	6.440	5.900	497439.	-497439.
52	6.560	6.020	502561.	-509229.
53	6.880	6.020	13401.	-6844.
54	7.330	6.020	0.	0.
55	7.780	6.020	0.	0.
56	8.250	6.020	0.	0.
57	6.880	6.640	26369.	0.
58	7.330	6.640	0.	0.
59	7.780	6.640	0.	0.
60	8.250	6.640	0.	0.
61	6.880	7.240	25937.	0.
62	7.330	7.240	0.	0.
63	7.780	7.240	0.	0.
64	8.250	7.240	0.	0.
65	6.880	7.840	25937.	0.
66	7.330	7.840	0.	0.
67	7.780	7.840	0.	0.
68	8.250	7.840	0.	0.
69	6.880	8.440	25937.	0.
70	7.330	8.440	0.	0.
71	7.780	8.440	0.	0.
72	8.250	8.440	0.	0.
73	6.880	9.040	25937.	0.
74	7.330	9.040	0.	0.
75	7.780	9.040	0.	0.
76	8.250	9.040	0.	0.
77	6.880	9.640	25937.	0.
78	7.330	9.640	0.	0.
79	7.780	9.640	0.	0.
80	8.250	9.640	0.	0.
81	6.880	10.240	25937.	0.
82	7.330	10.240	0.	0.
83	7.780	10.240	0.	0.
84	8.250	10.240	0.	0.
85	6.880	10.840	25937.	0.
86	7.330	10.840	0.	0.
87	7.780	10.840	0.	0.
88	8.250	10.840	0.	0.
89	6.880	11.440	25937.	0.
90	7.330	11.440	0.	0.
91	7.780	11.440	0.	0.
92	8.250	11.440	0.	0.
93	6.880	12.040	12968.	0.
94	7.330	12.040	0.	0.
95	7.780	12.040	0.	0.
96	8.250	12.040	0.	0.

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IZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

TIFFNESS MATRIX WIDTH FROM 1 TO 16

AUSS-SEIDEL ITERATION
CONVERGENCE AT ITERATION NO. AND BETA

.21531E-04	100	1.81856
.51108E-06	200	1.81856

TOTAL ITERATIONS, 298

NEL 07/24/75

ZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

DAL DISPLACEMENTS

DE	UR	UZ
1	0.0015541	-0.0000000
2	0.0015429	-0.0000000
3	0.0015686	-0.0000000
4	0.0016267	-0.0000000
5	0.0017211	-0.0000000
6	0.0016308	-0.0000465
7	0.0016192	-0.0001522
8	0.0016439	-0.0002519
9	0.0017004	-0.0003498
10	0.0017924	-0.0004567
11	0.0018585	-0.0001068
12	0.0018462	-0.0003141
13	0.0018682	-0.0005080
14	0.0019195	-0.0006983
15	0.0020041	-0.0009079
16	0.0022301	-0.0001966
17	0.0022175	-0.0004959
18	0.0022353	-0.0007723
19	0.0022779	-0.0010435
20	0.0023498	-0.0013463
21	0.0027317	-0.0003346
22	0.0027203	-0.0007097
23	0.0027331	-0.0010488
24	0.0027635	-0.0013817
25	0.0028163	-0.0017613
26	0.0033387	-0.0005445
27	0.0033322	-0.0009695
28	0.0033404	-0.0013417
29	0.0033554	-0.0017067
30	0.0033821	-0.0021372
31	0.0040127	-0.0008535
32	0.0040164	-0.0012922
33	0.0040228	-0.0016560
34	0.0040203	-0.0020094
35	0.0040129	-0.0024505
36	0.0046972	-0.0012914
37	0.0047208	-0.0016982
38	0.0047274	-0.0019982
39	0.0047056	-0.0022778
40	0.0046529	-0.0026653
41	0.0053423	-0.0018843
42	0.0053813	-0.0022112
43	0.0053855	-0.0023672
44	0.0053175	-0.0024884
45	0.0052053	-0.0027381
46	0.0058937	-0.0027332
47	0.0059944	-0.0028366
48	0.0058515	-0.0026804
49	0.0056930	-0.0026161
50	0.0055203	-0.0026505

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

NODAL DISPLACEMENTS

NODE	UR	UZ
51	0.0066766	-0.0037383
52	0.0066475	-0.0037658
53	0.0061676	-0.0032092
54	0.0058408	-0.0028844
55	0.0056284	-0.0026684
56	0.0054398	-0.0024638
57	0.0052146	-0.0035311
58	0.0051758	-0.0030540
59	0.0050780	-0.0027174
60	0.0049452	-0.0023244
61	0.0045301	-0.0037275
62	0.0044437	-0.0032366
63	0.0043710	-0.0027958
64	0.0042832	-0.0023111
65	0.0038156	-0.0038350
66	0.0037320	-0.0033440
67	0.0036609	-0.0028834
68	0.0035997	-0.0023853
69	0.0031448	-0.0038773
70	0.0030644	-0.0034128
71	0.0030047	-0.0029659
72	0.0029613	-0.0024972
73	0.0025398	-0.0038805
74	0.0024685	-0.0034571
75	0.0024191	-0.0030416
76	0.0023883	-0.0026148
77	0.0020048	-0.0038683
78	0.0019446	-0.0034864
79	0.0019045	-0.0031058
80	0.0018813	-0.0027208
81	0.0015279	-0.0038557
82	0.0014797	-0.0035069
83	0.0014476	-0.0031560
84	0.0014291	-0.0028043
85	0.0010893	-0.0038500
86	0.0010531	-0.0035219
87	0.0010284	-0.0031916
88	0.0010133	-0.0028609
89	0.0006676	-0.0038515
90	0.0006424	-0.0035320
91	0.0006248	-0.0032132
92	0.0006134	-0.0028915
93	0.0002441	-0.0038535
94	0.0002284	-0.0035360
95	0.0002184	-0.0032223
96	0.0002136	-0.0029031

NEL

IZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

AVERAGED STRESSES AT NODES

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
1	1804.	607.	7963.	1474.	2796.	-385.	34.	8348.
2	126.	-6093.	4937.	1468.	455.	-6422.	13.	11360.
3	198.	-11641.	2987.	1450.	373.	-11815.	7.	14802.
4	194.	-17066.	1211.	1417.	309.	-17182.	5.	18393.
5	-1453.	-23654.	-1274.	1371.	-1369.	-23739.	4.	22465.
6	1781.	334.	8231.	152.	1797.	318.	6.	7913.
7	123.	-6249.	5223.	252.	133.	-6259.	2.	11481.
8	198.	-11653.	3292.	349.	208.	-11663.	2.	14955.
9	196.	-16938.	1534.	248.	199.	-16942.	1.	18476.
10	-1430.	-23407.	-933.	96.	-1429.	-23407.	0.	22474.
11	1703.	-540.	9006.	327.	1749.	-586.	8.	9593.
12	112.	-6740.	606[illegible].	549.	156.	-6784.	5.	12646.
13	196.	-11691.	41[illegible]8.	761.	244.	-11739.	4.	15937.
14	201.	-16534.	2502.	541.	218.	-16551.	2.	19053.
15	-1354.	-22616.	97.	214.	-1352.	-22618.	1.	22715.
16	1548.	-2172.	10202.	546.	1626.	-2250.	8.	12452.
17	94.	-7641.	7405.	937.	205.	-7752.	7.	15158.
18	190.	-11760.	5678.	1296.	329.	-11899.	6.	17577.
19	207.	-15791.	4109.	921.	260.	-15844.	3.	19953.
20	-1210.	-21147.	1838.	377.	-1202.	-21154.	1.	22991.
21	1282.	-4813.	11666.	824.	1392.	-4923.	8.	16589.
22	67.	-9071.	9161.	1453.	293.	-9296.	9.	18457.
23	178.	-11879.	7676.	2009.	504.	-12205.	9.	19881.
24	213.	-14614.	6336.	1432.	350.	-14751.	5.	21087.
25	-963.	-18765.	4323.	607.	-942.	-18786.	2.	23108.
26	895.	-8743.	13199.	1172.	1036.	-8884.	7.	22082.
27	49.	-11192.	11187.	2118.	435.	-11577.	10.	22765.
28	168.	-12103.	10091.	2949.	840.	-12775.	13.	22866.
29	231.	-12879.	9144.	2120.	566.	-13213.	9.	22357.
30	-554.	-15118.	7597.	937.	-494.	-15178.	4.	22775.
31	347.	-14209.	14534.	1558.	512.	-14374.	6.	28908.
32	50.	-14223.	13261.	2935.	630.	-14803.	11.	28064.
33	205.	-12521.	12770.	4142.	1434.	-13750.	17.	26520.
34	276.	-10461.	12447.	3038.	1076.	-11261.	15.	23708.
35	168.	-9625.	11755.	1389.	361.	-9818.	8.	21573.
36	-79.	-21139.	15516.	2117.	132.	-21350.	6.	36866.
37	-0.	-18461.	15046.	3944.	807.	-19269.	12.	34315.
38	225.	-13062.	15497.	5671.	2316.	-15153.	20.	30650.
39	315.	-7042.	16127.	4132.	2169.	-8896.	24.	25023.
40	1080.	-1858.	16686.	1953.	2055.	-2833.	27.	19519.
41	-2859.	-32630.	14240.	2932.	-2573.	-32916.	6.	47156.
42	-904.	-23928.	16015.	5960.	547.	-25380.	14.	41395.
43	16.	-11469.	18605.	7255.	3526.	-14980.	26.	33585.
44	-919.	-2928.	19351.	4875.	3055.	-6901.	39.	26252.
45	1497.	7289.	21564.	2211.	8036.	749.	71.	20815.
46	-2700.	-45210.	13326.	10379.	-301.	-47609.	13.	60935.
47	-15077.	-30746.	13135.	13287.	-7487.	-38336.	30.	51471
48	-7073.	-9166.	19077.	7209.	-835.	-15404.	41.	34481
49	-4438.	435.	20751.	3412.	2191.	-6194.	63.	26946
50	610.	14248.	24531.	1436.	14398.	460.	84.	24071

IZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

AVERAGED STRESSES AT NODES

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
51	-22724.	-51006.	6550.	16040.	-15481.	-58248.	24.	64798.
52	-45549.	-37625.	3509.	20010.	-21188.	-61985.	51.	65495.
53	-29793.	-22577.	11358.	5515.	-19595.	-32775.	62.	44133.
54	-15621.	-8747.	16595.	646.	-8687.	-15682.	85.	32276.
55	-6527.	166[illegible].	20245.	-442.	1689.	-6550.	-87.	26795.
56	-238.	15089.	24236.	-328.	15096.	-245.	-89.	24481.
57	2314.	-5468.	21792.	-3218.	3472.	-6626.	-20.	28418.
58	1091.	-2074.	20889.	-2796.	2721.	-3704.	-30.	24592.
59	-613.	2737.	20218.	-2779.	4306.	-2183.	-61.	22401.
60	1103.	10474.	21456.	-132[illegible].	10656.	921.	-82.	20535.
61	-744.	-2156.	18883.	-864.	-334.	-2566.	-25.	21449.
62	-828.	-2325.	17241.	-1538.	501.	-3654.	-34.	20895.
63	296.	1122.	17280.	-2024.	2775.	-1357.	-51.	18637.
64	561.	3701.	16854.	-1038.	4013.	249.	-73.	16605.
65	-63.	1345.	17022.	-730.	1655.	-373.	-67.	17395.
66	-668.	-91.	15046.	-1062.	721.	-1481.	-53.	16527.
67	-129.	-75.	14055.	-1119.	1017.	-1221.	-46.	15277.
68	-393.	-966.	12682.	-482.	-119.	-1241.	-30.	13[illegible].
69	36.	3286.	14709.	-357.	3325.	-3.	-84.	1471[illegible].
70	-684.	734.	12557.	-465.	873.	-823.	-73.	1338[illegible].
71	-139.	-586.	11368.	-457.	146.	-872.	-32.	12240.
72	-825.	-3109.	9588.	-140.	-816.	-3118.	-3.	12706.
73	117.	3947.	12294.	-105.	39[illegible]0.	114.	-88.	12180.
74	-648.	1031.	10218.	-11.	1031.	-648.	-90.	10866.
75	-172.	-840.	9025.	-13.	-172.	-840.	-1.	9865.
76	-860.	-3648.	7332.	92.	-857.	-3651.	2.	10983.
77	-1.	3562.	9810.	63.	3563.	-2.	89.	9813.
78	-630.	987.	8066.	270.	1031.	-673.	81.	8740.
79	-212.	-814.	7036.	264.	-112.	-913.	21.	7949.
80	-776.	-3283.	5623.	228.	-756.	-3303.	5.	8927.
81	-209.	2611.	7383.	142.	2618.	-216.	87.	7599.
82	-617.	757.	6098.	398.	864.	-724.	75.	6823.
83	-255.	-628.	5317.	391.	-8.	-875.	32.	6192.
84	-613.	-2398.	4293.	288.	-568.	-2444.	9.	6737.
85	-444.	1491.	5064.	142.	1501.	-455.	86.	5519.
86	-610.	469.	4268.	389.	595.	-736.	72.	5004.
87	-296.	-390.	3759.	382.	42.	-728.	41.	4488.
88	-428.	-1366.	3146.	277.	-353.	-1441.	15.	4588.
89	-630.	594.	2901.	65.	598.	-633.	87.	3534.
90	-607.	218.	2513.	253.	290.	-679.	74.	3191.
91	-331.	-189.	2253.	247.	-3.	-518.	53.	2771.
92	-299.	-554.	1975.	208.	-183.	-670.	29.	2645.
93	-852.	-122.	772.	-5.	-122.	-852.	-90.	1624.
94	-727.	-223.	649.	129.	-192.	-759.	76.	1408.
95	-428.	-404.	593.	124.	-291.	-541.	48.	1134.
96	-297.	-503.	535.	146.	-223.	-583.	27.	1118.

