

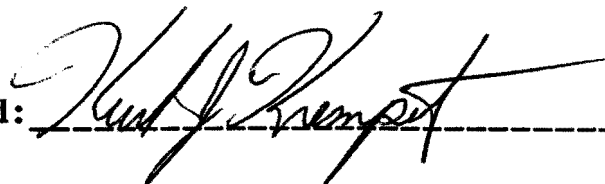
**D-ZERO END CAP CALORIMETER  
ANNULAR PIPING ANALYSIS**

**D-Zero Engineering Note: 3740.220-EN-175**

**C.H. Kurita**

**August 22, 1988**

**Approved:**

  
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In accordance with the ASME Code for Pressure Piping, B31 version of Chemical Plant and Petroleum Refinery Piping, ANSI/ASME B31.3-1984 Edition, the maximum allowable stress for 304 stainless steel piping is 25,500 psi. This "Allowable Displacement Stress Range" value was calculated using equation (1a) found on page 16 of the above mentioned reference.

Each of the lines that comprise the End Cap Calorimeter (EC) piping were modeled on ANSYS and the appropriate constraints were applied. This was done using the Piping Stress Analysis Module of ANSYS. The bending stresses and displacements due to the thermal contraction that occurs in cooling the piping from 300 K to 77 K were calculated by ANSYS. The seven lines involved and their maximum bending stresses are as follows:

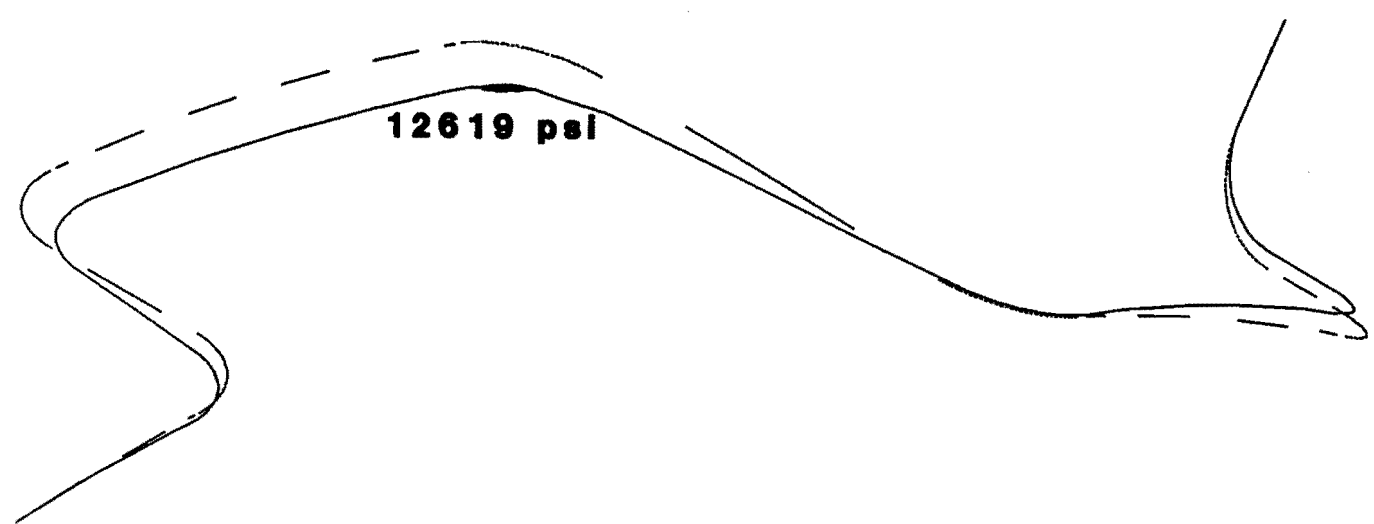
<u>LINE</u>	<u>MAX. BEND. STRESS</u>
1) Rupture Disc	8335 psi
2) Argon Relief	12,619 psi
3) Gaseous Argon Supply	5399 psi
4) Liquid Nitrogen Cooldown Supply	7049 psi
5) Liquid Nitrogen Operating Supply	5774 psi
6) Nitrogen Exhaust	1826 psi
7) Argon/Nitrogen Vent	48,364 psi

The maximum bending stress values and their positions are indicated on the attached diagrams. The dashed line indicates the original position of the piping, and the solid line shows the position of the displaced piping. Also attached are copies of the programs used to model the piping configurations. The original analysis was done by J. Wendlandt, but later changes and additions required that the programs be modified and re-run. The maximum bending stress found in each line of the annular piping fell sufficiently below the allowed maximum of 25,500 psi. The maximum bending stress for the Argon/Nitrogen Vent line was 48,364 psi, which is greater than the value of 25,500 psi allowed by the code. This line of piping is located on the outside of the annular space and will be installed at Fermilab. While fabrication of the EC vessel is underway, modifications will be made to the Argon/Nitrogen Vent line in order that its stress values remain within that allowed by the code.

