52-001

October 14, 1992

Shou-Nien Hou 7F21
U.S Nuclear Regulatory Commission
1155 Rockville Pike
Rockville, MD 20852

Dear Shou:

Enclosed are modified responses to the Piping Design Audit open items A-6 and A-26. Also included are the calculational summary for the SRV-quencher and pedestal weld stress analysis corresponding to open item A-4. In addition, a response is provided for SER item 5.18.

The remainder of the outstanding responses, with the exception of the open item A-18, should be available for transmittal to you next week. We are awaiting the piping environmental fatigue methodology for which Dave indicated the staff will take the lead.

If you have any questions, please call me (408-925-4824) or Maryann Herzog (408-925-1921).

Sincerely,

Jack Fox

Jack N. Fox
Advanced Reactor Programs

cc: Chet Poslusny (NRC)
Giuliano DeGrassi (BNL)



D050

A-4

GE-NE
ABWR PROGRAM
MECHANICAL SYSTEM DESIGN
FILE MH-A

DISTRIBUTION:
JBK,JW,EOS

DATE : OCTOBER 5, 1992

TO : M HERZOG
✓JACK N FOX

FROM : Henry Hwang

SUBJECT . SRV-QUENCHER AND PEDESTAL WELD STRESS ANALYSIS
(Response to NRC/BNL audit comment)

**1.0 INTRODUCTION**

The quencher hub and the pedestal welded region have been analyzed using ANSYS program. The configuration of the analysis model is shown in Figures 1 and 2. The analysis has two purposes. The first purpose is to calculate the effect of the SRV blowdown transient. The second purpose is to calculate the effect of the geometrical discontinuity at the quencher hub and the pedestal weld.

Since the SRV blowdown transient is the major temperature transient and has the major contribution to the fatigue usage factor. The quencher hub has the most severe effect due to the transient. The reason is that the hub is thicker than wetwell piping. Wetwell piping has more severe transient than drywell piping because stainless pipe has smaller thermal conductivity.

It is important to note that lug attachment should not be used for all the SRV pipings, otherwise, Code Case N-122 should be used for the detailed fatigue analysis which includes the thermal transient analysis of the pipe with the lug.

**2.0 HEAT TRANSFER ANALYSIS**

The heat transfer transient during relief valve blowdown create temperature transient with step change from 20 deg. C (68 F) to 166 deg. C (330 deg F) inside the quencher. At the outside of the quencher the water temperature is assumed to be the same as the air temperature of 20 deg. C. The transients are plotted in the figure below.

Figure 3a : Temperature transients.

The application of the heat transfer transients to the surface is shown in the figure below:

Figure 3b : Heat transfer surfaces

The heat transfer coefficients inside the quencher is calculated as follow:

assume V=100 ft

```
   Re = 100 (ft/sec) x 2 (ft) /(1.06E-5 sq ft/sec)
      = 1.88E7
   Pr = 6.82
   h1 = 0.023(k/D) (Re)**0.8*(Pr)**0.33
      = 0.023(0.347/2) (1.88E7)**0.8 (6.82)**0.33
      = 0.023(0.173) (659669) (1.895)
      = 4975 use 5000 btu/(hr-ft^2-F)
```

h2 for outside surface:

Assume V=2.5 ft/sec

```
 (h2 Do/kf)  = 1.1 (C) Pr**0.31 (VD/vis)**n

   Re = 2.5 (ft/sec) x 2 (ft) /(1.06E-5 sq ft/sec)
      = 4.7E5
   Pr = 6.82
   C  = 0.0239 for Re = 40000 to 400,000
   n  = 0.805

   h2 = (k/D) (1.1) (0.0239) 6.82**0.31 * 470000**0.805
      = (0.173) (1.1) (0.0239) (1.81) (378350)
      = 3123 btu/hr/ft^2 F
```

Inside natural convection heated surface face downward

```
    hL/k = 0.27(Gr PR)**0.25

   h3 = (0.347/2) * (0.27)*(3460,000*250*2**3 * 6.82)**0.25
      = (0.174) (0.27)*(466)
      = 21.89 btu/hr-ft^2-deg F
```

The heat transfer outside the quencher:

Assume the water flow outside the pool is 2.5 ft/sec

```
 h2 = 1.1 (k/D) C Pr**0.31(VD/mu)**n

   n  = 0.805
   C  = 0.0239
   Pr = 6.82
```

Substitute the values gives hc = 3123 Btu/hr-ft^2-F

The natural convection inside the pedestal is as follows:

```
 h3 = 0.27(k/L) (Gr Pr)**0.25
    = 21.89 btu/hr-ft**2-F
```

The boundary condition of the quencher is considered to be the most severe condition in the SRV discharge system. The reason is that the water outside the quencher has cooling effect and the steam inside has heating effect.

The results of the analysis is shown in the following figures:

Figure 4 : Temperature distribution. degree C
(at time 1.00 min. after SRV blowdown)

Figure 5 : Temperature distribution through section A-A
(nodes 66-115, 1.00 min after SRV blowdown)

Figure 6 : Temperature distribution. degree C
(at time 2.00 min. after SRV blowdown)

Figure 7 : Temperature distribution through section A-A
(nodes 66-115, 2.00 min after SRV blowdown)

Figure 8 : Temperature distribution through section B-B
(nodes 149-144, 2.00 min after SRV blowdown)

Figure 9 : Temperature distribution. degree C
(at time 3.00 min. after SRV blowdown)

Figure 10 : Temperature distribution through section A-A
(nodes 66-115, 3.00 min after SRV blowdown)

Figure 11 : Temperature distribution through section B-B
(nodes 149-144, 3.00 min after SRV blowdown)

## 3.0 STRESS ANALYSIS AND FATIGUE ANALYSIS

ANSYS program STIFF 42 axi-symmetric element is used for the stress analysis for all the temperature distributeion at 1.0, 2.0 and 3.0 minutes after SRV blowdown. The calculation of mechanical load input to the analysis are as follows:

Mechanical load calculations

```
quencher hub Ro = 304.8 mm
              t =  55.1 mm
             Ri = 249.7 mm
             ID =      4
             OD =
             Ai = 19   79 mm sq
```

**a) Pressure Load:**

```
(P)(Ai) = (0.38)(195878)
        = 74,434 kg
     Fp = 23,693 kg/rad
```

Force is distributed among Nodes,186,187,188,189,190,191

```
Fp,187,188,189,190 = 23,693/5
                   = 4,739 lb

Fp, 186,191        = 2,370 lb
```

**b) 10 ton-meter unit moment load :**

```
R avg = 277.25 mm
I     = (3.1416/4) (304.8^4-249.7^4)
      = 3.725E9
Z     = 3.725E9/304.8
      = 12.22E06

Sb = M/Z
   = 1000000/12.22E6
   = 0.08182 kg/mm^2

A metal = 3.1416(304.8^2 - 249.7^2)
        = 95985 mm^2

Force per radian =  0.08182 x (95985/6.2832)
                 =  1250 kg/rad for 1 m-t moment
```

The input value is to 10 m-t as unit load input

```
Fp,187,188,189,190 = 10(m-t) x 1250/5
                   = 2,500 lb/node-radian

Fp, 186,191        = 1.250 lb
```

**c) Shear load 10 ton unit load**

10 ton as unit load input

Fp,187,188,189,190 = 10,000/(6.2832 x 5)
= 318 lb/node-radian

Fp, 186,191 = 159 lb lb

The pressure load, unit moment and unit force loads have also been calculated for load combinations. The stress intensity calculation are performed in accordance with ASME Section NB-3214 procedures. NB-3216.2 fatig analysis procedures are used for Fatigue analysis.

**d) Apply Load**

The forces and moments due to thermal expansion is used for the fatigue analysis. It is conservative to combine torsion to the bending moment and the axial force to shear force for the finite element model. The shear force and moment due to thermal expansion are as follows:

Force = 10 tons
Moment = 6 meter-tons

The foeces and moments for the primary load combinations are as follows. These forces and moments are obtained from calculated results of one line. Enveloping process for all the line has not been performed.

| | Force(tons) | Moment(m-t) |
|---|---|---|
| Design | 10.0 | 1.0 |
| Upset | 30.0 | 25.0 |
| Level C | 30.0 | 25.0 |
| Level D | 30.0 | 40.0 |

## 4.0 RESULTS

Thermal transient due to blowdown, pressure, external forces and moments for each service level have been included in the analyses. The results are tabulated below:

| | | Node | Calc'd Value (kg/mm^2) | Allowable (kg/mm^2) |
|---|---|---|---|---|
| Primary membrane | Maximum | 150 | 1.7 | 10.3 |
| | Weld | 61 | 1.0 | 10.3 |
| Primary membrane plus bending | Maximum | 150 | 4.6 | 15.5 |
| | Weld | 66 | 3.4 | 15.5 |

Fatigue usage for quencher with low-low set SRV valve has 3064x1.5=4596 valve actuations for 60 years. These quenchers without low-low set SRV valve has 264x1.5=396 valve actuations for 60 years.

| | | Node | pcps | Usage Calc'd | Allowable Usage |
|---|---|---|---|---|---|
| Fatigue usage (with low-low set) | Maximum | 144 | 4596 | 0.5380 | 1.0 |
| | Weld | 61 | 4596 | 0.0180 | 1.0 |
| Fatigue usage (with out low-low set) | Maximum | 144 | 396 | 0.0470 | 1.0 |
| | Weld | 61 | 396 | 0.0016 | 1.0 |

The attached Table 5-1 and 5-2 show the detailed results at various nodes for reference. The usage factors tabulated in Tables 5-2 are for these quenchers with 1800 valve actuation.