INEL

IZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 07/24/75

ELEMENT CENTER DATA

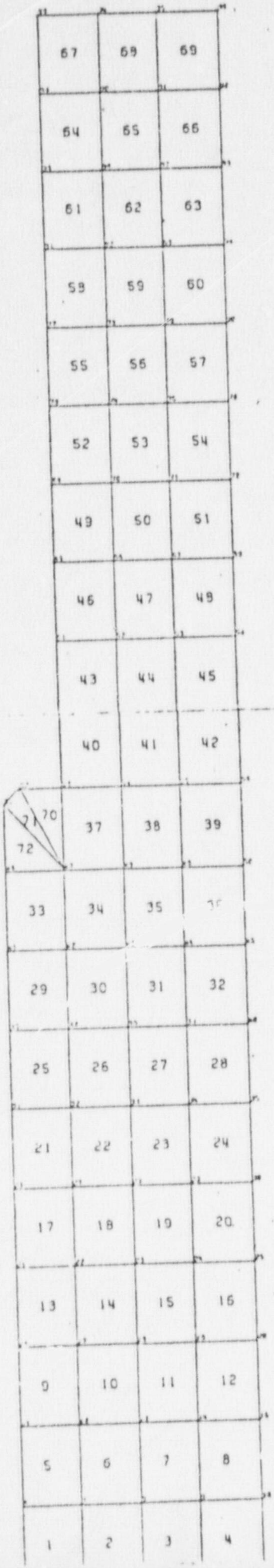
NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
1	215.	-3007.	6319.	84.	218.	-3010.	1.	9328.
2	318.	-8747.	4205.	181.	322.	-8751.	1.	12956.
3	209.	-14299.	2267.	179.	212.	-14301.	1.	16568.
4	69.	-20016.	417.	81.	69.	-20017.	0.	20434.
5	225.	-3422.	6882.	267.	244.	-3442.	4.	10324.
6	324.	-8912.	4795.	576.	360.	-8948.	4.	13743.
7	200.	-14189.	2886.	570.	222.	-14212.	2.	17098.
8	58.	-19657.	1061.	257.	62.	-19660.	1.	20722.
9	242.	-4328.	7966.	501.	296.	-4382.	6.	12348.
10	332.	-9269.	5948.	1072.	450.	-9388.	6.	15335.
11	178.	-13951.	4113.	1059.	257.	-14030.	4.	18143.
12	36.	-18874.	2353.	481.	49.	-18886.	1.	21239.
13	264.	-5874.	9479.	815.	370.	-5980.	7.	15458.
14	342.	-9873.	7607.	1731.	627.	-10158.	9.	17765.
15	144.	-13548.	5923.	1709.	354.	-13758.	7.	19681.
16	3.	-17541.	4295.	779.	37.	-17575.	3.	21870.
17	294.	-8270.	11275.	1230.	467.	-8443.	8.	19718.
18	360.	-10805.	9679.	2603.	937.	-11382.	13.	21061.
19	113.	-12932.	8267.	2582.	605.	-13424.	11.	21692.
20	-41.	-15470.	6880.	1187.	50.	-15561.	4.	22441.
21	320.	-11755.	13142.	1734.	564.	-11999.	8.	25141.
22	433.	-12192.	12017.	3704.	1439.	-13198.	15.	25215.
23	109.	-12077.	11054.	3745.	1169.	-13136.	16.	24190.
24	-76.	-12396.	10091.	1759.	170.	-12642.	8.	22734.
25	426.	-16516.	14841.	2269.	725.	-16815.	7.	31656.
26	455.	-14266.	14334.	5037.	2013.	-15825.	17.	30159.
27	122.	-10997.	14102.	5250.	2209.	-13084.	22.	27186.
28	-155.	-7970.	13852.	2571.	615.	-8740.	17.	22592.
29	19.	-22890.	15843.	2933.	388.	-23260.	7.	39103.
30	87.	-17153.	16240.	6832.	2466.	-19532.	19.	35772.
31	-842.	-9686.	16851.	7073.	3077.	-13605.	29.	30457.
32	-428.	-1828.	17948.	3375.	2319.	-4574.	39.	22522.
33	-150.	-32164.	15792.	5555.	787.	-33101.	10.	48893.
34	-5975.	-20469.	15965.	10379.	-563.	-25881.	28.	41846.
35	-3764.	-6438.	19051.	7362.	2382.	-12584.	40.	31635.
36	-1068.	5154.	21590.	3153.	6472.	-2387.	67.	23977.
37	-14575.	-13261.	16871.	7678.	-6212.	-21625.	47.	38495.
38	-7024.	-2283.	20085.	2893.	-914.	-8393.	65.	28479.
39	-1601.	9767.	23327.	739.	9815.	-1649.	86.	24977.
40	-9602.	-9375.	17987.	-4777.	-4711.	-14266.	-46.	32253.
41	-4517.	-627.	20050.	-4223.	2078.	-7222.	-57.	27272.
42	-1141.	8433.	21950.	-2388.	8995.	-1703.	-77.	23653.
43	723.	-3357.	19675.	-1212.	1056.	-3690.	-15.	23365.
44	-482.	-1130.	18468.	-3870.	3078.	-4690.	-43.	23158.
45	-322.	3841.	18554.	-2389.	4928.	-1410.	-66.	19964.
46	-653.	-424.	17140.	-1125.	592.	-1669.	-48.	18809.
47	33.	-32.	16108.	-2114.	2115.	-2114.	-45.	18223.
48	-136.	411.	14992.	-1336.	1501.	-1226.	51.	16218.
49	-573.	1496.	14819.	-619.	1667.	-744.	-75.	15563.
50	-331.	111.	13[illegible].	-1095.	1007.	-1228.	-51.	14541.

INEL 07/24/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

ELEMENT CENTER DATA

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
51	-150.	-1321.	11949.	-581.	89.	-1560.	-22.	13509.
52	-655.	2323.	12359.	-164.	2332.	-664.	-87.	13022.
53	-340.	149.	10832.	-303.	294.	-486.	-64.	11318.
54	-152.	-2048.	9432.	-147.	-140.	-2059.	-4.	11491.
55	-685.	2358.	9971.	144.	2365.	-692.	87.	10664.
56	-355.	142.	8620.	222.	227.	-440.	69.	9060.
57	-128.	-2075.	7389.	140.	-118.	-2085.	4.	9474.
58	-730.	1896.	7705.	312.	1933.	-766.	83.	8471.
59	-378.	115.	6656.	515.	439.	-703.	58.	7359.
60	-120.	-1669.	5704.	302.	-63.	-1726.	11.	7430.
61	-774.	1208.	5575.	360.	1272.	-837.	80.	6412.
62	-410.	75.	4878.	599.	478.	-814.	56.	5692.
63	-115.	-1063.	4254.	348.	-1.	-1177.	18.	5431.
64	-814.	534.	3566.	299.	598.	-878.	78.	4444.
65	-439.	39.	3208.	492.	346.	-747.	58.	3955.
66	-117.	-472.	2896.	283.	40.	-629.	29.	3525.
67	-833.	101.	1665.	112.	114.	-846.	83.	2511.
68	-443.	13.	1575.	220.	102.	-532.	68.	2107.
69	-89.	-90.	1511.	114.	24.	-203.	45.	1714.
70	-54939.	-34200.	1028.	23293.	-19072.	-70067.	57.	71095.
71	-36159.	-41051.	5990.	16727.	-21700.	-55509.	41.	61499.
72	-9290.	-60961.	7110.	15354.	-5072.	-65179.	15.	72289.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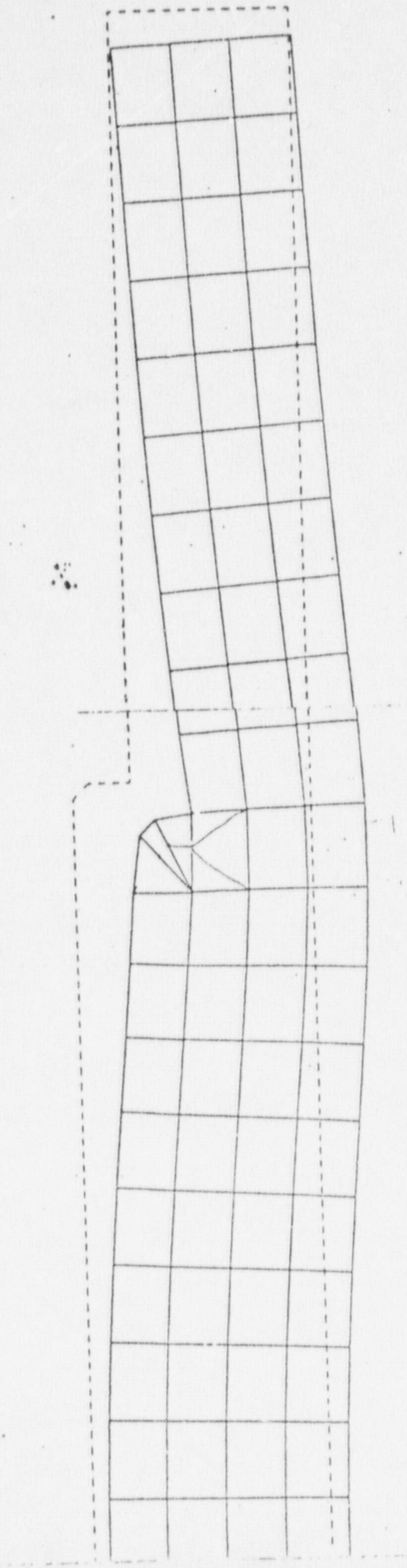

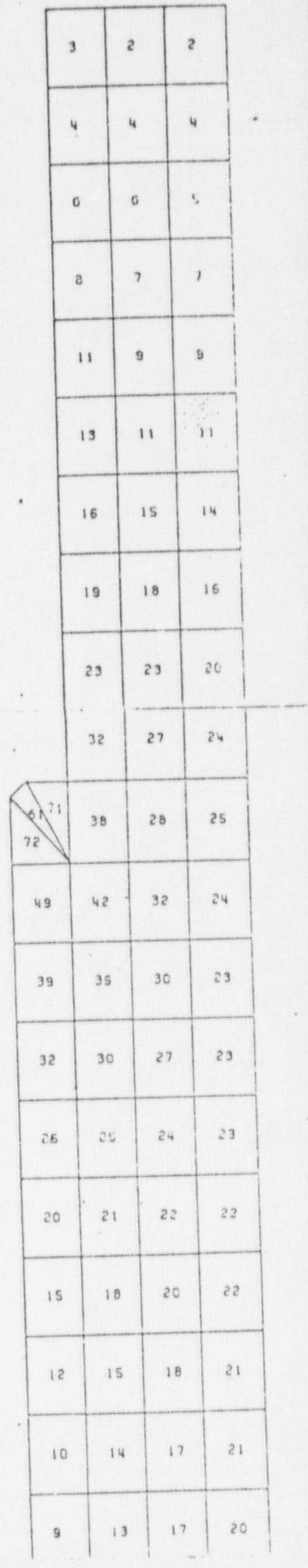
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39 35 30 23
32 30 27 23
26 25 24 23
20 21 22 22
15 18 20 22
12 15 18 21
10 14 17 21
9 13 17 20

EXHIBIT 2

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCES926

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

NT	NOREGT	NR	NZ	NPR	NPZ	NF	NSUPP	IBP1	MAXITS	NPLOT	NTRI	NCCUP
96	69	6	22	1	1	0	5	16	1000	13	3	0

NGRIDS
3

CC	BETA	E	NU
.10000E-07	.0	.30000E+08	.30000

GRID 1 -- 4 X 9 -- 1 5 50 46

GRID 2 -- 3 X 1 -- 47 50 56 53

GRID 3 -- 3 X 10 -- 53 56 96 93

RECTANGULAR ELEMENTS

1	2	7	6	2	3	8	7	3	4	9	8	4	5	10	9	6	7	12	11
7	8	13	12	8	9	14	13	9	10	15	14	11	12	17	16	12	13	18	17
13	14	19	18	14	15	20	19	16	17	22	21	17	18	23	22	18	19	24	23
19	20	25	24	21	22	27	26	22	23	28	27	23	24	29	28	24	25	30	29
26	27	32	31	27	28	33	32	28	29	34	33	29	30	35	34	31	32	37	36
32	33	38	37	33	34	39	38	34	35	40	39	36	37	42	41	37	38	43	42
38	39	44	43	39	40	45	44	41	42	47	46	42	43	48	47	43	44	49	48
44	45	50	49	47	48	54	53	48	49	55	54	49	50	56	55	53	54	58	57
54	55	59	58	55	56	60	59	57	58	62	61	58	59	63	62	59	60	64	63
61	62	66	65	62	63	67	66	63	64	68	67	65	66	70	69	66	67	71	70
67	68	72	71	69	70	74	73	70	71	75	74	71	72	76	75	73	74	78	77
74	75	79	78	75	76	80	79	77	78	82	81	78	79	83	82	79	80	84	83
81	82	86	85	82	83	87	86	83	84	88	87	85	86	90	89	86	87	91	90
87	88	92	91	89	90	94	93	90	91	95	94	91	92	96	95				

TRIANGULAR ELEMENTS

47 53 52 0 47 52 51 0 47 51 46 0

R LATTICE

6.4400	6.5600	6.8800	7.3300	7.7800	8.2500

Z LATTICE

.0	.60000	1.2000	1.8000	2.4000	3.0000
3.6000	4.2000	4.8000	5.4000	5.9000	6.0200
6.6400	7.2400	7.8400	8.4400	9.0400	9.6400
10.240	10.840	11.440	12.040		

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESP 26

12/11/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

NODAL LATTICE POSITIONS

1	1	1
2	3	1
3	4	1
4	5	1
5	6	1
6	1	2
7	3	2
8	4	2
9	5	2
10	6	2
11	1	3
12	3	3
13	4	3
14	5	3
15	6	3
16	1	4
17	3	4
18	4	4
19	5	4
20	6	4
21	1	5
22	3	5
23	4	5
24	5	5
25	6	5
26	1	6
27	3	6
28	4	6
29	5	6
30	6	6
31	1	7
32	3	7
33	4	7
34	5	7
35	6	7
36	1	8
37	3	8
38	4	8
39	5	8
40	6	8
41	1	9
42	3	9
43	4	9
44	5	9
45	6	9
46	1	10
47	3	10
48	4	10
49	5	10
50	6	10