The complete Argon/Nitrogen Vent line is analyzed in EN-312, DØ Cryogenic Piping Frame Stress Analysis, and the stresses are below the maximum allowable stress of 25,500 psi.

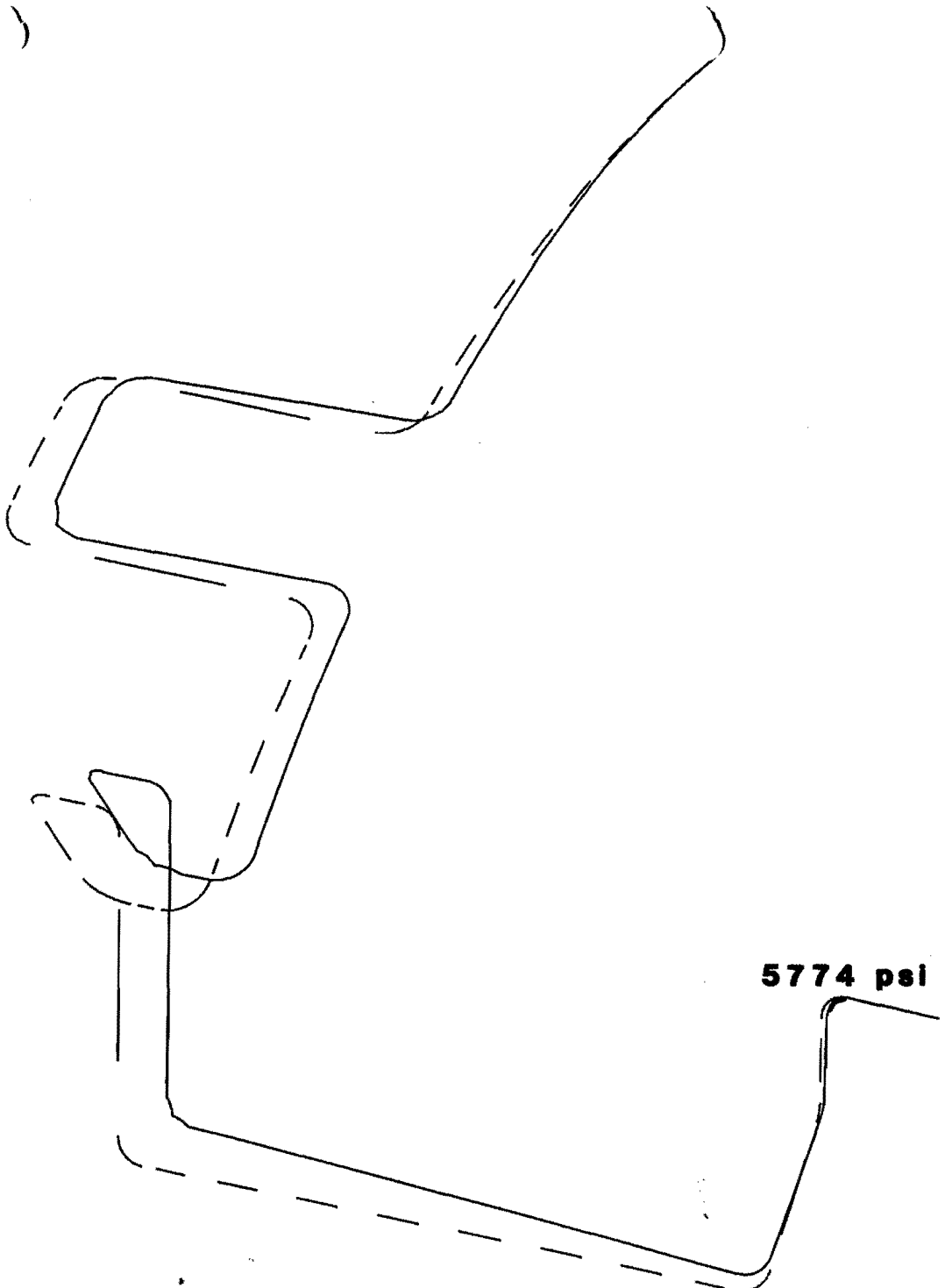
ANSYS 3  
JUL 21 1988  
8:55:33  
PLOT NO. 3  
POST1 DISPL.  
STEP=1  
ITER=1

ORIG  
XV=-1  
YV=1  
ZV=1  
DIST=26.9  
XF=30.8  
YF=91.7  
ZF=1.35  
DMAX=.1  
DSCA=26.9



1 ARGON RELIEF 2.5" SCH-40S

```
/PREP7
/TIT, ARGON RELIEF 2.5" SCH-40S
MPTEMP,1,75,144,200,294
MPDATA,EX,1,1,30.4E6,29.9E6,29.4E6,28.3E6
ALPX,1,1.4387E-5
TREF,300
TUNIF,77
CSYS,1
PSPEC,1,2.5,40S
BRANCH,1,98.25,53.82,0
RUN,0,0,11.25
RUN,0,11.516,0,4
BEND,,,3.75
RUN,0,0,-24.75
BEND,,,3.75
RUN,0,17.061,0,6
BEND,,,3.75
RUN,0,0,14.915
BEND,,,3.75
RUN,0,7.603,0,3
BEND,,,3.75
D,1,ALL,0
D,33,ALL,0
ITER,1,1
ACEL,,1
KRF,1
AFWR,,1
FINI
/INPUT,27
FINI
/POST1
SET,1,1
PRSTR
/VIEW,1,-1,1,1
PLELEM
PLDISP,1
FINI
```