In general the fatigue usage factor due to the blowdown transient at the inside surface of the hub are higher than the weld which is at the outside surface. The stress intensification factor used in the analysis for the weld is 2.4, which is conservative because the finite element analysis results has included stress concentration due to geometry change. A factor of 1.1 was used for all other locations for conservatism.

## 5.0 CONCLUSION

The fatigue usage factor inside surface is higner than the outside surface of the quencher.

If the thermal expansion moment at the quencher is less than 6 m-t and the number of valve actuations is less a than 4596 the fatigue usage factor will be less than 0.60.

The fatigue usage factor for other locations of the safety relief valve discharge piping depends on the expansion moment and are not covered by this analysis.

TABLE 5-1 PRIMARY STRESS INTENSITY

| Parts | Point | Material | Combination | Limits | Primary Membrane Intensity | Primary Membrane Limits | Primary Membrane Evaluation | Primary Memb+Bend Intensity | Primary Memb+Bend Limits | Primary Memb+Bend Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|
| ABWR-SRV N150 | N150 1 | | Design | DESGN | 1.7 | 10.3 | N150- | 2.3 | 15.5 | N150- |
| | | | Operation II | OCCAS | 1.7 | 10.3 | N150- | 4.6 | 15.5 | N150- |
| | | | Operation III | IIIAS | 1.7 | 15.5 | N150- | 4.6 | 23.2 | N150- |
| | | | Operation IV | IVAS | 1.7 | 21.6 | N150- | 5.9 | 32.4 | N150- |
| ABWR-QUEN N155 | N155 1 | | Design | DESGN | 1.7 | 10.3 | N155- | 1.4 | 15.5 | N155- |
| | | | Operation II | OCCAS | 1.7 | 10.3 | N155- | 3.1 | 15.5 | N155- |
| | | | Operation III | IIIAS | 1.7 | 15.5 | N155- | 3.1 | 23.2 | N155- |
| | | | Operation IV | IVAS | 1.7 | 21.6 | N155- | 4.4 | 32.4 | N155- |
| ABWR-QUEN N144 | N144 1 | | Design | DESGN | 1.6 | 10.3 | N144- | 2.1 | 15.5 | N144- |
| | | | Operation II | OCCAS | 1.6 | 10.3 | N144- | 4.2 | 15.5 | N144- |
| | | | Operation III | IIIAS | 1.6 | 15.5 | N144- | 4.2 | 23.2 | N144- |
| | | | Operation IV | IVAS | 1.6 | 21.6 | N144- | 5.3 | 32.4 | N144- |
| ABWR-QUEN N149 | N149 1 | | Design | DESGN | 1.6 | 10.3 | N149- | 1.3 | 15.5 | N149- |
| | | | Operation II | OCCAS | 1.6 | 10.3 | N149- | 3.1 | 15.5 | N149- |
| | | | Operation III | IIIAS | 1.6 | 15.5 | N149- | 3.1 | 23.2 | N149- |
| | | | Operation IV | IVAS | 1.6 | 21.6 | N149- | 4.3 | 32.4 | N149- |
| ABWR-QUEN N138 | N138 1 | | Design | DESGN | 1.5 | 10.3 | N138- | 1.9 | 15.5 | N138- |
| | | | Operation II | OCCAS | 1.5 | 10.3 | N138- | 3.8 | 15.5 | N138- |
| | | | Operation III | IIIAS | 1.5 | 15.5 | N138- | 3.8 | 23.2 | N138- |
| | | | Operation IV | IVAS | 1.5 | 21.6 | N138- | 5.0 | 32.4 | N138- |
| ABWR-QUEN N211 | N211 1 | | Design | DESGN | 1.5 | 10.3 | N211- | 1.2 | 15.5 | N211- |
| | | | Operation II | OCCAS | 1.5 | 10.3 | N211- | 2.9 | 15.5 | N211- |
| | | | Operation III | IIIAS | 1.5 | 15.5 | N211- | 2.9 | 23.2 | N211- |
| | | | Operation IV | IVAS | 1.5 | 21.6 | N211- | 4.1 | 32.4 | N211- |
| ABWR-QUEN N132 | N132 1 | | Design | DESGN | 1.3 | 10.3 | N132- | 1.8 | 15.5 | N132- |
| | | | Operation II | OCCAS | 1.3 | 10.3 | N132- | 3.5 | 15.5 | N132- |
| | | | Operation III | IIIAS | 1.3 | 15.5 | N132- | 3.5 | 23.2 | N132- |
| | | | Operation IV | IVAS | 1.3 | 21.6 | N132- | 4.5 | 32.4 | N132- |

TABLE 5.1 PRIMARY STRESS INTENSITY

| Parts | Point | Material | Combination | Limits | Primary Membrane Intensity | Primary Membrane Limits | Primary Membrane Evaluation | Primary Memb+Bend Intensity | Primary Memb+Bend Limits | Primary Memb+Bend Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|
| | N206 | | Design | DESGN | 1.3 | 10.3 | N206- | 1.0 | 15.5 | N206- |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 1.3 | 10.3 | N206 | 2.6 | 15.5 | N206- |
| N206 | | | Operation III | IIIAS | 1.3 | 15.5 | N206 | 2.6 | 23.2 | N206 |
| | | | Operation IV | IVAS | 1.3 | 21.6 | N206 | 3.7 | 32.4 | N206 |
| | N120 | | Design | DESGN | 1.0 | 10.3 | N120- | 1.8 | 15.5 | N120- |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 1.0 | 10.3 | N120 | 2.3 | 15.5 | N120- |
| N120 | | | Operation III | IIIAS | 1.0 | 15.5 | N120 | 2.3 | 23.2 | N120- |
| | | | Operation IV | IVAS | 1.0 | 21.6 | N120- | 2.6 | 32.4 | N120- |
| | N125 | | Design | DESGN | 1.0 | 10.3 | N125- | 0.5 | 15.5 | N125- |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 1.0 | 10.3 | N125 | 1.2 | 15.5 | N125 |
| N125 | | | Operation III | IIIAS | 1.0 | 15.5 | N125- | 1.2 | 23.2 | N125- |
| | | | Operation IV | IVAS | 1.0 | 21.6 | N125- | 1.6 | 32.4 | N125 |
| | N115 | | Design | DESGN | 1.0 | 10.3 | N115- | 1.7 | 15.5 | N115 |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 1.0 | 10.3 | N115- | 2.0 | 15.5 | N115- |
| N115 | | | Operation III | IIIAS | 1.0 | 15.5 | N115- | 2.0 | 23.2 | N115 |
| | | | Operation IV | IVAS | 1.0 | 21.6 | N115- | 2.2 | 32.4 | N115 |
| | N 61 | | Design | DESGN | 1.0 | 10.3 | N 61- | 0.1 | 15.5 | N 61- |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 1.0 | 10.3 | N 61- | 0.8 | 15.5 | N 61- |
| N 61 | | | Operation III | IIIAS | 1.0 | 15.5 | N 61- | 0.8 | 23.2 | N 61 |
| | | | Operation IV | IVAS | 1.0 | 21.6 | N 61- | 1.1 | 32.4 | N 61 |
| | N109 | | Design | DESGN | 0.9 | 10.3 | N109- | 1.6 | 15.5 | N109 |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 0.9 | 10.3 | N109- | 1.6 | 15.5 | N109- |
| N109 | | | Operation III | IIIAS | 0.9 | 15.5 | N109 | 1.6 | 23.2 | N109 |
| | | | Operation IV | IVAS | 0.9 | 21.6 | N109- | 1.7 | 32.4 | N109- |
| | N114 | | Design | DESGN | 0.9 | 10.3 | N114- | 0.3 | 15.5 | N114- |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 0.9 | 10.3 | N114- | 0.4 | 15.5 | N114 |
| N114 | | | Operation III | IIIAS | 0.9 | 15.5 | N114- | 0.4 | 23.2 | N114- |
| | | | Operation IV | IVAS | 0.9 | 21.6 | N114- | 0.6 | 32.4 | N114- |