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESR26

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

NODAL LATTICE POSITIONS

51	1	11
52	2	12
53	3	12
54	4	12
55	5	12
56	6	12
57	3	13
58	4	13
59	5	13
60	6	13
61	3	14
62	4	14
63	5	14
64	6	14
65	3	15
66	4	15
67	5	15
68	6	15
69	3	16
70	4	16
71	5	16
72	6	16
73	3	17
74	4	17
75	5	17
76	6	17
77	3	18
78	4	18
79	5	18
80	6	18
81	3	19
82	4	19
83	5	19
84	6	19
85	3	20
86	4	20
87	5	20
88	6	20
89	3	21
90	4	21
91	5	21
92	6	21
93	3	22
94	4	22
95	5	22
96	6	22

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCES926

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

PICTORIAL REPRESENTATION

0	0	93	94	95	96
0	0	89	90	91	92
0	0	85	86	87	88
0	0	81	82	83	84
0	0	77	78	79	80
0	0	73	74	75	76
0	0	69	70	71	72
0	0	65	66	67	68
0	0	61	62	63	64
0	0	57	58	59	60
0	52	53	54	55	56
51	0	0	0	0	0
46	0	47	48	49	50
41	0	42	43	44	45
36	0	37	38	39	40
31	0	32	33	34	35
26	0	27	28	29	30
21	0	22	23	24	25
16	0	17	18	19	20
11	0	12	13	14	15
6	0	7	8	9	10
1	0	2	3	4	5

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESR26

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

RADIAL PRESSURE, TYPE, NODES

.10000E+07	2	51	52

AXIAL PRESSURE, TYPE, NODES

-.10000E+07	2	51	52

DEFLECTION NODE DIRECTION

DEFLECTION	NODE	DIRECTION
.0	1	2
.0	2	2
.0	3	2
.0	4	2
.0	5	2

NODES, COORDINATES, AND FORCES

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

1	6.440	0.0	0.	0.
2	6.880	0.0	0.	0.
3	7.330	0.0	0.	0.
4	7.780	0.0	0.	0.
5	8.250	0.0	0.	0.
6	6.440	0.600	0.	0.
7	6.880	0.600	0.	0.
8	7.330	0.600	0.	0.
9	7.780	0.600	0.	0.
10	8.250	0.600	0.	0.
11	6.440	1.200	0.	0.
12	6.880	1.200	0.	0.
13	7.330	1.200	0.	0.
14	7.780	1.200	0.	0.
15	8.250	1.200	0.	0.
16	6.440	1.800	0.	0.
17	6.880	1.800	0.	0.
18	7.330	1.800	0.	0.
19	7.780	1.800	0.	0.
20	8.250	1.800	0.	0.
21	6.440	2.400	0.	0.
22	6.880	2.400	0.	0.
23	7.330	2.400	0.	0.
24	7.780	2.400	0.	0.
25	8.250	2.400	0.	0.
26	6.440	3.000	0.	0.
27	6.880	3.000	0.	0.
28	7.330	3.000	0.	0.
29	7.780	3.000	0.	0.
30	8.250	3.000	0.	0.
31	6.440	3.600	0.	0.
32	6.880	3.600	0.	0.
33	7.330	3.600	0.	0.
34	7.780	3.600	0.	0.
35	8.250	3.600	0.	0.
36	6.440	4.200	0.	0.
37	6.880	4.200	0.	0.
38	7.330	4.200	0.	0.
39	7.780	4.200	0.	0.
40	8.250	4.200	0.	0.
41	6.440	4.800	0.	0.
42	6.880	4.800	0.	0.
43	7.330	4.800	0.	0.
44	7.780	4.800	0.	0.
45	8.250	4.800	0.	0.
46	6.440	5.400	0.	0.
47	6.880	5.400	0.	0.
48	7.330	5.400	0.	0.
49	7.780	5.400	0.	0.
50	8.250	5.400	0.	0.

NODES, COORDINATES, AND FORCES

12/11/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

51	6.440	5.900	497439.	-497439.
52	6.560	6.020	502561.	-502561.
53	6.880	6.020	0.	0.
54	7.330	6.020	0.	0.
55	7.780	6.020	0.	0.
56	8.250	6.020	0.	0.
57	6.880	6.640	0.	0.
58	7.330	6.640	0.	0.
59	7.780	6.640	0.	0.
60	8.250	6.640	0.	0.
61	6.880	7.240	0.	0.
62	7.330	7.240	0.	0.
63	7.780	7.240	0.	0.
64	8.250	7.240	0.	0.
65	6.880	7.840	0.	0.
66	7.330	7.840	0.	0.
67	7.780	7.840	0.	0.
68	8.250	7.840	0.	0.
69	6.880	8.440	0.	0.
70	7.330	8.440	0.	0.
71	7.780	8.440	0.	0.
72	8.250	8.440	0.	0.
73	6.880	9.040	0.	0.
74	7.330	9.040	0.	0.
75	7.780	9.040	0.	0.
76	8.250	9.040	0.	0.
77	6.880	9.640	0.	0.
78	7.330	9.640	0.	0.
79	7.780	9.640	0.	0.
80	8.250	9.640	0.	0.
81	6.880	10.240	0.	0.
82	7.330	10.240	0.	0.
83	7.780	10.240	0.	0.
84	8.250	10.240	0.	0.
85	6.880	10.840	0.	0.
86	7.330	10.840	0.	0.
87	7.780	10.840	0.	0.
88	8.250	10.840	0.	0.
89	6.880	11.440	0.	0.
90	7.330	11.440	0.	0.
91	7.780	11.440	0.	0.
92	8.250	11.440	0.	0.
93	6.880	12.040	0.	0.
94	7.330	12.040	0.	0.
95	7.780	12.040	0.	0.
96	8.250	12.040	0.	0.

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESR25

12/11/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

STIFFNESS MATRIX WIDTH FROM 1 TO 16

GAUSS-SEIDEL ITERATION
CONVERGENCE AT ITERATION NO. AND BETA

.19593E-04	100	1.81328
.54708E-06	200	1.81328
.10955E-07	300	1.81328

TOTAL ITERATIONS, 303

FINEL 12/11/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

NODAL DISPLACEMENTS

NODE	UR	UZ
1	0.0016213	-0.0000000
2	0.0016115	-0.0000000
3	0.0016364	-0.0000000
4	0.0016912	-0.0000000
5	0.0017799	-0.0000000
6	0.0016932	-0.0000613
7	0.0016832	-0.0001596
8	0.0017073	-0.0002513
9	0.0017505	-0.0003412
10	0.0018467	-0.0004407
11	0.0019064	-0.0001370
12	0.0018964	-0.0003290
13	0.0019180	-0.0005065
14	0.0019661	-0.0006807
15	0.0020450	-0.0008748
16	0.0022527	-0.0002433
17	0.0022432	-0.0005187
18	0.0022612	-0.0007695
19	0.0023010	-0.0010157
20	0.0023670	-0.0012942
21	0.0027164	-0.0003993
22	0.0027095	-0.0007405
23	0.0027232	-0.0010442
24	0.0027513	-0.0013423
25	0.0027983	-0.0016870
26	0.0032713	-0.0006280
27	0.0032707	-0.0010082
28	0.0032808	-0.0013341
29	0.0032942	-0.0016537
30	0.0033155	-0.0020388
31	0.0038767	-0.0009563
32	0.0038873	-0.0013380
33	0.0038974	-0.0016442
34	0.0038944	-0.0019410
35	0.0038325	-0.0023245
36	0.0044741	-0.0014123
37	0.0045068	-0.0017493
38	0.0045181	-0.0019803
39	0.0044974	-0.0021921
40	0.0044416	-0.0025092
41	0.0050124	-0.0020193
42	0.0050619	-0.0022642
43	0.0050729	-0.0023410
44	0.0050082	-0.0023840
45	0.0048955	-0.0025509
46	0.0054378	-0.0028730
47	0.0055503	-0.0028871
48	0.0054165	-0.0026435
49	0.0052644	-0.0024927
50	0.0050645	-0.0024330

RINFL 12/11/75

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX

NODAL DISPLACEMENTS

NODE	UR	UZ
51	0.0061053	-0.0033703
52	0.0060495	-0.0038676
53	0.0055758	-0.0032506
54	0.0052618	-0.0028343
55	0.0050592	-0.0025258
56	0.0048733	-0.0022195
57	0.0044500	-0.0035711
58	0.0044374	-0.0029884
59	0.0043574	-0.0025576
60	0.0042389	-0.0020614
61	0.0036212	-0.0037436
62	0.0035599	-0.0031547
63	0.0035094	-0.0026214
64	0.0034412	-0.0020389
65	0.0027787	-0.0036163
66	0.0027218	-0.0032387
67	0.0026747	-0.0026942
68	0.0026364	-0.0021087
69	0.0019996	-0.0038184
70	0.0019476	-0.0032799
71	0.0019136	-0.0027599
72	0.0018951	-0.0022166
73	0.0013050	-0.0037797
74	0.0012642	-0.0032943
75	0.0012421	-0.0028165
76	0.0012373	-0.0023272
77	0.0006966	-0.0037267
78	0.0006690	-0.0032927
79	0.0006574	-0.0028590
80	0.0006606	-0.0024215
81	0.0001580	-0.0036757
82	0.0001446	-0.0032820
83	0.0001420	-0.0028851
84	0.0001500	-0.0024881
85	-0.0003346	-0.0036344
86	-0.0003343	-0.0032657
87	-0.0003286	-0.0028941
88	-0.0003170	-0.0025225
89	-0.0008069	-0.0036025
90	-0.0007941	-0.0032446
91	-0.0007803	-0.0028870
92	-0.0007649	-0.0025266
93	-0.0012805	-0.0035715
94	-0.0012572	-0.0032170
95	-0.0012349	-0.0028656
96	-0.0012121	-0.0025089

IZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

AVERAGED STRESSES AT NODES

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
1	1696.	-150.	3017.	1383.	2436.	-889.	28.	8906.
2	116.	-6404.	5141.	1380.	395.	-6684.	11.	11625.
3	189.	-11517.	3299.	1364.	346.	-11674.	7.	14973.
4	189.	-16517.	1623.	1333.	294.	-16623.	5.	18246.
5	-1359.	-22661.	-734.	1286.	-1282.	-22738.	3.	22004.
6	1669.	-449.	8253.	162.	1681.	-461.	4.	8715.
7	113.	-6571.	5403.	274.	124.	-6582.	2.	11985.
8	189.	-11530.	3585.	380.	201.	-11542.	2.	15128.
9	190.	-16380.	1932.	270.	195.	-16384.	1.	18316.
10	-1333.	-22385.	-401.	108.	-1332.	-22390.	0.	21989.
11	1578.	-1397.	8935.	345.	1618.	-1437.	7.	10372.
12	102.	-7095.	6171.	591.	150.	-7143.	5.	13314.
13	185.	-11571.	4434.	818.	242.	-11628.	4.	16062.
14	193.	-15949.	2855.	582.	214.	-15970.	2.	18825.
15	-1247.	-21531.	603.	237.	-1245.	-21534.	1.	22137.
16	1405.	-3143.	9972.	568.	1474.	-3213.	7.	13185.
17	82.	-8044.	7393.	992.	201.	-8163.	7.	15556.
18	177.	-11644.	5814.	1371.	334.	-11801.	7.	17616.
19	197.	-15167.	4382.	975.	258.	-15228.	4.	19610.
20	-1089.	-19959.	2293.	409.	-1080.	-19968.	1.	22261.
21	1115.	-5919.	11213.	846.	1215.	-6020.	7.	17232.
22	54.	-9530.	8972.	1512.	287.	-9763.	9.	18735.
23	161.	-11767.	7664.	2089.	516.	-12123.	10.	19786.
24	199.	-13944.	6485.	1489.	354.	-14099.	6.	20585.
25	-824.	-17456.	4692.	643.	-799.	-17481.	2.	22173.
26	702.	-9980.	12455.	1186.	832.	-10110.	6.	22566.
27	35.	-11700.	10762.	2166.	422.	-12087.	10.	22849.
28	147.	-11995.	9873.	3014.	854.	-12702.	13.	22576.
29	212.	-12169.	9115.	2167.	580.	-12537.	10.	21653.
30	-397.	-13693.	7829.	970.	-327.	-13764.	4.	21593.
31	129.	-15537.	13436.	1556.	282.	-15690.	6.	29127.
32	35.	-14755.	12537.	2955.	604.	-15324.	11.	27861.
33	180.	-12415.	12281.	4168.	1434.	-13669.	17.	25950.
34	251.	-9732.	12173.	3057.	1113.	-10593.	16.	22766.
35	340.	-8122.	11783.	1411.	569.	-8351.	9.	20134.
36	-308.	-22464.	14010.	2083.	-114.	-22659.	5.	36669.
37	-13.	-18972.	13956.	3910.	762.	-19746.	11.	33703.
38	197.	-12961.	14662.	5626.	2274.	-15038.	20.	29700.
39	288.	-6332.	15529.	4102.	2249.	-8293.	26.	23822.
40	1261.	-354.	16424.	1956.	2570.	-1662.	34.	18085.
41	-3050.	-33740.	12313.	2845.	-2788.	-34001.	5.	46314.
42	-910.	-24372.	14488.	5839.	463.	-25744.	13.	40232.
43	3.	-11377.	17350.	7102.	3413.	-14787.	26.	32137.
44	-941.	-2296.	18341.	4775.	3204.	-6442.	41.	24782.
45	1661.	8681.	20910.	2182.	9305.	1056.	74.	19854.
46	-2871.	-46001.	10377.	10220.	-572.	-48300.	13.	59176.
47	-15180.	-31081.	10926.	13003.	-7890.	-38372.	29.	49297.
48	-7066.	-9105.	17317.	6920.	-1091.	-15080.	41.	32397.
49	-2424.	924.	19244.	3220.	2431.	-5951.	65.	25195.
50	768.	15350.	23360.	1367.	15477.	641.	85.	22720.