ANSYS 3  
JUL 25 1988  
7:56:38  
PLOT NO. 3  
POST1 DISPL.  
STEP=1  
ITER=1

ORIG  
XV=-2  
YV=1  
ZV=1  
DIST=37  
XF=-45.1  
YF=80.7  
ZF=7.45  
DMAX=.229  
DSCA=16.1

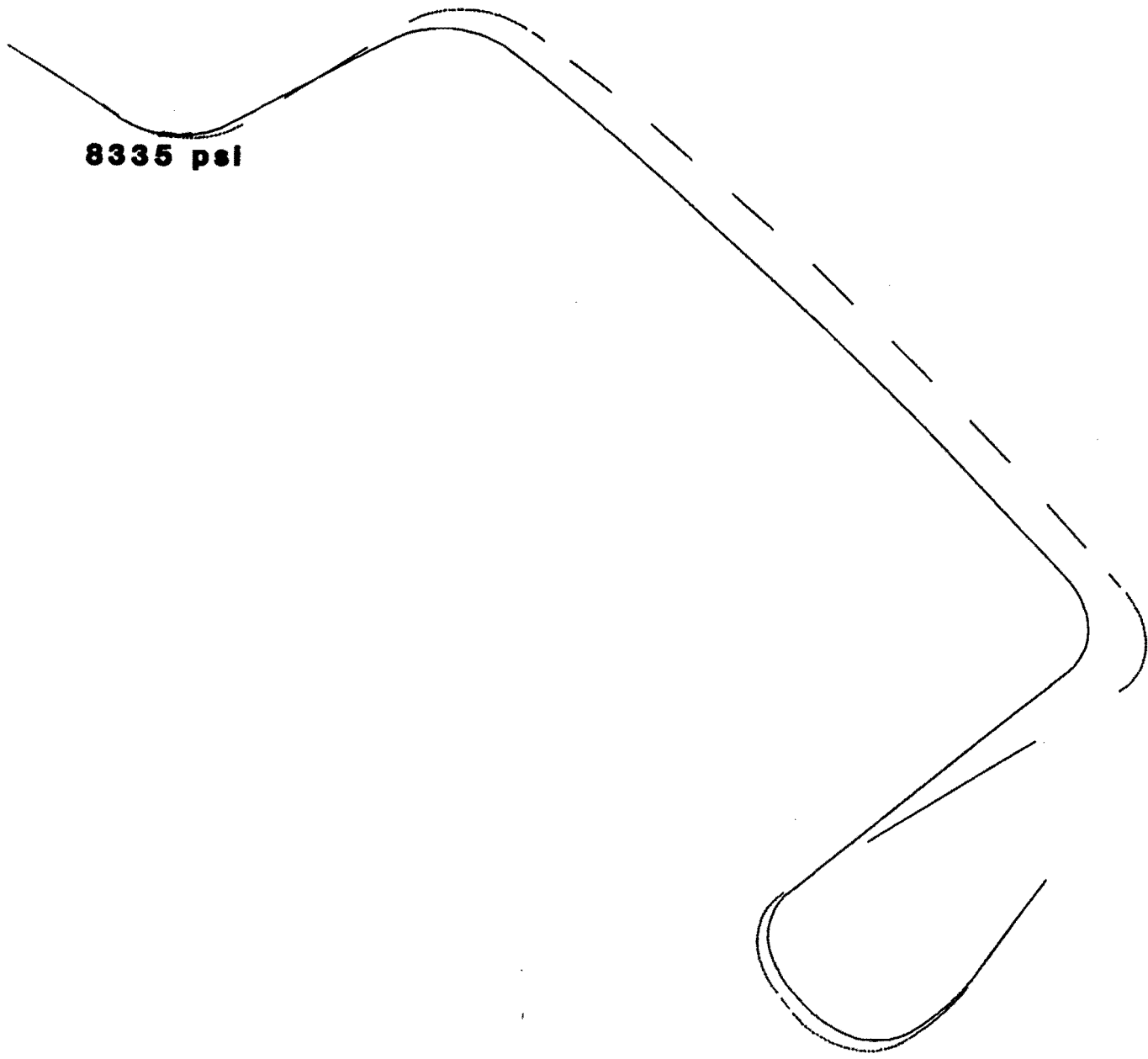
**5774 psi**

1 LIQUID NITROGEN OPERATING SUPPLY 1.5" SCH-40S

/PREP7  
/TIT, LIQUID NITROGEN OPERATING SUPPLY 1.5" SCH-40S  
MPTEMP,1,75,144,200,294  
MPDATA,EX,1,1,30.4E6,29.9E6,29.4E6,28.3E6  
ALPX,1,1.4387E-5  
TREF,300  
TUNIF,77  
CSYS,1  
PSPEC,1,1.5,40S  
BRANCH,1,98,90,0  
RUN,0,22.931,0,8  
RUN,0,0,-21  
BEND,,,2.25  
RUN,0,7.126,0,3  
BEND,,,2.25  
RUN,0,0,21  
BEND,,,2.25  
RUN,0,11.884,0,5  
BEND,,,2.25  
RUN,0,0,4.042  
BEND,,,2.25  
D,1,ALL  
D,36,ALL  
ITER,1,1  
ACEL,,1  
KRF,1  
AFWR,,1  
FINI  
/INPUT,27  
FINI  
/POST1  
SET,1,1  
PRSTR  
/VIEW,1,-1,1,1  
PLELEM  
PLDISP,1  
FINI