TABLE 5-1 PRIMARY STRESS INTENSITY

| Parts | Point | Material | Combination | Limits | Primary Membrane Intensity | Primary Membrane Limits | Primary Membrane Evaluation | Primary Memb+Bend Intensity | Primary Memb+Bend Limits | Primary Memb+Bend Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|
| ABWR-QUEN N125 | N125 1 | | Design | DESGN | 1 0 | 10 3 | N125- | 1 1 | 15 5 | N125- |
| | | | Operation II | OCCAS | 1 0 | 10 3 | N125- | 3 4 | 15 5 | N125 |
| | | | Operation III | IIIAS | 1 0 | 15 5 | N125 | 3 4 | 23 2 | N125 |
| | | | Operation IV | IVAS | 1 0 | 21 6 | N125 | 2 9 | 32 4 | N125 |
| ABWR-QUEN N196 | N196 1 | | Design | DESGN | 1 0 | 10 3 | N196- | [illegible] 2 | 15 5 | N196- |
| | | | Operation II | OCCAS | 1 0 | 10 3 | N196 | [illegible] 5 | 15 5 | N196 |
| | | | Operation III | IIIAS | 1 0 | 15 5 | N196 | [illegible] 5 | 23 2 | N196 |
| | | | Operation IV | IVAS | 1 0 | 21 6 | N196- | 5 0 | 32 4 | N196- |
| ABWR-QUEN N 61 | N 61 1 | | Design | DESGN | 1 0 | 10 3 | N 61 | 1 1 | 15 5 | N 61 |
| | | | Operation II | OCCAS | 1 0 | 10 3 | N 61 | 3 4 | 15 5 | N 61 |
| | | | Operation III | IIIAS | 1 0 | 15 5 | N 61- | 3 4 | 23 2 | N 61- |
| | | | Operation IV | IVAS | 1 0 | 21 6 | N 61- | 4 8 | 32 4 | N 61- |
| [illegible]-QUEN [illegible] | N 66 1 | | Design | DESGN | 1 0 | 10 3 | N 66 | 1 1 | 15 5 | N 66 |
| | | | Operation II | OCCAS | 1 0 | 10 3 | N 66- | 3 4 | 15 5 | N 66- |
| | | | Operation III | IIIAS | 1 0 | 15 5 | N 66 | 3 4 | 23 2 | N 66 |
| | | | Operation IV | IVAS | 1 0 | 21 6 | N 66 | 4 8 | 32 4 | N 66 |
| ABWR-QUEN N 55 | N 55 1 | | Design | DESGN | 0 9 | 10 3 | N 55- | 1 2 | 15 5 | N 55- |
| | | | Operation II | OCCAS | 0 9 | 10 3 | N 55 | 3 4 | 15 5 | N 55 |
| | | | Operation III | IIIAS | 0 9 | 15 5 | N 55 | 3 4 | 23 2 | N 55 |
| | | | Operation IV | IVAS | 0 9 | 21 6 | N 55 | 4 8 | 32 4 | N 55 |
| ABWR-QUEN N 60 | N 60 1 | | Design | DESGN | 0 9 | 10 3 | N 60- | 0 8 | 15 5 | N 60- |
| | | | Operation II | OCCAS | 0 9 | 10 3 | N 60- | 3 1 | 15 5 | N 60 |
| | | | Operation III | IIIAS | 0 9 | 15 5 | N 60 | 3 1 | 23 2 | N 60 |
| | | | Operation IV | IVAS | 0 9 | 21 6 | N 60- | 4 5 | 32 4 | N 60- |
| ABWR-QUEN N001 | N001 1 | | Design | DESGN | 0 6 | 10 3 | N001- | 0 5 | 15 5 | N001 |
| | | | Operation II | OCCAS | 0 6 | 10 3 | N001- | 1 9 | 15 5 | N001 |
| | | | Operation III | IIIAS | 0 6 | 15 5 | N001- | 1 9 | 23 2 | N001- |
| | | | Operation IV | IVAS | 0 6 | 21 6 | N001- | 2 8 | 32 4 | N001- |

TABLE 5-1 PRIMARY STRESS INTENSITY

| Parts | Point | Material | Combination | Limits | Primary Membrane Intensity | Primary Membrane Limits | Primary Membrane Evaluation | Primary Memb+Bend Intensity | Primary Memb+Bend Limits | Primary Memb+Bend Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|
| | N006 | | Design | DESGN | 0.6 | 10.3 | N006- | 0.7 | 15.5 | N006- |
| ABWR-QUEN | 1 | | Operation II | OCCAS | 0.6 | 10.3 | N006- | 2.2 | 15.5 | N006- |
| N006 | | | Operation III | IIIAS | 0.6 | 15.5 | N006 | 2.2 | 23.2 | N006- |
| | | | Operation IV | IVAS | 0.6 | 21.6 | N006 | 3.3 | 32.4 | N006 |

TABLE 5-2 PRIMARY PLUS SECONDARY STRESS INTENSITY RANGE + FATIGUE

| | | | | Primary+Secondary stress | | | | Fatigue Analysis | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parts | Point | Material | Combination | Limits | Intensity | Limits | Evaluation | Usage Fac | Limits | Evaluation |
| ABWR-SRV-N150 | N150 1 | | Operation IA, IIA | I&IIA | 37.4 | 30.9 | N150- | 0.105 | 1.000 | N150- |
| ABWR-QUEN N155 | N155 1 | | Operation IA, IIA | I&IIA | 33.2 | 30.9 | N155- | 0.005 | 1.000 | N155- |
| ABWR-QUEN N144 | N144 1 | | Operation IA, IIA | I&IIA | 38.3 | 30.9 | N144- | 0.211 | 1.000 | N144- |
| ABWR-QUEN N149 | N149 1 | | Operation IA, IIA | I&IIA | 27.1 | 30.9 | N149- | 0.003 | 1.000 | N149- |
| ABWR-QUEN N138 | N138 1 | | Operation IA, IIA | I&IIA | 36.0 | 30.9 | N138- | 0.110 | 1.000 | N138- |
| ABWR-QUEN N211 | N211 1 | | Operation IA, IIA | I&IIA | 25.5 | 30.9 | N211- | 0.003 | 1.000 | N211- |
| ABWR-QUEN N132 | N132 1 | | Operation IA, IIA | I&IIA | 33.2 | 30.9 | N132- | 0.042 | 1.000 | N132- |
| ABWR-QUEN N206 | N206 1 | | Operation IA, IIA | I&IIA | 24.2 | 30.9 | N206- | 0.007 | 1.000 | N206- |

TABLE 5-2 PRIMARY PLUS SECONDARY STRESS INTENSITY RANGE + FATIGUE

| | | | | Primary+Secondary Stress | | | | Fatigue Analysis | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parts | Point | Material | Combination | Limits | Intensity | Limits | Evaluation | Usage Fac | Limits | Evaluation |
| ABWR-QUEN N120 | N120 1 | | Operation IA, IIA | I&IIA | 36 3 | 30 9 | N120 | 0 165 | 1 000 | N120 |
| ABWR-QUEN N125 | N125 1 | | Operation IA, IIA | I&IIA | 22 5 | 30 9 | N125 | 0 003 | 1 000 | N125 |
| ABWR-QUEN N115 | N115 1 | | Operation IA, IIA | I&IIA | 35 9 | 30 9 | N115 | 0 154 | 1 000 | N115 |
| ABWR-QUEN N 61 | N 61 1 | | Operation IA, II | I&IIA | 26 3 | 30 9 | N 61 | 0 007 | 1 000 | N 61 |
| ABWR-QUEN N109 | N109 1 | | Operation IA, IIA | I&IIA | 36 6 | 30 9 | N109 | 0 206 | 1 000 | N109 |
| ABWR-QUEN N114 | N114 1 | | Operation IA, IIA | I&IIA | 24 6 | 30 9 | N114 | 0 003 | 1 000 | N114 |
| ABWR-QUEN N125 | N125 1 | | Operation IA, IIA | I&IIA | 10 6 | 30 9 | N125 | 0 003 | 1 000 | N125 |
| ABWR-QUEN N196 | N196 1 | | Operation IA, IIA | I&IIA | 15 3 | 30 9 | N196 | 0 003 | 1 000 | N196 |

TABLE 5-2 PRIMARY PLUS SECONDARY STRESS INTENSITY RANGE - FATIGUE

| Parts | Point | Material | Combination | Limits | Primary+Secondary Stress Intensity | Primary+Secondary Stress Limits | Primary+Secondary Stress Evaluation | Fatigue Analysis Usage Fa | Fatigue Analysis Limits | Fatigue Analysis Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|
| ABWR-QUEN N 61 | N 61 | | Operation IA, IIA | I&IIA | 14.2 | 30.9 | N 61- | 0.003 | 1.000- | N 61- |
| ABWR-QUEN N 66 | N 66 1 | | Operation IA, IIA | I&IIA | 14.7 | 30.9 | N 66- | 0.003 | 1.000 | N 66- |
| ABWR-QUEN N 55 | N 55 1 | | Operation IA, IIA | I&IIA | 10.6 | 30.9 | N 55 | 0.003 | 1.000 | N [illegible] |
| ABWR-QUEN N 60 | N 60 1 | | Operation IA, IIA | I&IIA | 7.8 | 30.9 | N 60- | 0.003 | 1.000 | N 60- |
| ABWR-QUEN N001 | N001 1 | | Operation IA, IIA | I&IIA | 0.7 | 30.9 | N001- | 0.003 | 1.000 | N001- |
| ABWR-QUEN N006 | N006 1 | | Operation IA, IIA | I&IIA | 0.7 | 30.9 | N006- | 0.003 | 1.000 | N006 |