FINEL

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

AVERAGED STRESSES AT NODES

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
51	-22783.	-51029.	4191.	15773.	-15734.	-58078.	24.	62269.
52	-45814.	-37784.	958.	19617.	-21775.	-61823.	51.	62781.
53	-30019.	-23196.	8558.	4394.	-20642.	-32573.	62.	41130.
54	-15579.	-8745.	14240.	183.	-8740.	-15579.	88.	29819.
55	-6517.	1913.	18127.	-724.	1975.	-6578.	-85.	24706.
56	-122.	15676.	22405.	-443.	15688.	-135.	-88.	22540.
57	3102.	-5534.	18675.	-3505.	4346.	-6778.	-20.	25452.
58	1774.	-1916.	18119.	-3116.	3550.	-3692.	-30.	21811.
59	-352.	2789.	17534.	-3069.	4665.	-2229.	-59.	19763.
60	1243.	10436.	18918.	-1438.	10656.	1023.	-81.	17895.
61	73.	-1498.	15362.	-969.	535.	-1960.	-25.	17323.
62	-217.	-2164.	13856.	-2109.	1133.	-3513.	-33.	17369.
63	643.	986.	14021.	-2193.	3015.	-1385.	-47.	15407.
64	676.	3115.	13651.	-1108.	3543.	247.	-69.	13403.
65	806.	2287.	13044.	-781.	2623.	470.	-67.	12574.
66	-46.	213.	11190.	-1117.	1208.	-1041.	-48.	12231.
67	195.	-322.	10276.	-1178.	1142.	-1269.	-39.	11545.
68	-320.	-1858.	8934.	-494.	-175.	-2003.	-16.	10936.
69	389.	4259.	10264.	-363.	4298.	850.	-84.	9413.
70	-61.	1073.	8275.	-445.	1227.	-215.	-71.	8489.
71	177.	-852.	7177.	-439.	338.	-1013.	-20.	8190.
72	-763.	-4057.	5445.	-113.	-759.	-4061.	-2.	9506.
73	941.	4796.	7412.	-82.	4798.	939.	-89.	6473.
74	-21.	1345.	5571.	56.	1347.	-23.	88.	5595.
75	137.	-1085.	4505.	52.	139.	-1087.	2.	5592.
76	-775.	-4479.	2923.	141.	-770.	-4484.	2.	7407.
77	778.	4193.	4529.	100.	4195.	776.	88.	3753.
78	-2.	1242.	3110.	359.	1338.	-98.	75.	3208.
79	90.	-1011.	2259.	352.	193.	-1114.	16.	3372.
80	-650.	-3909.	1033.	287.	-630.	-3934.	5.	4967.
81	522.	2988.	1742.	182.	3001.	508.	86.	2493.
82	12.	940.	877.	489.	1151.	-199.	67.	1349.
83	40.	-767.	330.	481.	264.	-991.	25.	1321.
84	-452.	-2789.	-427.	346.	-402.	-2839.	8.	2437.
85	241.	1634.	-896.	174.	1650.	219.	83.	2552.
86	19.	584.	-1187.	465.	846.	-243.	61.	2033.
87	-7.	-474.	-1411.	457.	273.	-754.	31.	1684.
88	-229.	-1538.	-1683.	326.	-153.	-1614.	13.	1530.
89	33.	583.	-3334.	82.	595.	21.	82.	2929.
90	21.	275.	-3161.	299.	473.	-176.	57.	3634.
91	-44.	-226.	-3090.	293.	171.	-442.	36.	3261.
92	-81.	-578.	-2979.	241.	17.	-676.	22.	2996.
93	-228.	-234.	-5722.	-20.	-211.	-251.	-41.	5512.
94	-127.	-239.	-5255.	144.	-28.	-338.	34.	5227.
95	-149.	-453.	-4943.	142.	-93.	-509.	22.	4849.
96	-72.	-510.	-4582.	155.	-23.	-559.	18.	4560.

SIZE 14 FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

ELEMENT CENTER DATA

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
1	213.	-3520.	6460.	92.	216.	-3523.	1.	9982.
2	310.	-8844.	4453.	197.	314.	-8848.	1.	13301.
3	194.	-13969.	2616.	195.	197.	-13972.	1.	16588.
4	59.	-19271.	861.	89.	59.	-19271.	0.	20132.
5	221.	-3972.	6969.	291.	242.	-3992.	4.	10961.
6	313.	-9022.	4999.	624.	355.	-9063.	4.	14062.
7	164.	-13851.	3202.	617.	211.	-13878.	3.	17080.
8	48.	-18880.	1481.	280.	52.	-18884.	1.	20365.
9	236.	-4945.	7943.	537.	291.	-5000.	6.	12944.
10	318.	-9404.	6063.	1144.	451.	-9537.	7.	15599.
11	161.	-13598.	4359.	1131.	253.	-13690.	5.	18048.
12	26.	-18038.	2721.	515.	41.	-18053.	2.	20774.
13	253.	-6581	9288.	858.	359.	-6687.	7.	15975.
14	322.	-10039.	7584.	1817.	631.	-10348.	10.	17932.
15	124.	-13175.	6055.	1794.	362.	-13412.	8.	19468.
16	-7.	-16628.	4576.	821.	33.	-16668.	3.	21244.
17	277.	-9073.	10854.	1272.	447.	-9243.	8.	20096.
18	332.	-11005.	9461.	2685.	936.	-11608.	13.	21069.
19	91.	-12538.	8237.	2663.	629.	-13076.	11.	21313.
20	-50.	-14474.	7029.	1228.	54.	-14578.	5.	21607.
21	295.	-12638.	12425.	1765.	532.	-12874.	8.	25300.
22	396.	-12417.	11542.	3759.	1417.	-13438.	15.	24980.
23	85.	-11667.	10800.	3799.	1206.	-12788.	16.	23588.
24	-84.	-11333.	10048.	1787.	193.	-11610.	9.	21659.
25	394.	-17432.	13765.	2273.	679.	-17718.	7.	31482.
26	410.	-14498.	13535.	5033.	1950.	-16038.	17.	29573.
27	99.	-10583.	13555.	5246.	2244.	-12728.	22.	26283.
28	-150.	-5880.	13545.	2573.	713.	-7752.	19.	21297.
29	-17.	-23751.	14348.	2884.	328.	-24096.	7.	38445.
30	51.	-17361.	15051.	6728.	2347.	-19658.	19.	34709.
31	-855.	-9294.	15932.	6979.	3081.	-13230.	29.	29162.
32	-426.	-782.	17289.	3336.	2737.	-3945.	43.	21235.
33	-167.	-32610.	13846.	5391.	700.	-33677.	9.	47523.
34	-5990.	-20539.	14312.	10138.	-808.	-25822.	27.	40134.
35	-3755.	-6105.	17677.	7148.	2313.	-12174.	40.	29851.
36	-1059.	6055.	20483.	3061.	7191.	-2195.	70.	22679.
37	-14523.	-13364.	14687.	7258.	-6655.	-21227.	47.	35915.
38	-6999.	-2067.	18158.	2541.	-992.	-8074.	67.	26232.
39	-1560.	10391.	21662.	571.	10419.	-1607.	87.	23269.
40	-9249.	-9707.	15167.	-5340.	-4133.	-14822.	-44.	29989.
41	-4317.	-531.	17548.	-4721.	2663.	-7511.	-56.	25058.
42	-1082.	8617.	19627.	-2629.	9284.	-1748.	-76.	21375.
43	1596.	-3024.	16553.	-1387.	1980.	-3409.	-15.	19961.
44	-75.	-1153.	15398.	-4232.	3653.	-4880.	-41.	20279.
45	-213.	3577.	15575.	-2583.	4886.	-1522.	-63.	17097.
46	170.	189.	13512.	-1203.	1383.	-1023.	-45.	14535.
47	510.	-4.	12541.	-2268.	2536.	-2029.	-42.	14570.
48	-5.	-133.	11445.	-1428.	1361.	-1499.	-44.	12944.
49	249.	2209.	10724.	-627.	2392.	66.	-74.	10658.
50	130.	150.	9285.	-1116.	1350.	-976.	-45.	10261.

SIZE 14. FIG. 607 BODY SEAT AREA FINITE ANALYSIS MICHAUX 12/11/75

ELEMENT CENTER DATA

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
51	-13.	-1558.	7951.	-589.	151.	-2123.	-16.	10074.
52	157.	3003.	7837.	-122.	3009.	152.	-88.	7685.
53	115.	186.	6419.	-235.	389.	-87.	-49.	6506.
54	-15.	-2657.	5088.	-106.	-11.	-2662.	-2.	7750.
55	119.	2923.	5073.	214.	2940.	103.	86.	4970.
56	95.	172.	3889.	340.	476.	-208.	48.	4097.
57	10.	-2583.	2785.	208.	26.	-2599.	5.	5384.
58	67.	2307.	2476.	392.	2374.	1.	80.	2476.
59	67.	136.	1664.	650.	752.	-549.	47.	2213.
60	18.	-2040.	901.	379.	86.	-2108.	10.	3009.
61	16.	1461.	57.	434.	1581.	-104.	75.	1685.
62	29.	86.	-339.	723.	781.	-666.	46.	1447.
63	23.	-1294.	-713.	419.	145.	-1416.	16.	1561.
64	-28.	655.	-2211.	352.	805.	-177.	67.	3015.
65	-3.	42.	-2212.	583.	603.	-564.	46.	2815.
66	18.	-587.	-2223.	235.	157.	-736.	24.	2391.
67	-52.	144.	-4347.	126.	205.	-114.	64.	4552.
68	-11.	9.	-4042.	266.	265.	-267.	46.	4307.
69	51.	-134.	-3765.	131.	119.	-201.	27.	3883.
70	-55292.	-34666.	-1630.	22722.	-20020.	-69932.	57.	68302.
71	-36336.	-40902.	3546.	16512.	-21950.	-55288.	41.	58835.
72	-9230.	-61156.	4836.	15034.	-5192.	-65195.	15.	70030.

EXHIBIT 3

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESR26

08/14/75

6 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS   S. MICHAUX

NT	NOREGT	NR	NZ	NPR	NPZ	NF	NSUPP	IBP1	MAXITS	NPLOT	NTRI	NCOUP
100	68	14	16	0	11	2	2	32	1000	0	23	0

NGRIDS
8

CC	BETA	E	NU
.10000E-07	.0	.30000E+08	.30000

GRID 1 -- 3 X 6 -- 7 28 22 1
GRID 2 -- 1 X 1 -- 28 30 29 27
GRID 3 -- 1 X 4 -- 26 39 35 22
GRID 4 -- 1 X 8 -- 40 51 43 32
GRID 5 -- 1 X 8 -- 51 61 53 43
GRID 6 -- 3 X 7 -- 60 87 80 53
GRID 7 -- 1 X 4 -- 85 92 88 81
GRID 8 -- 1 X 4 -- 92 100 96 88

RECTANGULAR ELEMENTS

7	14	13	6	14	21	20	13	21	28	27	20	6	13	12	5	13	20	19	12
20	27	26	19	5	12	11	4	12	19	18	11	19	26	25	18	4	11	10	3
11	18	17	10	18	25	24	17	3	10	9	2	10	17	16	9	17	24	23	16
2	9	8	1	9	16	15	8	16	23	22	15	28	30	29	27	26	39	38	25
25	38	37	24	24	37	36	23	23	36	35	22	40	51	50	39	39	50	49	38
38	49	48	37	37	48	47	36	36	47	46	35	35	46	45	34	34	45	44	33
33	44	43	32	51	61	60	50	50	60	59	49	49	59	58	48	48	58	57	47
47	57	56	46	46	56	55	45	45	55	54	44	44	54	53	43	60	69	68	59
69	78	77	68	78	87	86	77	59	68	67	58	68	77	76	67	77	86	85	76
58	67	66	57	67	76	75	66	76	85	84	75	57	66	65	56	66	75	74	65
75	84	83	74	56	65	64	55	65	74	73	64	74	83	82	73	55	64	63	54
64	73	72	63	73	82	81	72	54	63	62	53	63	72	71	62	72	81	80	71
85	92	91	84	84	91	90	83	83	90	89	82	62	89	88	81	92	100	99	91
91	99	98	90	90	98	97	89	89	97	96	88								

TRIANGULAR ELEMENTS

29	26	27	0	29	39	26	0	29	40	39	0	29	30	41	0	29	41	40	0
52	40	41	0	52	51	40	0	52	61	51	0	61	70	60	0	70	69	60	0
79	69	70	0	79	78	69	0	79	87	78	0	87	94	86	0	94	93	86	0
93	85	86	0	93	92	85	0	93	100	92	0	96	95	88	0	88	95	80	0
88	80	81	0	43	42	32	0	32	2	31	0								

R LATTICE

.0	.41000	.97000	1.5700	2.3100	2.5500
2.8500	3.5000	4.2500	5.0000	5.7900	6.1900
6.5600	6.8600				

Z LATTICE

.80000E-01	.33000	.53000	.73000	.91000

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESR26

14 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/14/75

NODAL LATTICE POSITIONS

1	1	12
2	1	11
3	1	10
4	1	8
5	1	7
6	1	4
7	1	1
8	2	12
9	2	11
10	2	10
11	2	8
12	2	7
13	2	4
14	2	1
15	3	12
16	3	11
17	3	10
18	3	8
19	3	7
20	3	4
21	3	1
22	4	12
23	4	11
24	4	10
25	4	8
26	4	7
27	4	4
28	4	1
29	5	4
30	5	1
31	6	16
32	6	15
33	6	14
34	6	13
35	6	12
36	6	11
37	6	10
38	6	8
39	6	7
40	6	4
41	6	2
42	7	16
43	8	15
44	8	14
45	8	13
46	8	12
47	8	11
48	8	10
49	8	8
50	8	7

ROCKWELL INTERNATIONAL
FLOW CONTROL DIVISION
PROGRAM NO. NCCESR26

24 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/14/75

NODAL LATTICE POSITIONS

51	8	4
52	8	3
53	9	15
54	9	14
55	9	13
56	9	12
57	9	11
58	9	10
59	9	8
60	9	7
61	9	4
62	10	15
63	10	14
64	10	13
65	10	12
66	10	11
67	10	10
68	10	8
69	10	7
70	10	5
71	11	15
72	11	14
73	11	13
74	11	12
75	11	11
76	11	10
77	11	8
78	11	7
79	11	6
80	12	15
81	12	14
82	12	13
83	12	12
84	12	11
85	12	10
86	12	8
87	12	7
88	13	14
89	13	13
90	13	12
91	13	11
92	13	10
93	13	9
94	13	8
95	14	15
96	14	14
97	14	13
98	14	12
99	14	11
100	14	10