ANSYS 3  
JUL 20 1988  
11:15:04  
PLOT NO. 3  
POST1 DISPL.  
STEP=1  
ITER=1

ORIG  
XV=1  
YV=1  
ZV=1  
DIST=22.6  
XF=29.5  
YF=92.3  
ZF=-2.59  
DMAX=.113  
DSCA=19.9



8335 psi

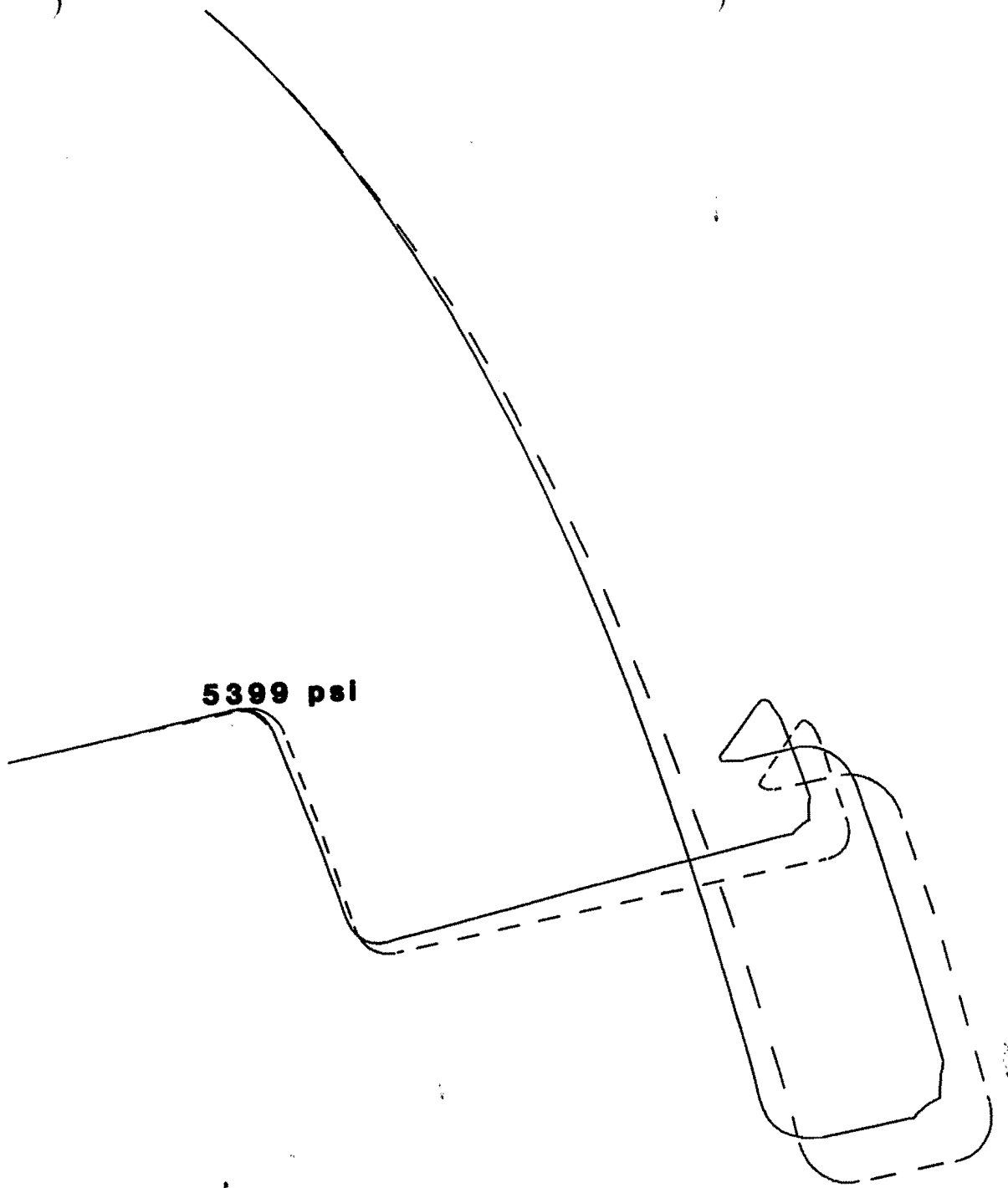
1 R.D. LINE 2" SCH-40S

/PREP7  
/TIT, R.D. LINE 2" SCH-40S  
MPTEMP,1,75,144,200,294  
MPDATA,EX,1,1,30.4E6,29.9E6,29.4E6,28.3E6  
ALPX,1,1.309E-5  
TREF,300  
TUNIF,77  
CSYS,1  
PSPEC,1,2,40S  
BRANCH,1,107.678,58.641,0  
RUN,-9.678,0,0  
RUN,0,0,5.25  
BEND,,,2  
RUN,0,4.026,0  
BEND,,,3  
RUN,0,0,-23.0  
BEND,,,3  
RUN,0,22.065,0,9  
BEND,,,3  
RUN,0,0,14.6875  
BEND,,,3  
RUN,0,5.269,0,2  
BEND,,,3  
D,1,ALL  
D,37,ALL  
ITER,1,1  
ACEL,1  
KRF,1  
AFWR,,1  
FINI  
/INPUT,27  
FINI  
/POST1  
SET,1,1  
PRSTR  
PRDIS  
FINI