TABLE 9 MAXIMUM VALUE SORTING

| ELEM | DESGN M | ELEM | DESGN B | ELEM | OP IV-M | ELEM | OP IV-B | ELEM | SN10 | ELEM | SN13 | ELEM | USAG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 1.7 | 150 | 2.3 | 150 | 1.7 | 150 | 5.9 | 144 | 38.3 | 144 | 38.3 | 144 | 0.2106 |
| 155 | 1.7 | 144 | 2.1 | 155 | 1.7 | 144 | 5.3 | 150 | 37.4 | 150 | 37.4 | 109 | 0.2064 |
| 144 | 1.6 | 138 | 1.9 | 144 | 1.6 | 138 | 5.0 | 109 | 36.6 | 109 | 36.6 | 120 | 0.1649 |
| 149 | 1.6 | 132 | 1.8 | 149 | 1.6 | 196 | 5.0 | 120 | 36.3 | 120 | 36.3 | 115 | 0.1543 |
| 138 | 1.5 | 120 | 1.8 | 138 | 1.5 | 125 | 4.9 | 138 | 36.0 | 138 | 36.0 | 138 | 0.1100 |
| 211 | 1.5 | 115 | 1.7 | 211 | 1.5 | 55 | 4.8 | 115 | 35.9 | 115 | 35.9 | 150 | 0.1055 |
| 132 | 1.3 | 109 | 1.6 | 132 | 1.3 | 61 | 4.8 | 155 | 33.2 | 155 | 33.2 | 132 | 0.0417 |
| 206 | 1.3 | 155 | 1.4 | 206 | 1.3 | 66 | 4.8 | 132 | 33.2 | 132 | 33.2 | 61 | 0.0070 |
| 120 | 1.0 | 149 | 1.3 | 120 | 1.0 | 132 | 4.5 | 149 | 27.1 | 149 | 27.1 | 155 | 0.0051 |
| 125 | 1.0 | 211 | 1.2 | 125 | 1.0 | 60 | 4.5 | 61 | 26.3 | 61 | 26.3 | 125 | 0.0032 |
| 115 | 1.0 | 196 | 1.2 | 115 | 1.0 | 155 | 4.4 | 211 | 25.5 | 211 | 25.5 | 149 | 0.0032 |
| 61 | 1.0 | 55 | 1.2 | 61 | 1.0 | 149 | 4.3 | 114 | 24.6 | 114 | 24.6 | 206 | 0.0032 |
| 125 | 1.0 | 61 | 1.1 | 125 | 1.0 | 211 | 4.1 | 206 | 24.2 | 206 | 24.2 | 211 | 0.0032 |
| 196 | 1.0 | 66 | 1.1 | 196 | 1.0 | 206 | 3.7 | 125 | 22.5 | 125 | 22.5 | 114 | 0.0032 |
| 61 | 1.0 | 125 | 1.1 | 61 | 1.0 | 6 | 3.1 | 196 | 15.3 | 196 | 15.3 | 125 | 0.0032 |
| 66 | 1.0 | 206 | 1.0 | 66 | 1.0 | 1 | 2.8 | 66 | 14.7 | 66 | 14.7 | 196 | 0.0032 |
| 55 | 0.9 | 60 | 0.8 | 55 | 0.9 | 120 | 2.6 | 61 | 14.2 | 61 | 14.2 | 61 | 0.0032 |
| 60 | 0.9 | 6 | 0.7 | 60 | 0.9 | 115 | 2.2 | 125 | 10.6 | 125 | 10.6 | 66 | 0.0032 |
| 109 | 0.9 | 1 | 0.5 | 109 | 0.9 | 109 | 1.7 | 55 | 10.6 | 55 | 10.6 | 55 | 0.0032 |
| 114 | 0.9 | 125 | 0.5 | 114 | 0.9 | 125 | 1.6 | 60 | 7.8 | 60 | 7.8 | 60 | 0.0032 |
| 1 | 0.6 | 61 | 0.3 | 1 | 0.6 | 61 | 1.1 | 1 | 0.7 | 1 | 0.7 | 1 | 0.0032 |
| 6 | 0.6 | 114 | 0.3 | 6 | 0.6 | 114 | 0.6 | 6 | 0.7 | 6 | 0.7 | 6 | 0.0032 |

TABLE ? MAXIMUM VALUE SORTING

| ELEM | OP-11-M | ELEM | OP-11-B | ELEM | OP-03-M | ELEM | OP-03-B | ELEM | OP V M | ELEM | OP V B | ELEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 1.7 | 150 | 4.6 | 150 | 1.7 | 150 | 4.6 | 150 | 0.0 | 150 | 0.0 | |
| 155 | 1.7 | 144 | 4.2 | 155 | 1.7 | 144 | 4.2 | 155 | 0.0 | 155 | 0.0 | |
| 144 | 1.6 | 138 | 3.8 | 144 | 1.6 | 138 | 3.8 | 144 | 0.0 | 144 | 0.0 | |
| 149 | 1.6 | 196 | 3.5 | 149 | 1.6 | 196 | 3.5 | 149 | 0.0 | 149 | 0.0 | |
| 138 | 1.5 | 132 | 3.5 | 138 | 1.5 | 132 | 3.5 | 138 | 0.0 | 138 | 0.0 | |
| 211 | 1.5 | 55 | 3.4 | 211 | 1.5 | 55 | 3.4 | 211 | 0.0 | 211 | 0.0 | |
| 132 | 1.3 | 125 | 3.4 | 132 | 1.3 | 125 | 3.4 | 132 | 0.0 | 132 | 0.0 | |
| 206 | 1.3 | 61 | 3.4 | 206 | 1.3 | 61 | 3.4 | 206 | 0.0 | 206 | 0.0 | |
| 120 | 1.0 | 66 | 3.4 | 120 | 1.0 | 66 | 3.4 | 120 | 0.0 | 120 | 0.0 | |
| 125 | 1.0 | 155 | 3.1 | 125 | 1.0 | 155 | 3.1 | 125 | 0.0 | 125 | 0.0 | |
| 115 | 1.0 | 60 | 3.1 | 115 | 1.0 | 60 | 3.1 | 115 | 0.0 | 115 | 0.0 | |
| 61 | 1.0 | 149 | 3.1 | 61 | 1.0 | 149 | 3.1 | 61 | 0.0 | 61 | 0.0 | |
| 125 | 1.0 | 211 | 2.9 | 125 | 1.0 | 211 | 2.9 | 109 | 0.0 | 109 | 0.0 | |
| 196 | 1.0 | 206 | 2.6 | 196 | 1.0 | 206 | 2.6 | 114 | 0.0 | 114 | 0.0 | |
| 61 | 1.0 | 120 | 2.3 | 61 | 1.0 | 120 | 2.3 | 125 | 0.0 | 125 | 0.0 | |
| 66 | 1.0 | 6 | 2.2 | 66 | 1.0 | 6 | 2.2 | 196 | 0.0 | 196 | 0.0 | |
| 55 | 0.9 | 115 | 2.0 | 55 | 0.9 | 115 | 2.0 | 61 | 0.0 | 61 | 0.0 | |
| 60 | 0.9 | 1 | 1.9 | 60 | 0.9 | 1 | 1.9 | 66 | 0.0 | 66 | 0.0 | |
| 109 | 0.9 | 109 | 1.6 | 109 | 0.9 | 109 | 1.6 | 55 | 0.0 | 55 | 0.0 | |
| 114 | 0.9 | 125 | 1.2 | 114 | 0.9 | 125 | 1.2 | 60 | 0.0 | 60 | 0.0 | |
| 1 | 0.6 | 61 | 0.8 | 1 | 0.6 | 61 | 0.8 | 1 | 0.0 | 1 | 0.0 | |
| 6 | 0.6 | 114 | 0.4 | 6 | 0.6 | 114 | 0.4 | 6 | 0.0 | 6 | 0.0 | |

SDRC I-DEAS 4.0: Pre/Post Processing 11-AUG-92 07:41:51

DATABASE: K-6/7 QUENCHER TO PEDESTAL WELD
VIEW : No stored VIEW
Task: Model Preparation
Model: 1-FE_MODEL1