CKWELL INTERNATICNAL
CW CONTROL CIVISICN
OGRAM NO. NCCESR26

08/14/75

INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX

ICTORIAL REPRESENTATICN

0	0	0	0	0	31	42	0	C	C	0	0	0	0
0	0	0	0	0	32	0	43	53	62	71	80	0	95
0	0	0	0	0	33	C	44	54	63	72	81	88	96
0	0.	0	0	0	34	0	45	55	64	73	82	89	97
1	8	15	22	0	35	C	46	56	65	74	83	90	98
2	9	16	23	0	36	0	47	57	66	75	84	91	99
3	10	17	24	C	37	C	48	58	67	76	85	92	100
0	0	0	0	0	0	0	0	C	C	0	0	93	0
4	11	18	25	0	38	C	49	59	68	77	86	94	0
5	12	19	26	0	39	0	50	60	69	78	87	0	0
0	0	0	0	0	0	0	0	0	C	79	0	0	0
0	0	0	0	0	0	0	0	C	70	0	0	0	0
6	13	20	27	29	40	0	51	61	C	0	0	0	0
0	0	0	0	0	0	C	52	C	C	0.	0	0	0
0	0	0	0	0	41	0	0	0	C	0	0	0	0
7	14	21	28	30	C	C	0	0	C	0	0	0	0

OCKWELL INTERNATIONAL
LOW CONTROL DIVISION
ROGRAM NO. NCC&5P20

4 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/14/75

AXIAL PRESSURE,	TYPE,	NODES	
-209.00	1	1	8
-250.00	1	8	15
-250.00	1	15	22
-250.0C	1	22	35
-1200.0	1	31	42
-400.00	1	42	43
-342.00	1	43	53
-322.00	1	53	62
-302.00	1	62	71
-286.00	1	71	80
-238.00	1	80	95

LOAD	NODE	DIRECTION
-22835.	87	1
-22835.	94	1

DEFLECTION	NODE	DIRECTION
.0	87	2
.0	94	2

[N]ODES, COORDINATES, AND FORCES 08/14/75

[2]4 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX

1	0.0	2.500	C.	-40.
2	0.0	2.160	C.	0.
3	0.0	1.790	0.	0.
4	0.0	1.420	C.	0.
5	0.0	1.C50	0.	0.
6	C.0	0.530	C.	0.
7	0.0	0.C	0.	0.
8	0.410	2.500	C.	-325.
9	C.410	2.160	0.	0.
10	0.410	1.790	C.	0.
11	C.41C	1.420	0.	0.
12	0.410	1.050	C.	0.
13	C.410	C.530	0.	0.
14	C.410	0.C	C.	0.
15	C.970	2.500	0.	-887.
16	C.970	2.160	0.	0.
17	C.970	1.790	0.	0.
18	C.970	1.420	0.	0.
19	C.970	1.C50	C.	0.
20	C.970	0.530	C.	0.
21	C.970	0.C	C.	0.
22	1.570	2.500	0.	-2077.
23	1.570	2.160	C.	0.
24	1.570	1.790	0.	0.
25	1.570	1.420	0.	0.
26	1.570	1.C50	C.	0.
27	1.570	C.530	C.	0.
28	1.570	0.0	0.	0.
29	2.310	0.530	0.	0.
30	2.310	C.C	0.	0.
31	2.550	4.500	C.	-2964.
32	2.550	3.830	C.	0.
33	2.550	3.390	C.	0.
34	2.550	2.950	0.	0.
35	2.550	2.500	C.	-1756.
36	2.550	2.160	0.	0.
37	2.550	1.790	C.	0.
38	2.550	1.420	0.	0.
39	2.55C	1.C50	C.	0.
40	2.550	C.530	0.	0.
41	2.550	0.C80	C.	0.
42	2.850	4.500	0.	-5602.
43	3.500	3.830	C.	-5696.
44	3.500	3.390	0.	0.
45	3.500	2.950	C.	0.
46	3.5C0	2.500	C.	0.
47	3.500	2.160	C.	0.
48	3.500	1.790	C.	0.
49	3.500	1.420	0.	0.
50	3.500	1.C50	C.	0.

ODES, COORDINATES, AND FORCES

4 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/14/75

51	3.500	0.530	0.	0.
52	3.500	0.330	0.	0.
53	4.250	3.830	0.	-6638.
54	4.250	3.390	0.	0.
55	4.250	2.950	0.	0.
56	4.250	2.500	0.	0.
57	4.250	2.160	0.	0.
58	4.250	1.790	0.	0.
59	4.250	1.420	0.	0.
60	4.250	1.050	0.	0.
61	4.250	0.530	0.	0.
62	5.000	3.830	0.	-7546.
63	5.000	3.390	0.	0.
64	5.000	2.950	0.	0.
65	5.000	2.500	0.	0.
66	5.000	2.160	0.	0.
67	5.000	1.790	0.	0.
68	5.000	1.420	0.	0.
69	5.000	1.050	0.	0.
70	5.000	0.730	0.	0.
71	5.790	3.830	0.	-6312.
72	5.790	3.390	0.	0.
73	5.790	2.950	0.	0.
74	5.790	2.500	0.	0.
75	5.790	2.160	0.	0.
76	5.790	1.790	0.	0.
77	5.790	1.420	0.	0.
78	5.790	1.050	0.	0.
79	5.790	0.940	0.	0.
80	6.190	3.830	0.	-5371.
81	6.190	3.390	0.	0.
82	6.190	2.950	0.	0.
83	6.190	2.500	0.	0.
84	6.190	2.160	0.	0.
85	6.190	1.790	0.	0.
86	6.190	1.420	0.	0.
87	6.190	1.050	-22835.	0.
88	6.560	3.390	0.	0.
89	6.560	2.950	0.	0.
90	6.560	2.500	0.	0.
91	6.560	2.160	0.	0.
92	6.560	1.790	0.	0.
93	6.560	1.520	0.	0.
94	6.560	1.420	-22835.	0.
95	6.860	3.830	0.	-3358.
96	6.860	3.390	0.	0.
97	6.860	2.950	0.	0.
98	6.860	2.500	0.	0.
99	6.860	2.160	0.	0.
100	6.860	1.790	0.	0.

OCKWELL INTERNATIONAL
LOW CONTROL DIVISION
PROGRAM NO. NCCESR26

4 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/14/75

STIFFNESS MATRIX WIDTH FROM 1 TO 32

GAUSS-SEIDEL ITERATION
CONVERGENCE AT ITERATION NO. AND BETA

.15141E-05	100	1.79699
.38823E-06	200	1.79699
.12025E-06	300	1.79699
.29420E-07	400	1.79699

TOTAL ITERATIONS, 480

INEL

4 INCH FIG. 607 DISC FI ... T ANALYSIS S. MICHAUX 08/14/75

ODAL DISPLACEMENTS

ODE	UR	
1	0.0	4
2	0.0	2
3	0.0	9
4	0.0	9
5	0.0	4
6	0.0	8
7	0.0	0
8	-0.0000100	6
9	-0.0000065	5
10	-0.0000036	4
11	-0.0000010	6
12	0.0000015	3
13	0.0000051	0
14	0.0000101	5
15	-0.0000217	6
16	-0.0000151	8
17	-0.0000084	6
18	-0.0000023	4
19	0.0000035	8
20	0.0000120	3
21	0.0000225	2
22	-0.0000341	6
23	-0.0000236	9
24	-0.0000127	9
25	-0.0000031	4
26	0.0000057	6
27	0.0000190	4
28	0.0000342	3
29	0.0000258	4
30	0.0000450	2
31	-0.0001722	1
32	-0.0001341	7
33	-0.0001085	8
34	-0.0000829	5
35	-0.0000518	21
36	-0.0000334	1
37	-0.0000178	35
38	-0.0000039	32
39	0.0000095	19
40	0.0000278	20
41	0.0000451	24
42	-0.0001638	45
43	-0.0001218	15
44	-0.0000997	17
45	-0.0000767	14
46	-0.0000550	24
47	-0.0000391	38
48	-0.0000225	35
49	-0.0000061	67
50	0.0000108	71

NODAL DISPLACEMENTS

NODE	UR	UZ
51	0.0000356	-0.0002253
52	0.0000455	-0.0002239
53	-0.0001258	-0.0001667
54	-0.0000985	-0.0001683
55	-0.0000772	-0.0001628
56	-0.0000579	-0.0001697
57	-0.0000438	-0.0001711
58	-0.0000276	-0.0001732
59	-0.0000101	-0.0001753
60	0.0000093	-0.0001768
61	0.0000410	-0.0001758
62	-0.0001226	-0.0001156
63	-0.0000973	-0.0001152
64	-0.0000772	-0.0001145
65	-0.0000604	-0.0001137
66	-0.0000488	-0.0001137
67	-0.0000353	-0.0001152
68	-0.0000176	-0.0001183
69	0.0000049	-0.0001207
70	0.0000268	-0.0001219
71	-0.0001146	-0.0000681
72	-0.0000923	-0.0000661
73	-0.0000736	-0.0000633
74	-0.0000584	-0.0000588
75	-0.0000498	-0.0000546
76	-0.0000423	-0.0000504
77	-0.0000336	-0.0000491
78	-0.0000093	-0.0000538
79	0.0000030	-0.0000553
80	-0.0001096	-0.0000473
81	-0.0000890	-0.0000456
82	-0.0000704	-0.0000426
83	-0.0000549	-0.0000375
84	-0.0000465	-0.0000314
85	-0.0000413	-0.0000225
86	-0.0000401	-0.0000122
87	-0.0000287	-0.0000000
88	-0.0000859	-0.0000267
89	-0.0000675	-0.0000265
90	-0.000051[illegible]	-0.0000231
91	-0.0000420	-0.0000189
92	-0.0000383	-0.0000114
93	-0.0000409	-0.0000042
94	-0.0000474	-0.0000000
95	-0.0001035	-0.0000167
96	-0.0000838	-0.0000156
97	-0.0000656	-0.0000147
98	-0.0000496	-0.0000134
99	-0.0000402	-0.0000129
100	-0.0000355	-0.0000141

INEL 08/14/75

4 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX

AVERAGED STRESSES AT NODES

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
1	-1212.	-395.	-1212.	0.	-395.	-1212.	90.	816.
2	-771.	-226.	-771.	0.	-226.	-771.	90.	545.
3	-470.	-212.	-470.	0.	-212.	-470.	90.	258.
4	-182.	-172.	-182.	0.	-172.	-182.	90.	11.
5	97.	-138.	97.	0.	97.	-138.	0.	234.
6	501.	-80.	501.	0.	501.	-80.	0.	581.
7	1141.	192.	1141.	0.	1141.	192.	0.	949.
8	-1135.	-346.	-1174.	43.	-344.	-1138.	87.	830.
9	-755.	-202.	-759.	61.	-195.	-762.	84.	566.
10	-454.	-187.	-458.	77.	-166.	-475.	75.	308.
11	-166.	-147.	-170.	80.	-76.	-237.	48.	161.
12	104.	-116.	105.	77.	128.	-141.	17.	269.
13	508.	56.	510.	55.	513.	-61.	6.	574.
14	1101.	198.	1131.	28.	1102.	197.	2.	934.
15	-1064.	-365.	-1100.	10.	-365.	-1064.	89.	735.
16	-744.	-240.	-761.	26.	-239.	-745.	87.	522.
17	-430.	-201.	-449.	52.	-189.	-441.	78.	260.
18	-153.	-167.	-166.	74.	-86.	-235.	42.	149.
19	97.	-136.	96.	80.	121.	-161.	17.	282.
20	491.	-63.	499.	62.	498.	-70.	6.	569.
21	974.	138.	1030.	31.	975.	137.	2.	892.
22	-993.	-325.	-1047.	35.	-323.	-995.	87.	724.
23	-642.	-220.	-709.	57.	-212.	-649.	82.	497.
24	-377.	-219.	-421.	96.	-174.	-422.	65.	248.
25	-132.	-179.	-152.	131.	-22.	-289.	40.	267.
26	143.	-117.	148.	117.	188.	-162.	21.	350.
27	423.	-98.	449.	82.	436.	-110.	9.	559.
28	830.	125.	939.	59.	835.	120.	5.	820.
29	366.	-58.	418.	106.	391.	-83.	13.	501.
30	675.	82.	778.	56.	680.	77.	5.	701.
31	1.	-800.	-2013.	173.	37.	-836.	12.	2050.
32	-301.	-771.	-1907.	130.	-268.	-804.	14.	1640.
33	-386.	-632.	-1582.	71.	-367.	-651.	15.	1214.
34	-313.	-480.	-1213.	8.	-313.	-480.	3.	900.
35	-655.	-426.	-934.	-40.	-420.	-662.	-80.	515.
36	-516.	-285.	-633.	55.	-273.	-529.	77.	360.
37	-325.	-207.	-368.	148.	-107.	-425.	56.	318.
38	-128.	-144.	-127.	173.	37.	-309.	44.	345
39	118.	-77.	151.	182.	227.	-186.	31.	413
40	404.	13.	469.	164.	463.	-46.	20.	515
41	485.	-1.	577.	131.	518.	-34.	14.	611
42	-178.	-771.	-1879.	176.	-130.	-819.	15.	1749
43	-424.	-560.	-1413.	211.	-270.	-714.	36.	1143
44	-274.	-400.	-1057.	191.	-136.	-538.	36.	921
45	-249.	-300.	-823.	196.	-78.	-472.	41.	745
46	-365.	-211.	-644.	220.	-55.	-521.	55.	587
47	-366.	-123.	-482.	237.	22.	-511.	59.	532[illegible]
48	-281.	-51.	-292.	239.	99.	-431.	58.	52[illegible]
49	-146.	-7.	-98.	219.	153.	-306.	54.	45[illegible]
50	20.	-2.	98.	181.	191.	-172.	43.	36