ANSYS 3  
JUL 22 1988  
15:22:25  
PLOT NO. 1  
POST1 DISPL.  
STEP=1  
ITER=1

ORIG  
XV=2  
YV=1  
ZV=1  
DIST=38.1  
XF=48.5  
YF=80.8  
ZF=8.88  
DMAX=.298  
DSCA=12.8

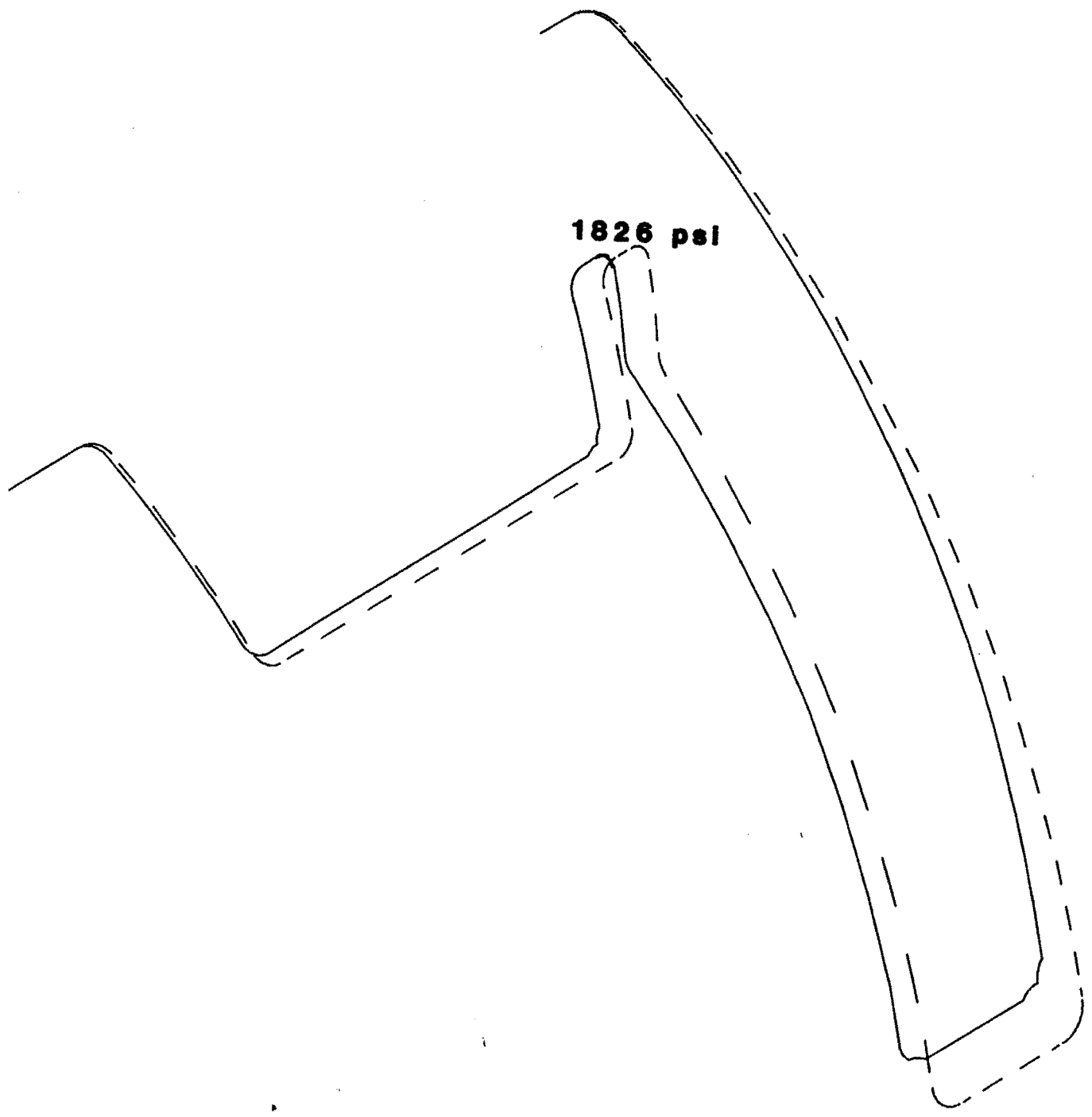


1 ARGON GAS SUPPLY 2" SCH-40S

/PREP7  
/TIT, ARGON GAS SUPPLY 2" SCH-40S  
MPTEMP,1,75,144,200,294  
MPDATA,EX,1,1,30.4E6,29.9E6,29.4E6,28.3E6  
ALPX,1,1.4387E-5  
TREF,300  
TUNIF,77  
CSYS,1  