UNITS : GM
DISPLAY : No stored OPTION
Associated Workset: 1-WORKING SET1

FIG. 1 QUENCHER MODEL

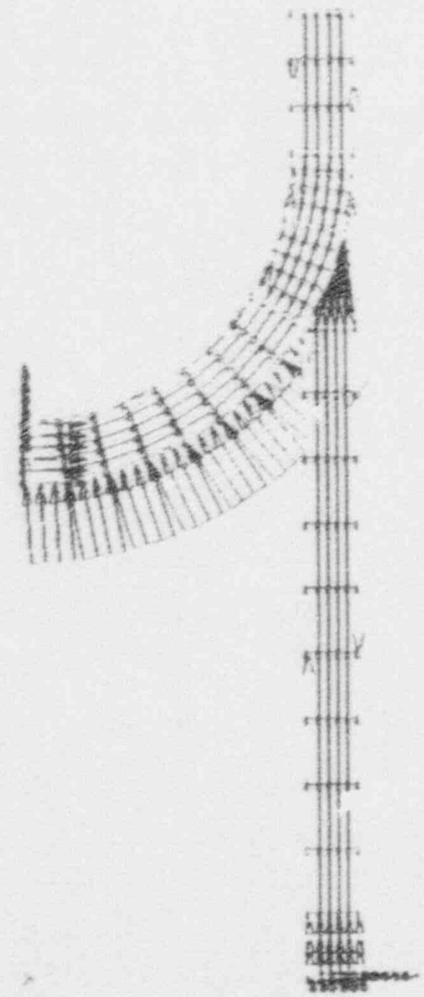
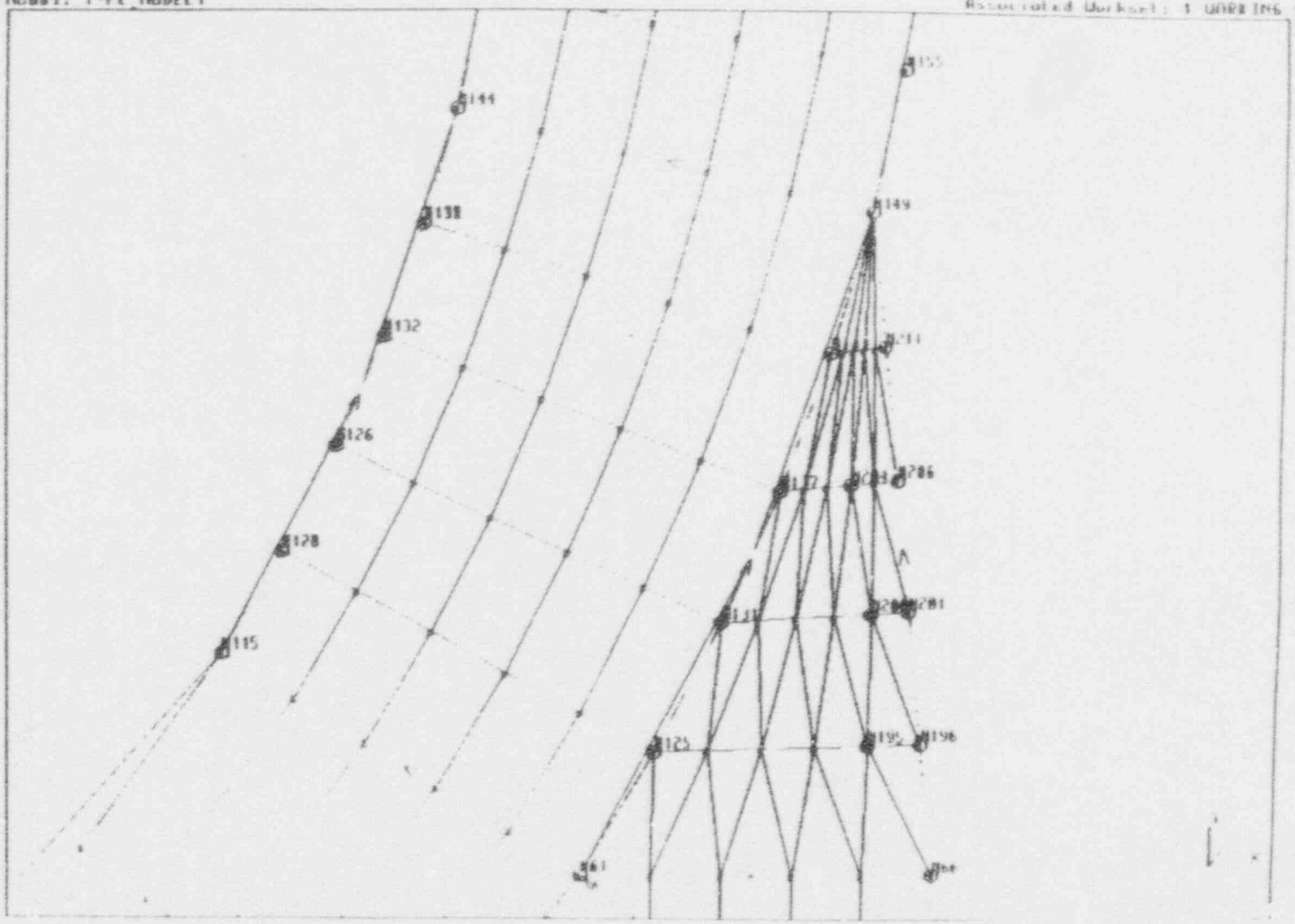


FIG. 2

SDRC I-DEAS 4.0: Pre/Post Processing 11 AUG 92 08:05:2?

DATABASE: K-6/7 QUENCHER TO PEDESTAL WELD
VIEW : No stored VIEW
Task: Model Preparation
Model: 1-FE MODEL1