FINEL

14 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/.4/75

AVERAGED STRESSES AT NODES

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
51	413.	127.	477.	145.	473.	66.	23.	410.
52	418.	32.	495.	151.	470.	-20.	19.	515.
53	-468.	-371.	-1140.	97.	-312.	-528.	58.	828.
54	-295.	-275.	-866.	182.	-102.	-467.	47.	764.
55	-300.	-255.	-712.	297.	20.	-575.	47.	732.
56	-329.	-176.	-560.	349.	105.	-609.	51.	714.
57	-354.	-92.	-443.	355.	155.	-601.	55.	756.
58	-360.	-30.	-312.	322.	167.	-557.	59.	724.
59	-269.	19.	-146.	258.	171.	-421.	60.	591.
60	-53.	61.	85.	141.	157.	-148.	56.	305.
61	317.	119.	401.	110.	367.	70.	24.	331.
62	-151.	-341.	-883.	78.	-123.	-369.	20.	760.
63	-200.	-322.	-740.	172.	-78.	-443.	35.	662.
64	-204.	-295.	-613.	313.	66.	-566.	41.	679.
65	-238.	-248.	-508.	420.	176.	-663.	45.	840.
66	-293.	-157.	-428.	467.	247.	-697.	49.	943.
67	-400.	-38.	-343.	434.	251.	-689.	56.	940.
68	-545.	-22.	-276.	317.	127.	-695.	65.	822.
69	-347.	84.	-40.	95.	104.	-367.	78.	471.
70	-155.	33.	75.	78.	60.	-183.	70.	258.
71	37.	-326.	-681.	60.	46.	-336.	9.	727.
72	-78.	-371.	-613.	117.	-37.	-412.	19.	576.
73	-107.	-443.	-547.	232.	11.	-562.	27.	573.
74	-141.	-529.	-504.	366.	79.	-749.	31.	828.
75	-216.	-570.	-494.	503.	140.	-926.	35.	1066.
76	-391.	-480.	-478.	624.	196.	-1057.	43.	1253.
77	-754.	-226.	-468.	523.	95.	-1075.	58.	1171.
78	-1142.	-77.	-408.	329.	17.	-1235.	74.	1252.
79	-390.	-48.	-279.	20.	-48.	-891.	89.	843.
80	79.	-259.	-546.	25.	81.	-260.	4.	628.
81	-11.	-331.	-537.	53.	-2.	-340.	9.	534.
82	-31.	-423.	-477.	106.	-4.	-450.	14.	474.
83	-43.	-589.	-456.	191.	17.	-649.	18.	667.
84	-83.	-804.	-492.	305.	29.	-916.	20.	944.
85	-394.	-1086.	-642.	492.	-139.	-1341.	27.	1202.
86	-1274.	-1668.	-1076.	703.	-741.	-2202.	37.	1461.
87	-2114.	-1654.	-1261.	671.	-1175.	-2594.	54.	1419.
88	7.	-276.	-492.	14.	8.	-276.	3.	500.
89	-4.	-313.	-404.	33.	-0.	-316.	6.	403.
90	5.	-404.	-355.	45.	10.	-409.	6.	419.
91	-23.	-610.	-382.	92.	-9.	-624.	9.	616.
92	-142.	-856.	-476.	80.	-133.	-865.	6.	732
93	-681.	-1369.	-803.	472.	-441.	-1609.	27.	1168
94	-1562.	-1976.	-1253.	577.	-1155.	-2382.	35.	1227
95	21.	-235.	-495.	-9.	21.	-235.	-2.	516
96	20.	-190.	-430.	14.	21.	-191.	4.	451
97	42.	-160.	-322.	12.	43.	-160.	3.	365
98	92.	-102.	-220.	8.	93.	-102.	2.	312
99	159.	43.	-115.	-2.	159.	43.	-1.	274
100	165.	-199.	-171.	-166.	229.	-263.	-21.	492

FINEL

14 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX 08/14/75

ELEMENT CENTER DATA

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
1	795.	-5.	795.	-9.	795.	-5.	-1.	800.
2	740.	-16.	763.	28.	741.	-17.	2.	780.
3	679.	-15.	720.	55.	683.	-19.	5.	739.
4	315.	-71.	315.	14.	316.	-71.	2.	387.
5	311.	-67.	314.	62.	321.	-77.	9.	398.
6	289.	-102.	294.	95.	311.	-124.	13.	435.
7	-35.	-136.	-35.	22.	-30.	-141.	12.	110.
8	-31.	-138.	-33.	64.	-1.	-168.	25.	167.
9	-18.	-151.	-29.	103.	38.	-208.	29.	246.
10	-325.	-188.	-325.	27.	-183.	-330.	79.	147.
11	-312.	-188.	-318.	51.	-170.	-331.	70.	161.
12	-279.	-203.	-302.	79.	-154.	-328.	58.	174.
13	-623.	-224.	-623.	29.	-222.	-625.	86.	403.
14	-608.	-218.	-614.	33.	-215.	-610.	85.	398.
15	-572.	-239.	-598.	40.	-234.	-576.	83.	363.
16	-960.	-237.	-960.	18.	-236.	-960.	89.	724.
17	-889.	-227.	-920.	-2.	-227.	-889.	-90.	693.
18	-862.	-240.	-891.	16.	-240.	-863.	89.	651.
19	540.	-27.	638.	86.	552.	-40.	8.	677.
20	6.	-125.	-7.	161.	114.	-234.	34.	348.
21	-222.	-181.	-260.	143.	-57.	-347.	49.	289.
22	-460.	-240.	-534.	94.	-206.	-494.	70.	328.
23	-763.	-295.	-844.	-2.	-295.	-763.	-90.	549.
24	221.	-17.	270.	174.	313.	-109.	28.	422.
25	-24.	-42.	7.	204.	171.	-237.	44.	409.
26	-197.	-85.	-210.	223.	88.	-371.	52.	459
27	-336.	-144.	-426.	210.	-9.	-471.	57.	462
28	-389.	-200.	-629.	141.	-124.	-465.	62.	505
29	-316.	-339.	-875.	57.	-270.	-385.	39.	605
30	-236.	-433.	-1142.	105.	-190.	-479.	23.	951
31	-251.	-524.	-1420.	123.	-203.	-572.	21.	1217
32	166.	44.	251.	141.	259.	-49.	33.	307
33	-101.	41.	-9.	217.	199.	-258.	54.	457
34	-242.	4.	-199.	267.	175.	-413.	57.	588
35	-324.	-52.	-371.	295.	136.	-513.	57.	649
36	-355.	-143.	-531.	301.	70.	-568.	55.	638
37	-358.	-258.	-706.	283.	-21.	-596.	50.	685
38	-373.	-377.	-913.	236.	-139.	-611.	45.	774
39	-541.	-449.	-1167.	183.	-306.	-684.	52.	862
40	-244.	60.	-76.	217.	173.	-357.	63.	530
41	-647.	15.	-264.	263.	107.	-739.	71.	846
42	-1559.	-1046.	-920.	750.	-509.	2095.	54.	158
43	-372.	25.	-250.	335.	-215.	-563.	60.	77
44	-647.	-253.	-448.	568	152.	-1051.	55.	120
45	-657.	-862.	-652.	181.	28.	-1547.	41.	157
46	-403.	-97.	-40[illegible]	426.	202.	-702.	55.	90
47	-409.	-380.	-482.	579.	185.	-974.	46.	115
48	-223.	-757.	-520.	538.	110.	-1090.	32.	120
49	-353.	-301.	-512.	436.	162.	-725.	50.	88
50	[illegible]	-413.	-504.	490.	162.	-830.	40.	99

FINEL 08/14/75

.4 INCH FIG. 607 DISC FINITE ELEMENT ANALYSIS S. MICHAUX

ELEMENT CENTER DATA

NO.	RADIAL	AXIAL	HOOP	SHEAR	PRINCIPAL STRESSES		θ DEG	STRESS INTENSITY
51	-74.	-618.	-471.	352.	98.	-791.	26.	889.
52	-320.	-278.	-624.	386.	88.	-685.	47.	773.
53	-177.	-393.	-548.	364.	95.	-664.	37.	759.
54	-30.	-471.	-473.	211.	55.	-556.	22.	610.
55	-302.	-325.	-760.	285.	-29.	-599.	44.	731.
56	-125.	-344.	-617.	224.	15.	-484.	32.	632.
57	-22.	-361.	-523.	106.	8.	-392.	16.	531.
58	-276.	-313.	-902.	111.	-181.	-407.	40.	721.
59	-61.	-313.	-710.	81.	-37.	-337.	16.	673.
60	50.	-285.	-579.	33.	54.	-289.	6.	633.
61	-89.	-837.	-476.	229.	-25.	-902.	16.	877.
62	41.	-556.	-384.	117.	63.	-578.	11.	641.
63	15.	-402.	-404.	73.	27.	-414.	10.	441.
64	18.	-308.	-456.	28.	20.	-310.	5.	476.
65	60.	-312.	-250.	-67.	72.	-323.	-10.	395.
66	12.	-287.	-287.	-20.	14.	-289.	-4.	302.
67	11.	-256.	-336.	4.	11.	-256.	1.	346.
68	7.	-228.	-405.	1.	7.	-228.	0.	412.
69	358.	-81.	361.	172.	418.	-141.	19.	558.
70	169.	-47.	228.	120.	223.	-100.	24.	328.
71	350.	-13.	356.	146.	402.	-65.	19.	466.
72	577.	16.	663.	97.	594.	2.	10.	661.
73	389.	-34.	506.	108.	415.	-60.	14.	566.
74	489.	13.	563.	188.	554.	-52.	19.	615.
75	409.	56.	481.	72.	423.	42.	11.	440.
76	356.	28.	441.	194.	446.	-62.	25.	508.
77	66.	23.	202.	131.	177.	-89.	40.	291.
78	-120.	103.	85.	1.	103.	-120.	90.	223.
79	-411.	-28.	-62.	100.	-4.	-436.	76.	432.
80	-495.	223.	-84.	-308.	337.	-609.	-70.	946.
81	-1764.	-339.	-690.	268.	-291.	-1813.	80.	1522.
82	-1475.	-1778.	-1160.	24.	-1473.	-1780.	5.	620.
83	-1649.	-2173.	-1346.	1131.	-751.	-3072.	38.	2221.
84	-648.	-1259.	-766.	297.	-527.	-1380.	22.	853.
85	-242.	-1037.	-571.	457.	-34.	-1245.	24.	1210.
86	-185.	-1007.	-530.	4.	-185.	-1007.	0.	822.
87	3.	-210.	-466.	-12.	4.	-211.	-3.	470.
88	38.	-259.	-524.	-6.	38.	-259.	-1.	562.
89	17.	-273.	-527.	-14.	18.	-274.	-3.	546.
90	-358.	-742.	-1744.	178.	-288.	-812.	21.	1455.
91	1.	-800.	-2013.	173.	37.	-836.	12.	2050.

Flow Control Division
Rockwell International

SUBJECT: EXHIBIT FOUR

MAXIMUM SHEAR TRAJECTORIES
24" - 4007 VALVE SEAT

BY DATE	REVIEWED BY DATE	REV DATE

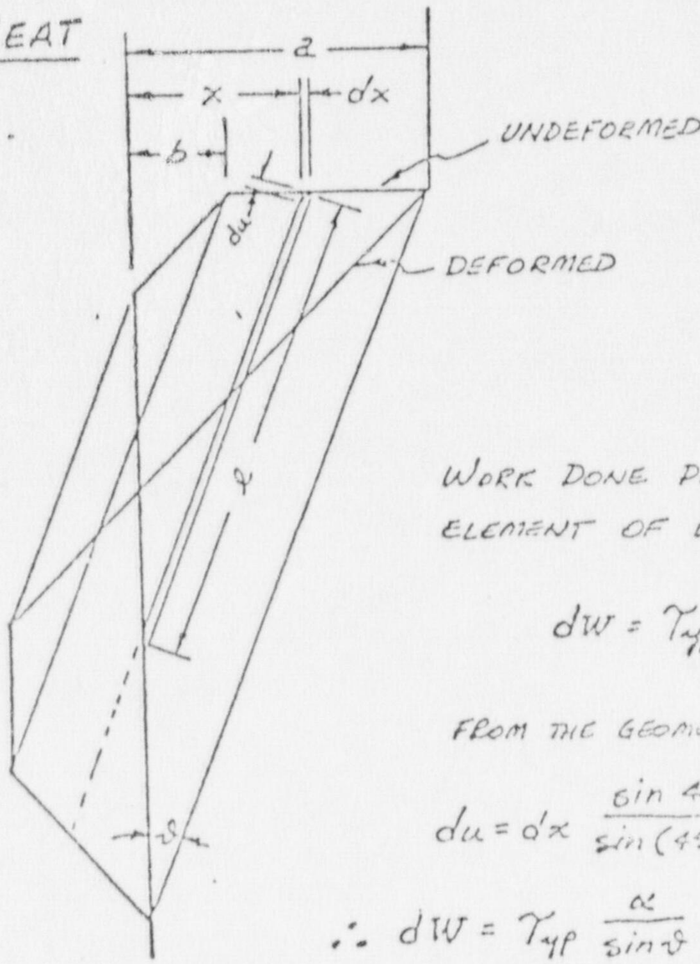
Flow Control Division
Rockwell International

SUBJECT: EXHIBIT FIVE

BY-DATE | REVIEWED BY-DATE | REV-DATE

DERIVATION OF PLASTIC ENERGY ABSORPTION EQUATIONS

A. SEAT



FIRST, ASSUME THAT ALL PLASTIC DEFORMATION OCCURS IN THE SEAT. ONE WAY FOR THIS TO OCCUR WOULD BE FOR THE ENTIRE SEAT SHELF TO BE DEFORMED INTO A 45° CONE BY THE DISK.

WORK DONE PER UNIT DEPTH ON AN ELEMENT OF WIDTH dx:

$$dW = \tau_{yp}\, l\, du$$

FROM THE GEOMETRY,

$$du = dx \frac{\sin 45°}{\sin(45° - \vartheta)} \quad ; \quad l = \frac{x}{\sin\vartheta}$$

$$\therefore\ dW = \tau_{yp} \frac{\alpha}{\sin\vartheta} x\, dx \quad \text{where } \alpha = \frac{\sin 45°}{\sin(45° - \vartheta)}$$

FOR THE ENTIRE SEAT,

$$W = \pi d_{av} \tau_{yp} \frac{\alpha}{\sin\vartheta} \int_b^a x\, dx = \pi d_{av.} \tau_{yp} \frac{\alpha}{\sin\vartheta} \left(\frac{a^2 - b^2}{2}\right)$$

IT CAN BE SHOWN THAT THIS EXPRESSION IS A MINIMUM AT $\vartheta = 22\frac{1}{2}°$.