PSPEC,1,2,40S  
BRANCH,1,98,48.059,0  
RUN,0,0,-10  
RUN,0,-19.407,0,8  
BEND,,,3  
RUN,0,0,14  
BEND,,,3  
RUN,0,56.666,0,19  
BEND,,,3  
D,1,ALL  
D,38,ALL  
ITER,1,1  
ACEL,,1  
KRF,1  
AFWR,,1  
FINI  
/INPUT,27  
FINI  
/POST1  
SET,1,1  
PRSTR  
/VIEW,1,-1,1,1  
PLELEM  
PLDISP,1  
FINI

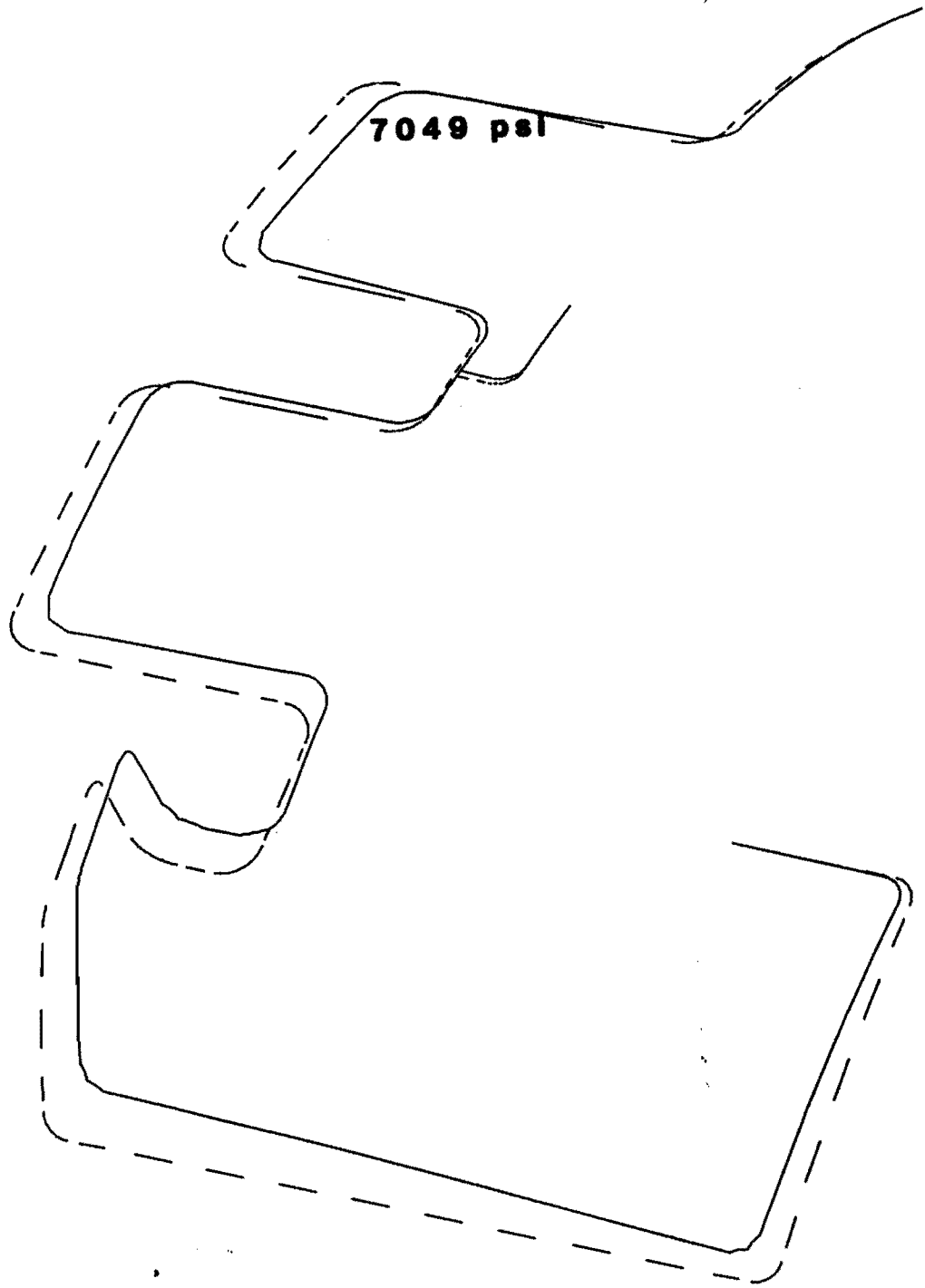
ANSYS 2.3  
AUG 3 1988  
10:25:35  
PLOT NO. 3  
POST1 DISPL.  
STEP=1  
ITER=1