UNITS : ?
DISPLAY : No stored OPTION
Associated Workset: 1 WORKING SET



NUMBER ______ DATE ______
SUBJECT ______ BY ______ SHEET ___ OF ___

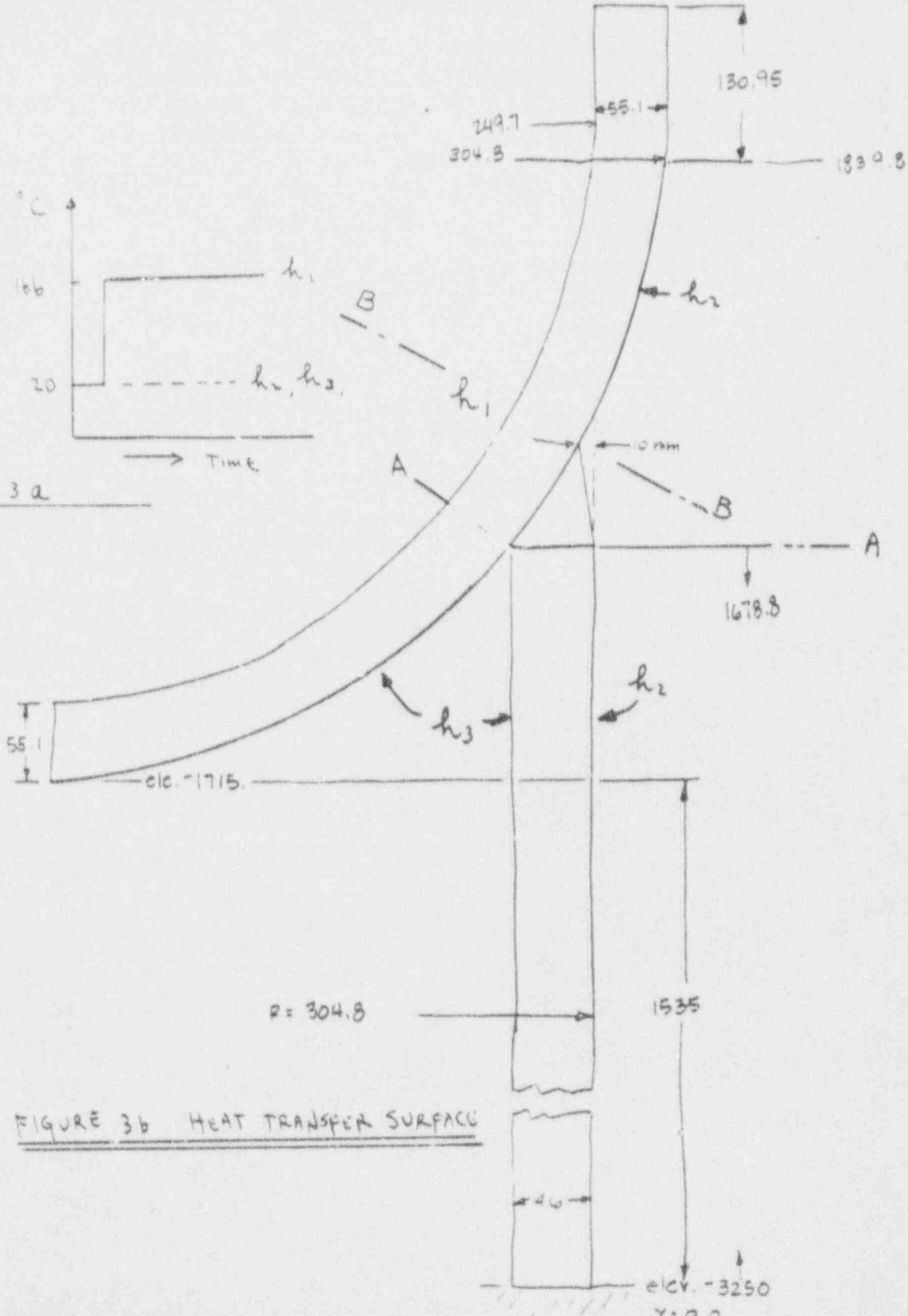



FIG. 3 a

FIGURE 3b HEAT TRANSFER SURFACE

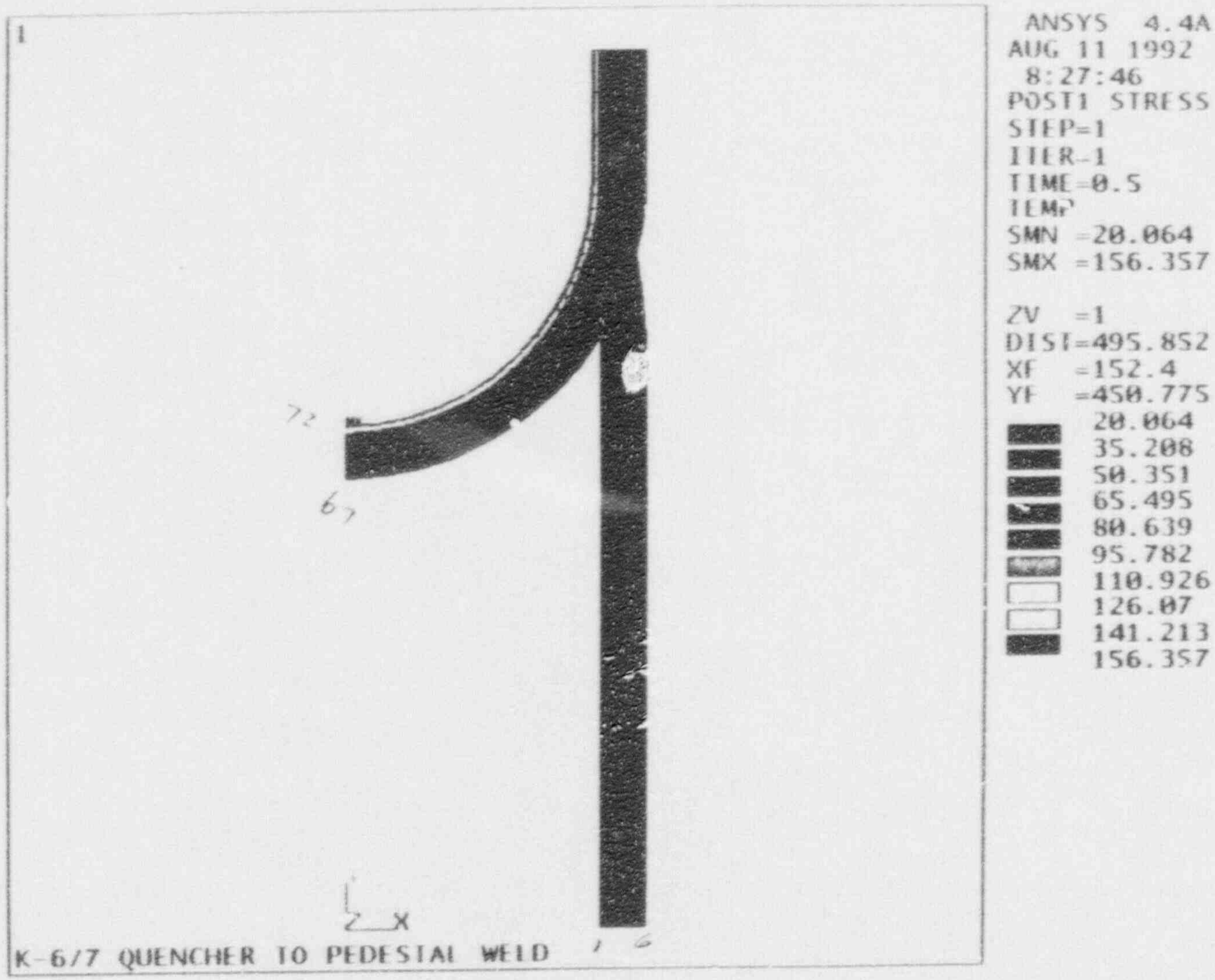



Figure 4 : Temperature distribution. degree C
(at time 1.00 min. after SRV blowdown)

19

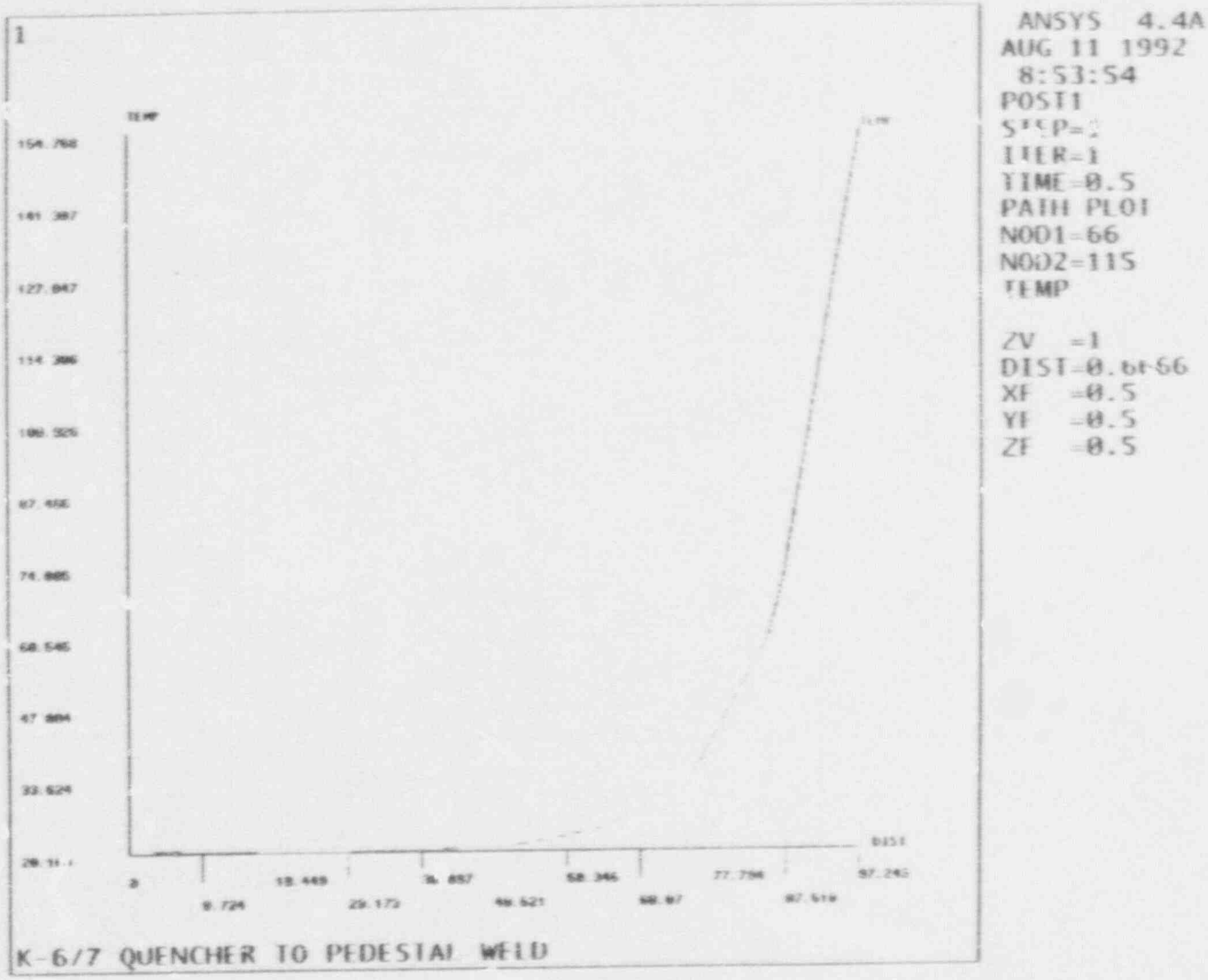



Figure 5 : Temperature distribution through section A-A
(nodes 66-115, 1.00 min after SRV blowdown)