THUS, $$W = 7.5845\, d_{av} \tau_{yp} (a^2 - b^2)$$

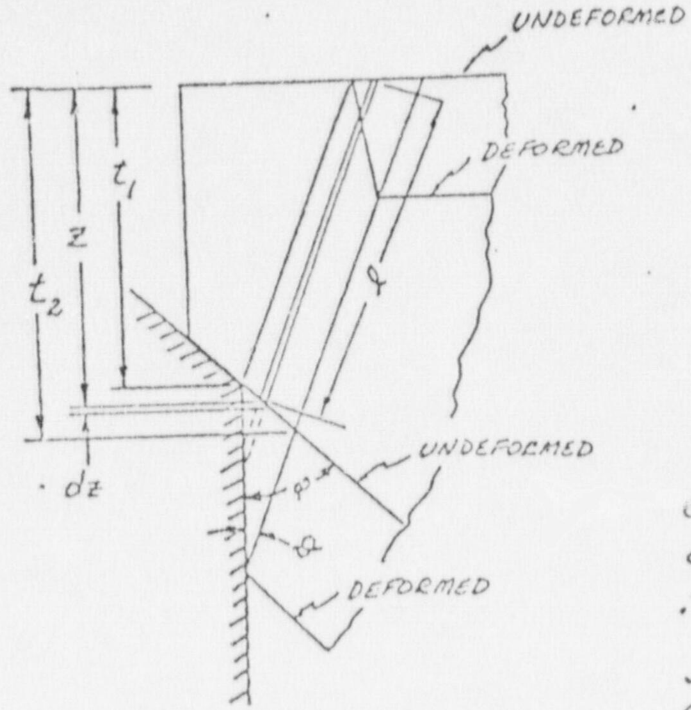
Flow Control Division
Rockwell International

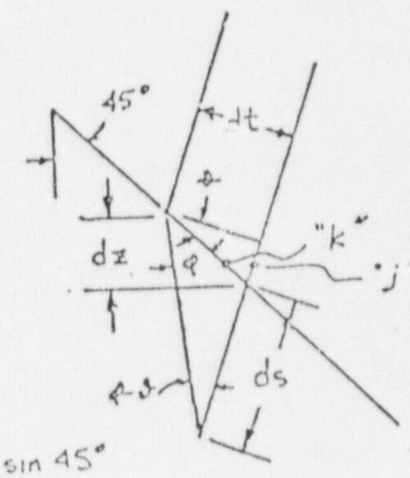
SUBJECT: EXHIBIT FIVE

BY DATE | REVIEWED BY DATE | REV. DATE

B. DISK

A SIMILAR DEFORMATION ANALYSIS APPLIES TO THE DISK.





$$dz = k \sin 45^\circ$$

$$dt = k \cos\vartheta$$

$$\therefore\ dt = dz \frac{\cos\vartheta}{\sin 45^\circ}$$

$$j = k \sin\vartheta = dz \frac{\sin\vartheta}{\sin 45^\circ}$$

$$ds = k \frac{\sin(\phi)}{\sin(\phi-\vartheta)}$$

$$ds = dz \frac{\sin\phi}{\sin(\phi-\vartheta)\sin 45^\circ}$$

$$l = \frac{z}{\cos\vartheta}$$

$$dW = F\,ds = \tau_{yp} \frac{z\,dz}{\cos\vartheta} \frac{\sin\phi}{\sin(\phi-\vartheta)\sin 45^\circ}$$

$$W = \tau_{yp} \frac{\sin\phi}{\sin(\phi-\vartheta)\sin 45^\circ} \int_{t_1}^{t_2} z\,dz = \tau_{yp} \frac{\sin\phi\,(t_2^2 - t_1^2)}{2\sin(\phi-\vartheta)\sin 45^\circ}$$ per unit depth

FOR THE ENTIRE DISK,

$$W = \frac{\pi}{2}\tau_{yp} \frac{d\sin\phi\,(t_2^2 - t_1^2)}{\sin(\phi-\vartheta)\sin 45^\circ}$$

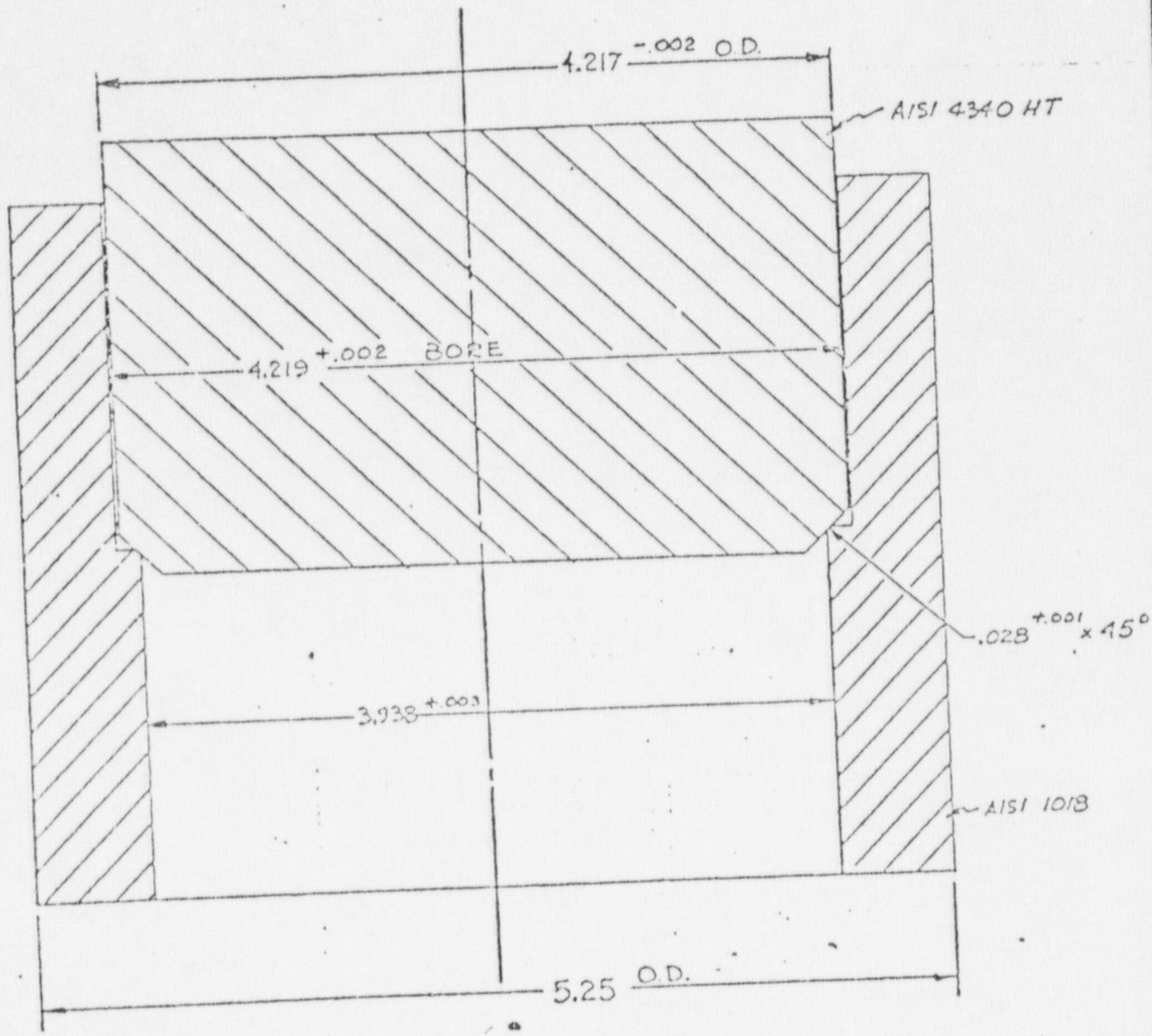
FOR THE CASE WHERE $\phi = 45^\circ$, IT CAN BE SHOWN THAT $\vartheta = \frac{\phi}{2} = 22\frac{1}{2}^\circ$.
THE EXPRESSION SIMPLIFIES TO:

$$W = \frac{\pi}{2}\tau_{yp} \frac{d\,(t_2^2 - t_1^2)}{\sin 22\frac{1}{2}^\circ} = 4.1047\,\tau_{yp}\,d\,(t_2^2 - t_1^2)$$

Rockwell

SUBJECT: 3/16 SCALE MODEL OF 24"-4007 STOP-CHECK VALVE DISK AND SEAT

BY/DATE	REVIEWED BY/DATE	REV/DATE
7-30-75		



PROJECTED SEAT AREA = 0.346 - 0.360 IN^2

FORCE SCALE FACTOR = $\frac{1}{28.44}$

ENERGY SCALE FACTOR = $\frac{1}{151.7}$

EXHIBIT SEVEN

LOAD-DEFLECTION CURVE FOR MODEL OF 24-4007 SEAT

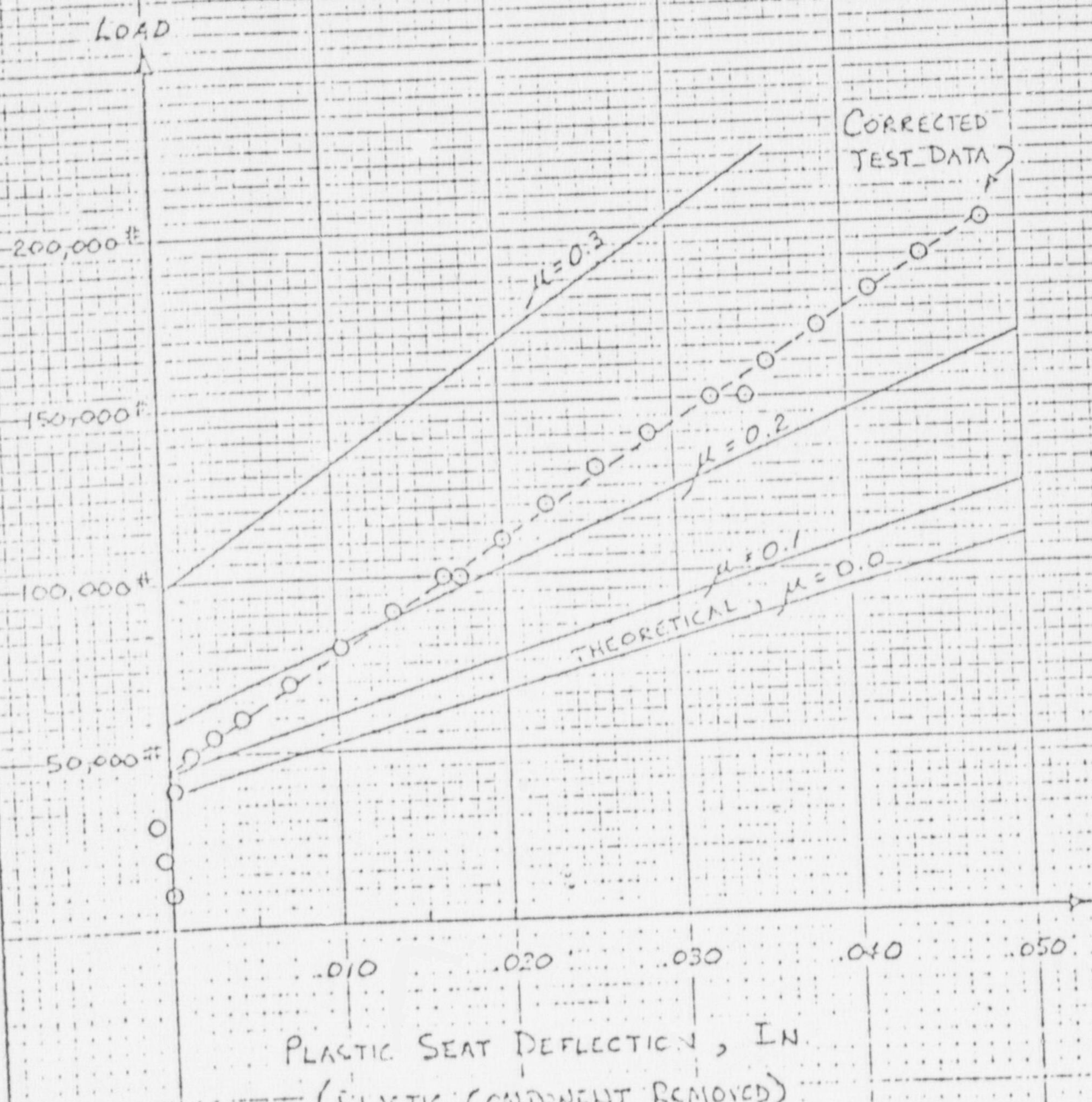
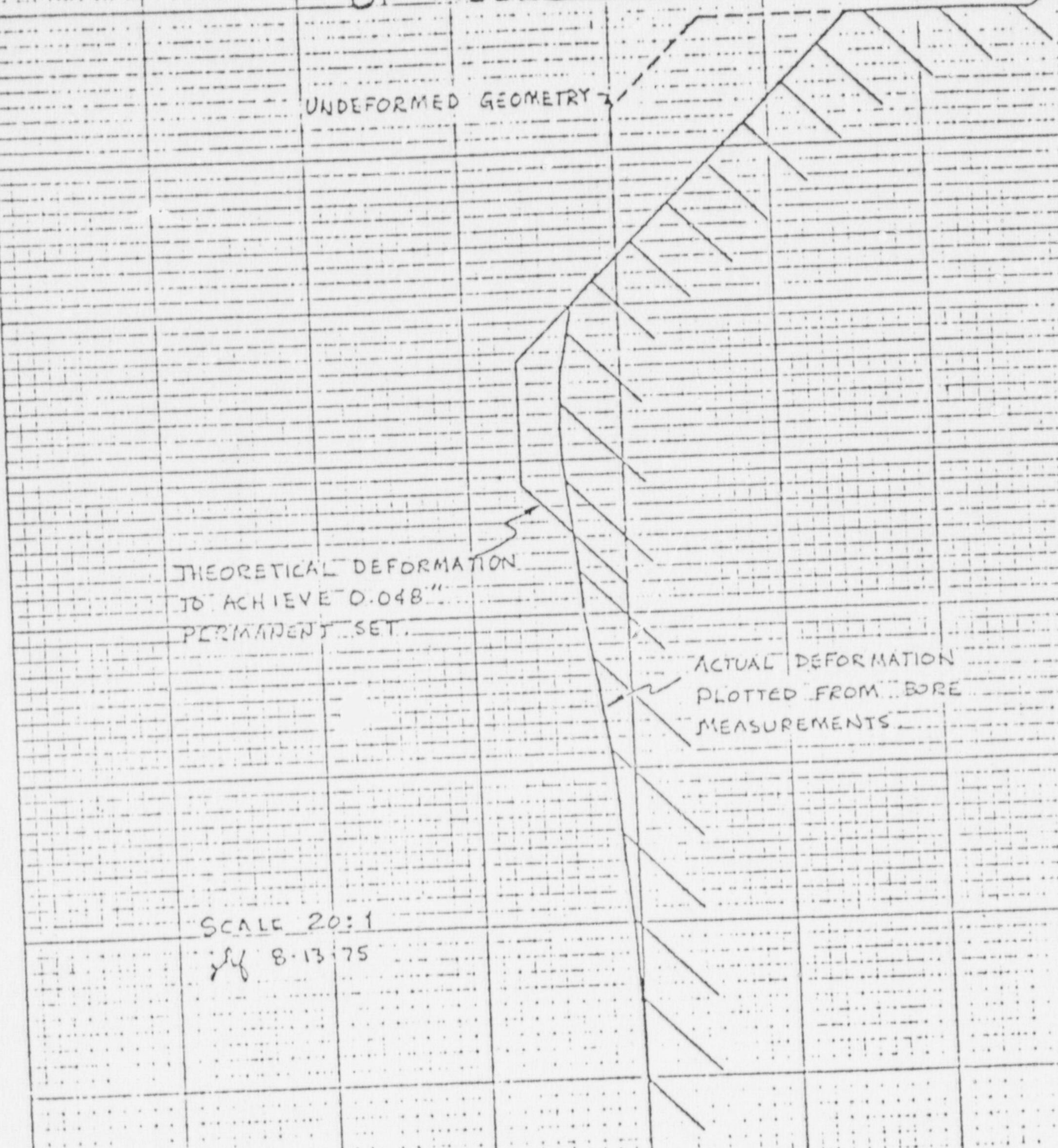