ORIG  
XV=1  
YV=1  
ZV=1  
DIST=53.3  
XF=63.1  
YF=64.6  
ZF=-48.6  
DMAX=.311  
DSCA=17.1



1 NITROGEN EXHAUST 2" SCH-40S

```
/PREP7
/TIT NITROGEN EXHAUST 2" SCH-40S
MPTEMP,1,75,144,200,294
MPDATA,EX,1,1,30.4E6,29.9E6,29.4E6,28.3E6
ALPX,1,1.309E-5
TREF,300
TUNIF,77
CSYS,1
PSPEC,1,2,10S
BRANCH,1,96.444,63.364,0
RUN,0,0,-11.35
RUN,0,-15.277,0,4
BEND,,,2
RUN,0,0,-47.463,8
BEND,,,2
RUN,10.547,7.946,0,3
BEND,,,2
RUN,0,0,-6
BEND,,,2
PSPEC,1,2,40S
RUN,-8.991,-4.902,0,2
BEND,,,2
RUN,0,-42.931,0,8
BEND,,,3
RUN,0,0,-19,4
BEND,,,3
RUN,0,61.348,0,24
BEND,,,3
RUN,0,0,7.0625
BEND,,,3
D,1,ALL
D,89,ALL
ITER,1,1
ACEL,,1
KRF,1
AFWR,,1
FINI
/INPUT,27
FINI
/POST1
SET,1,1
PRSTR
FINI
```



ANSYS )3  
AUG 3 1988  
10:33:25  
PLOT NO. 3  
POST1 DISPL.  
STEP=1  
ITER=1

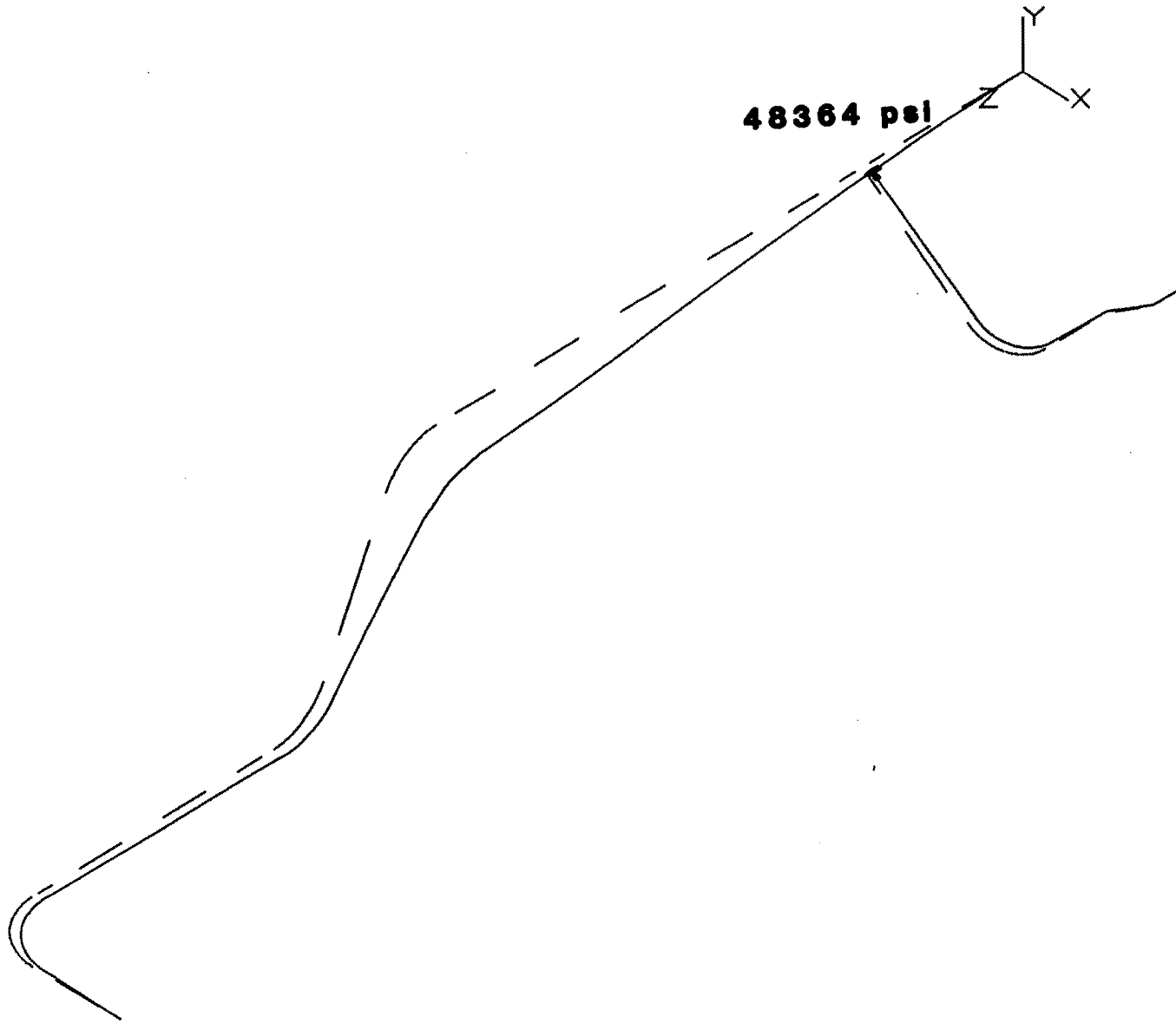
ORIG  
XV=-2  
YV=1  
ZV=1  
DIST=38.6  
XF=-35.6  
YF=80.1  
ZF=-.124  
DMAX=.194  
DSCA=19.9