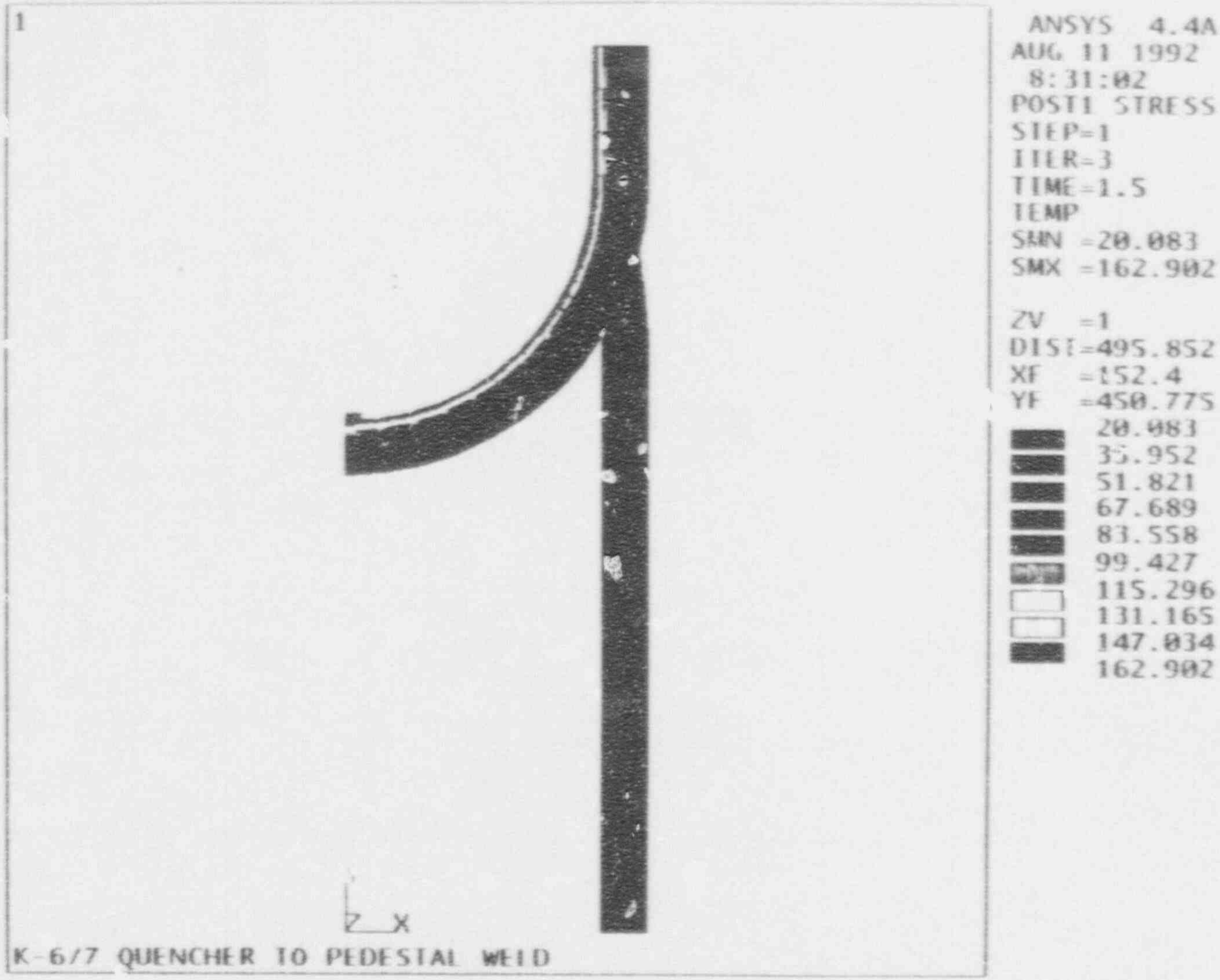



Figure 6 : Temperature distribution. degree C
(at time 2.00 min. after SRV blowdown)

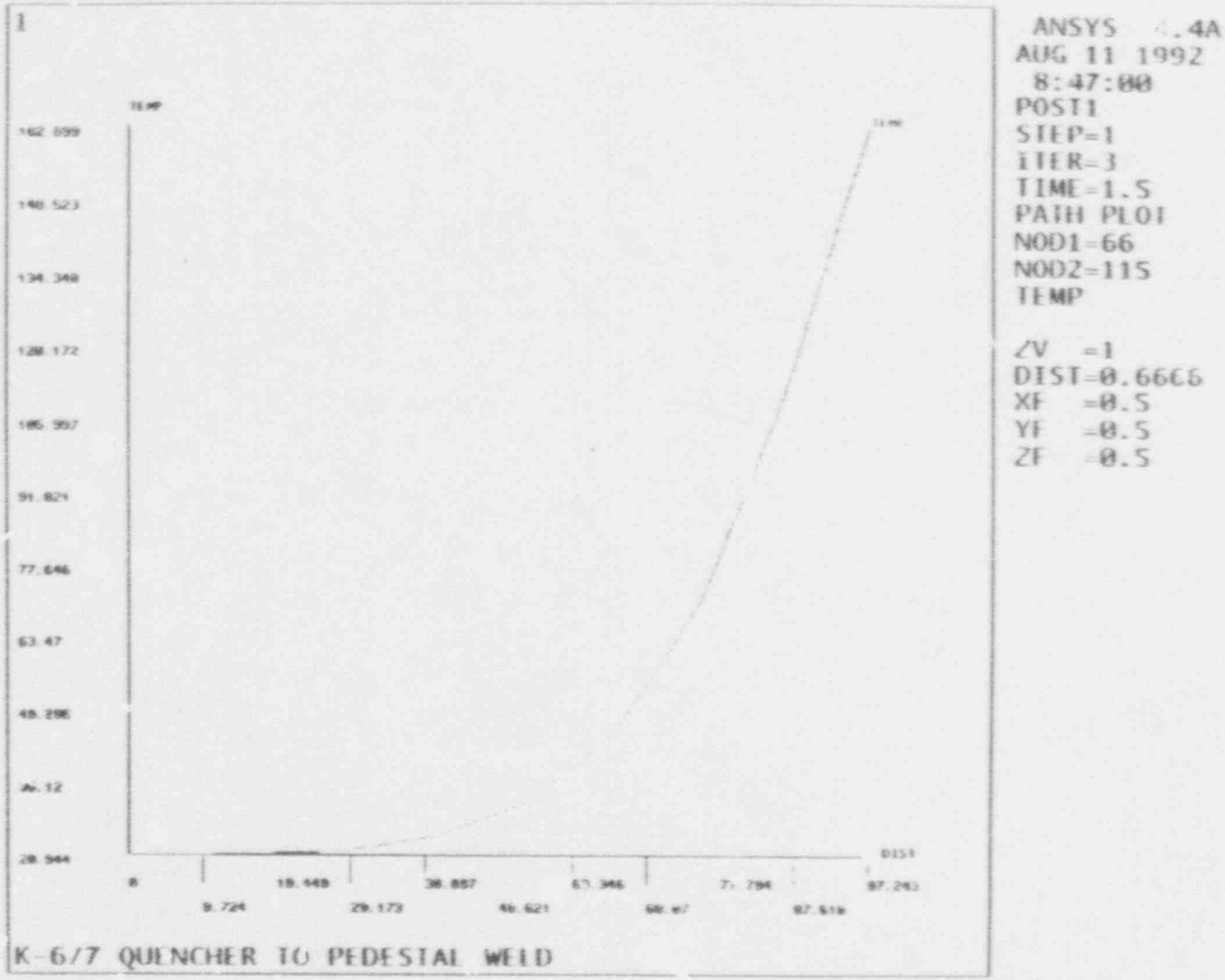



Figure 7 : Temperature distribution through section A-A
(nodes 66-115, 2.00 min after SRV blowdown)

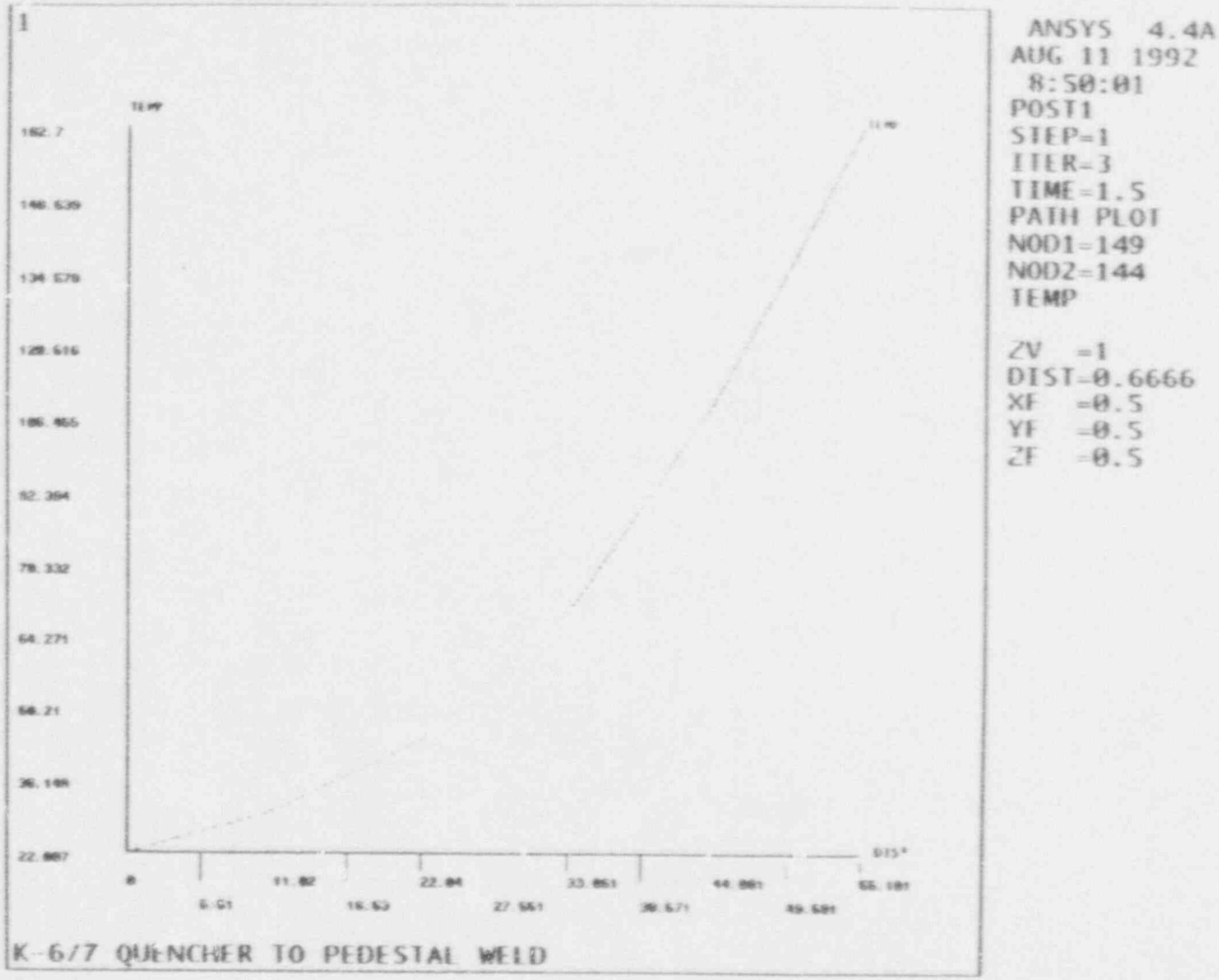



Figure 8 : Temperature distribution through section B-B (nodes 149-144, 2.00 min after SRV blowdown)