EXHIBIT EIGHT
DEFORMATION OF MODEL



Flow Control Division
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SUBJECT

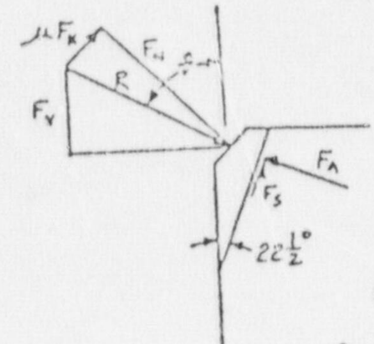
EXHIBIT NINE
FORCE-DEFLECTION CALCULATIONS
WITH ALLOWANCE FOR FRICTION

REVIEWED BY DATE

REV. DATE

BY DATE jly 8/13/75

CONSIDER THE FORCES ACTING ON AN ELEMENT OF THE SEAT THAT IS SHEARING ALONG A $22\frac{1}{2}°$ SLIP PLANE:



$$\sum F_x = 0 = R\sin\vartheta + F_s \sin 22\tfrac{1}{2}° - F_A \cos 22\tfrac{1}{2}°$$
$$\therefore \quad F_A = R(\sin\vartheta / \cos 22\tfrac{1}{2}°) + F_s \tan 22\tfrac{1}{2}°$$

$$\sum F_z = 0 = R\cos\vartheta - F_s \cos 22\tfrac{1}{2}° - F_A \sin 22\tfrac{1}{2}°$$
$$\therefore \quad F_A = R(\cos\vartheta / \sin 22\tfrac{1}{2}°) - F_s \cot 22\tfrac{1}{2}°$$

Combining,

$$R\left(\frac{\cos\vartheta}{\sin 22\frac{1}{2}°} - \frac{\sin\vartheta}{\cos 22\frac{1}{2}°}\right) = F_s\left(\cot 22\tfrac{1}{2}° + \tan 22\tfrac{1}{2}°\right)$$

But $R = F_v/\cos\vartheta$. Thus,

$$F_v\left(\frac{1}{\sin 22\frac{1}{2}°} - \frac{\tan\vartheta}{\cos 22\frac{1}{2}°}\right) = F_s\left(\cot 22\tfrac{1}{2}° + \tan 22\tfrac{1}{2}°\right)$$

$$\frac{F_v}{F_s} = \frac{\sin 22\frac{1}{2}°\left(\cot 22\frac{1}{2}° + \tan 22\frac{1}{2}°\right)}{1 - \tan\vartheta \tan 22\frac{1}{2}°} = \frac{1.08238}{1 - 0.4142 \tan\vartheta}$$

μ	$\tan\vartheta$	F_v/F_s
0.0	1.000	1.8477
0.1	1.222	2.1921
0.2	1.500	2.8582
0.3	1.857	4.6903

USING THE TERMINOLOGY OF EXHIBIT FIVE,

$$F_s = \pi d' \ell\, \tau_{yp} = \pi d' \tau_{yp} \frac{x}{\sin 22\frac{1}{2}°} = 8.2094\, \tau_y d x$$

FOR THE MODEL OF THE 24"-4007 VALVE, THEORETICAL VERTICAL FORCES:

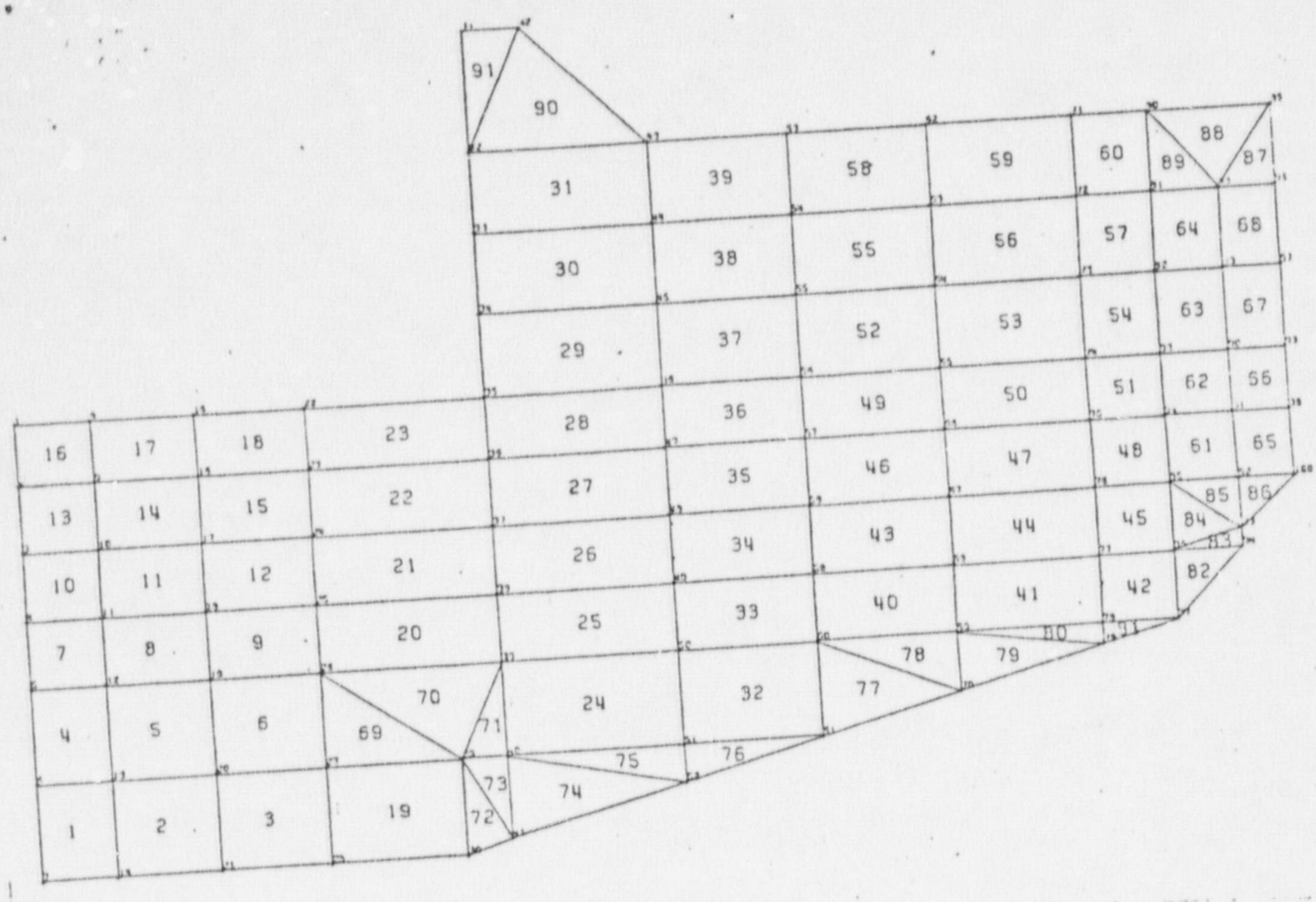
$\tau_{yp} = 0.57(43280) = 24670$ psi

$d = 4"$

$\mu = 0 \quad \mu = .1 \quad \mu = .2 \quad \mu = .3$

$x = 0.029, \quad \delta = 0.0 \rightarrow F_s = 23493 \Rightarrow F_v = 43408; 51499; 67148; 110189$

$x = 0.079, \quad \delta = 0.050 \rightarrow F_s = 63993 \Rightarrow F_v = 118240; 140279; 182919; 3[illegible]$



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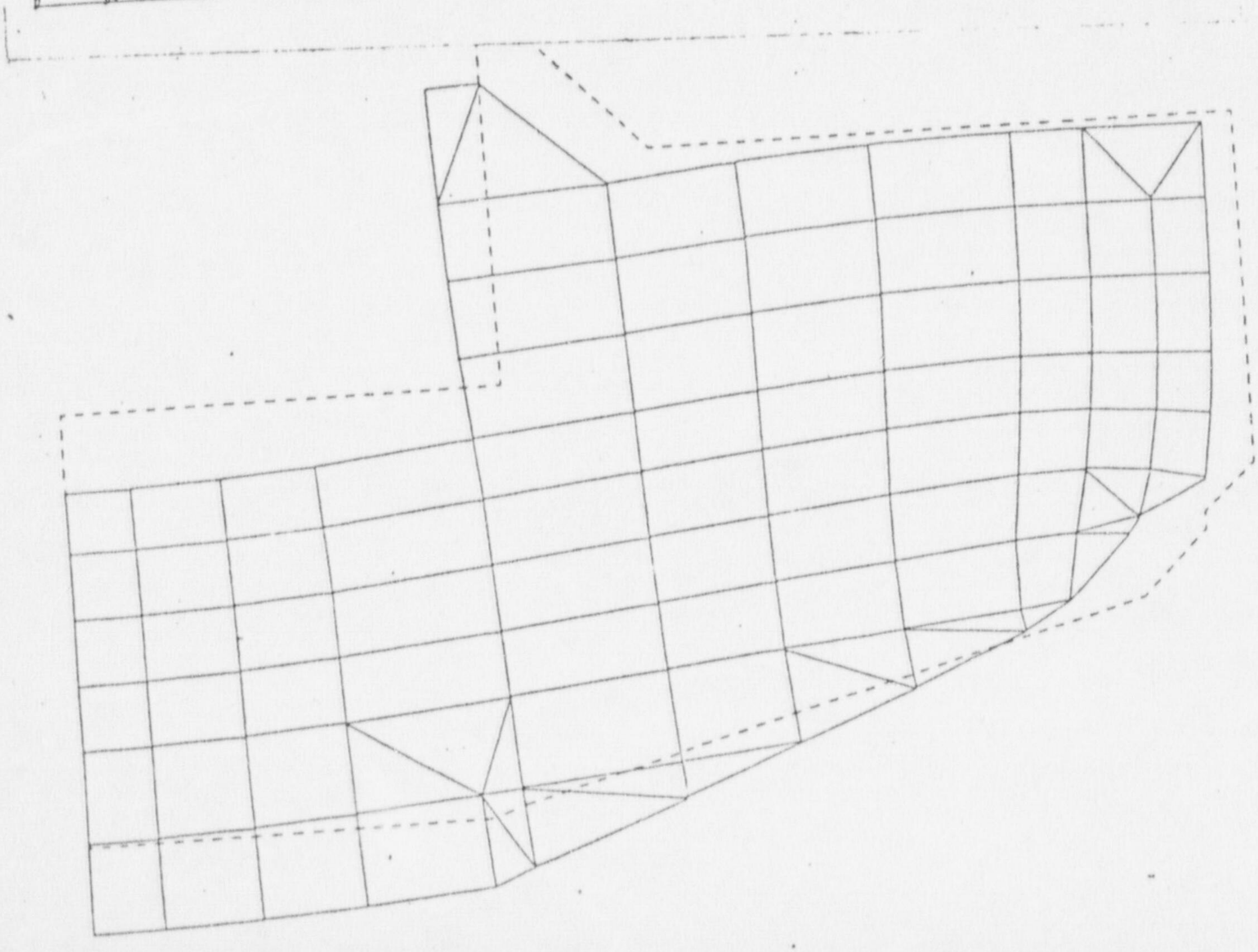

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WESTBOROUGH, MASS

J L FRENCH......

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DESCRIPTION
LTR REF OUR 4-29-76 LTR.....TRANS THE FOLLOWING.....

ENCLOSURE
(1) RPT NO 2573-48 "DISK VELOCITY AT IMPACT WITH SEAT FOR LINE BREAK UPSTREAM SIDE OF SIZE 14 FIGURE 607 NON-RETURN VALVE."
(2) REPORT NO 2573-62, "ENERGY ABSORPTION IN THE SIZE 14 FIG 607 VALVE SEAT AND DISK AT YANKEE ROWE.....

ACKNOWLEDGED

DO NOT REMOVE

PLANT NAME: YANKEE ROWE

FOR ACTION/INFORMATION

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		OPERATING TECH	
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