1 LN2 C/D SUPPLY 1.5" SCH-40S

/PREP7  
/TIT, LN2 C/D SUPPLY 1.5" SCH-40S  
MPTEMP, 1, 75, 144, 200, 294  
MPDATA, EX, 1, 1, 30.4E6, 29.9E6, 29.4E6, 28.3E6  
ALPX, 1, 1.309E-5  
TREF, 300  
TUNIF, 77  
CSYS, 1  
PSPEC, 1, 1.5, 40S  
BRANCH, 1, 98, 76.818, 0  
RUN, 0, 16.16, 0, 7  
RUN, 0, 0, -21.750  
BEND, , , 2.25  
RUN, 0, 11.666, 0, 5  
BEND, , , 2.25  
RUN, 0, 0, 18  
BEND, , , 2.25  
RUN, 0, 3.043, 0  
BEND, , , 2.25  
RUN, 0, 3.095, 0  
RUN, 0, 0, -18  
BEND, , , 2.25  
RUN, 0, 11.577, 0, 5  
BEND, , , 2.25  
RUN, 0, 0, 20.6875, 5  
BEND, , , 2.25  
RUN, 0, 6.564, 0, 3  
BEND, , , 2.25  
RUN, 0, 0, -6.9375  
BEND, , , 2.25  
RUN, 9.825, 0, 0  
BEND, , , 2.25  
PSPEC, 1, 1.5, 10S  
RUN, 0, 4.782, 0  
BEND, , , 1.5  
RUN, -9.125, 5.297, 0, 3  
BEND, , , 1.5  
RUN, 0, 0, 46.8125, 10  
BEND, , , 1.5  
RUN, 0, -14.730, 0, 5  
BEND, , , 1.5  
RUN, 0, 0, -12, 3  
BEND, , , 1.5  
BRANCH, 28  
RUN, 0, 0, 3.75  
TEE, , , , 1.3, 1.3, 1.3  
RUN, 0, -4.434, 0, 2  
BEND, , , 1.5  
D, 1, ALL  
D, 111, ALL  
D, 121, ALL  
ITER, 1, 1  
ACEL, , 1  
KRF, 1  
AFWR, , 1  
FINI  
/INPUT, 27  
FINI  
/POST1  
SET, 1, 1  
PRSTR  
FINI

ANSYS 3  
AUG 3 1988  
9:46:00  
PLOT NO. 1  
POST1 DISPL.  
STEP=1  
ITER=1

ORIG  
XV=1  
YV=1  
ZV=1  
DIST=31.6  
XF=5.82  
YF=-6.47  
ZF=35.6  
DMAX=.182  
DSCA=17.3



1 AR/N2 VENT MANIFOLD 4" SCH-10S

/PREP7  
/TIT,AR/N2 VENT MANIFOLD 4" SCH-10S  
MPTEMP,1,75,144,200,294  
MPDATA,EX,1,1,30.4E6,29.9E6,29.4E6,28.3E6  
ALPX,1,1.309E-5  
TREF,300  
TUNIF,77  
PSPEC,1,3,10S  
BRANCH,1,0,0,0  
RUN,0,0,11.06,2  
RUN,0,0,24.155,4  
PSPEC,1,4,10S  
RUN,0,0,7.685  
RUN,0,-12.9362,6.750  
BEND,,,4  
RUN,0,0,23.1,4  
BEND,,,4  
RUN,10,0,0  
BEND,,,4  
PSPEC,1,3,10S  
BRANCH,3  
RUN,9.75,-7,0  
TEE,,,,,2,2,2  
RUN,0,0,-6.9975  
BEND,,,3  
RUN,1.1908,0,-2.0625  
RUN,0,0,-2  
D,1,ALL  
D,22,ALL  
D,37,ALL  
ITER,1,1  
ACEL,,1  
KRF,1  
AFWR,,1  
FINI  
/INPUT,27  
FINI  
/POST1  
SET,1,1  
PRSTR  
FINI