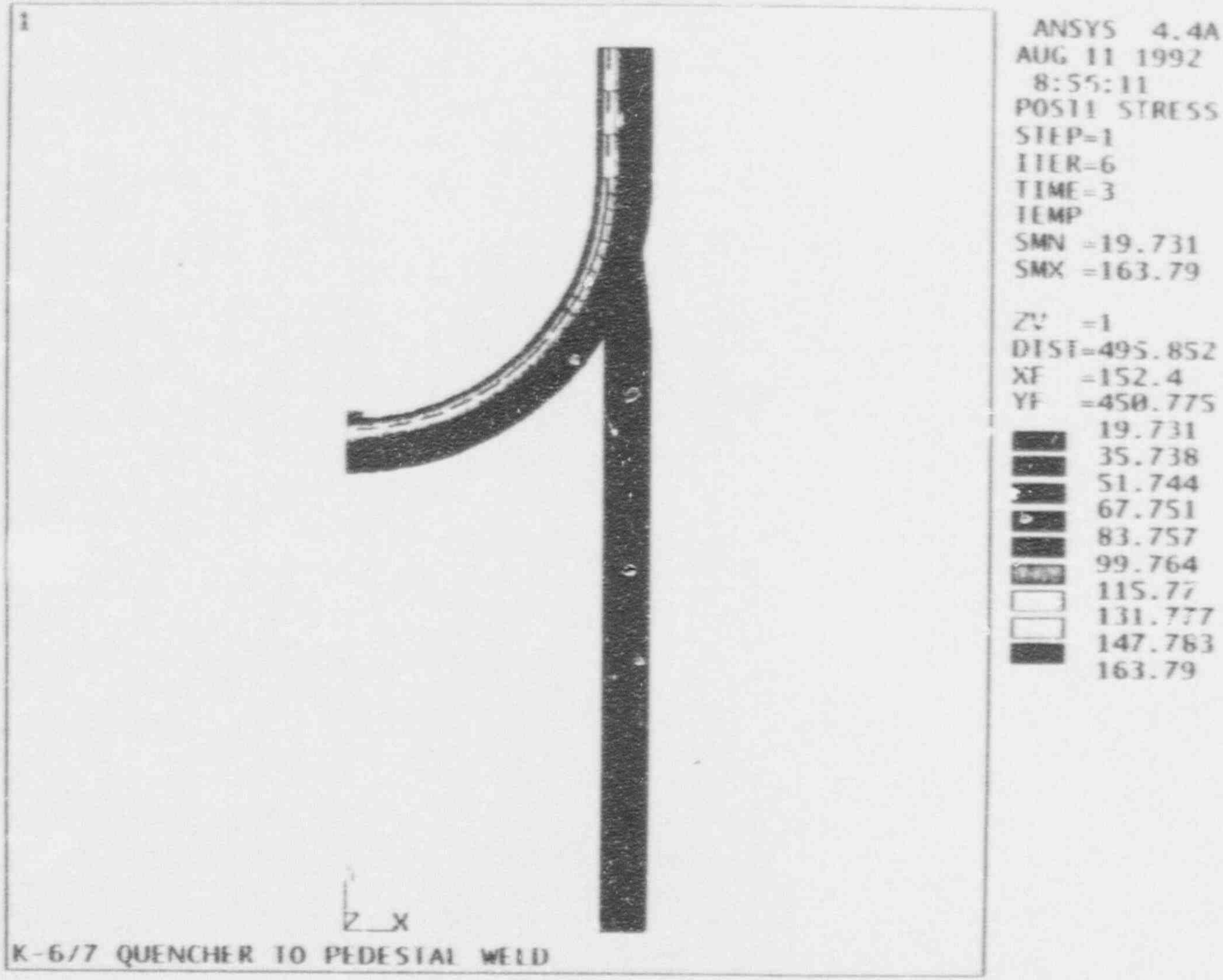



Figure 9 : Temperature distribution. degree C
(at time 3.00 min. after SRV blowdown)

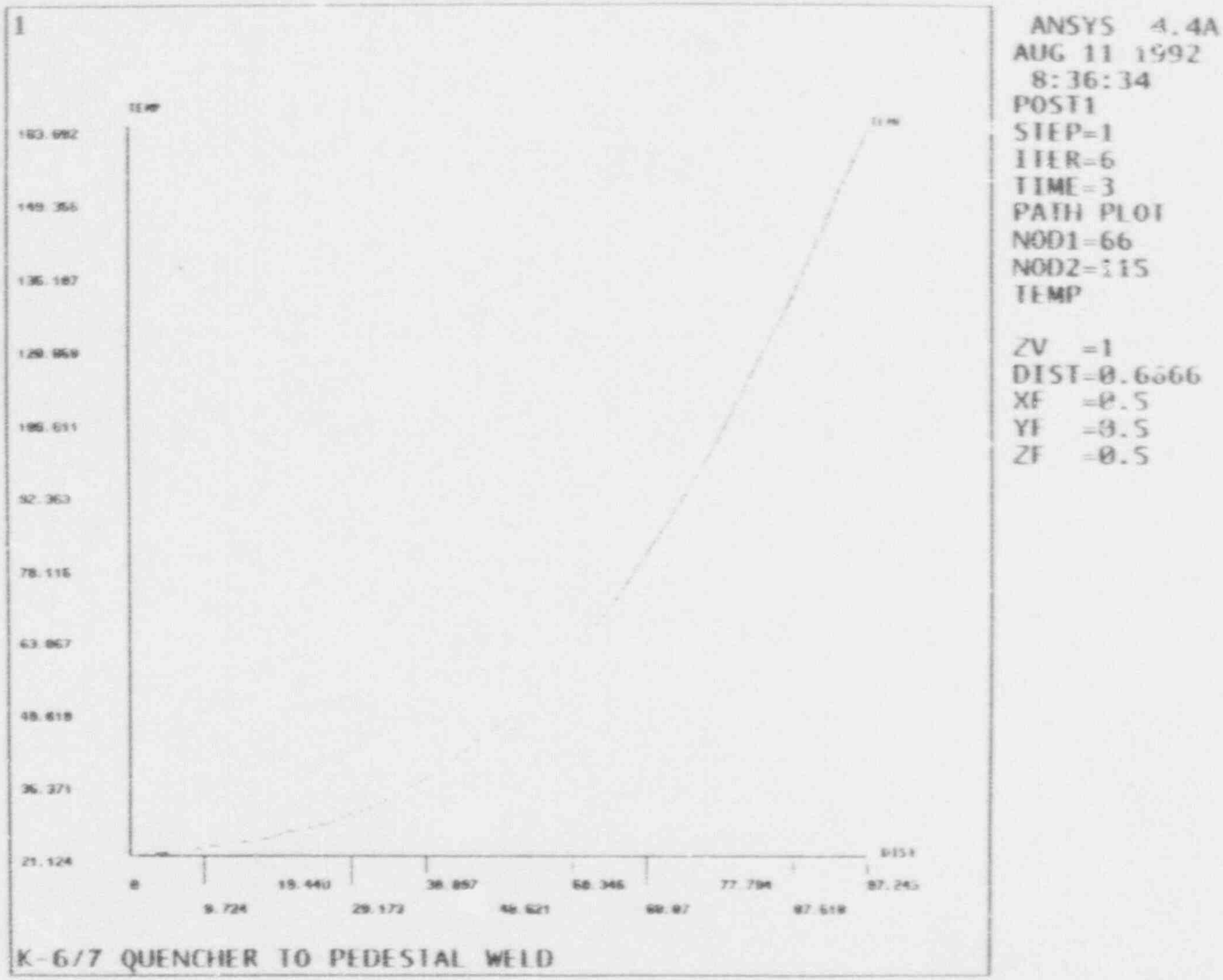



Figure 10 : Temperature distribution through section A-A
(nodes 66-115, 3.00 min after SRV blowdown)

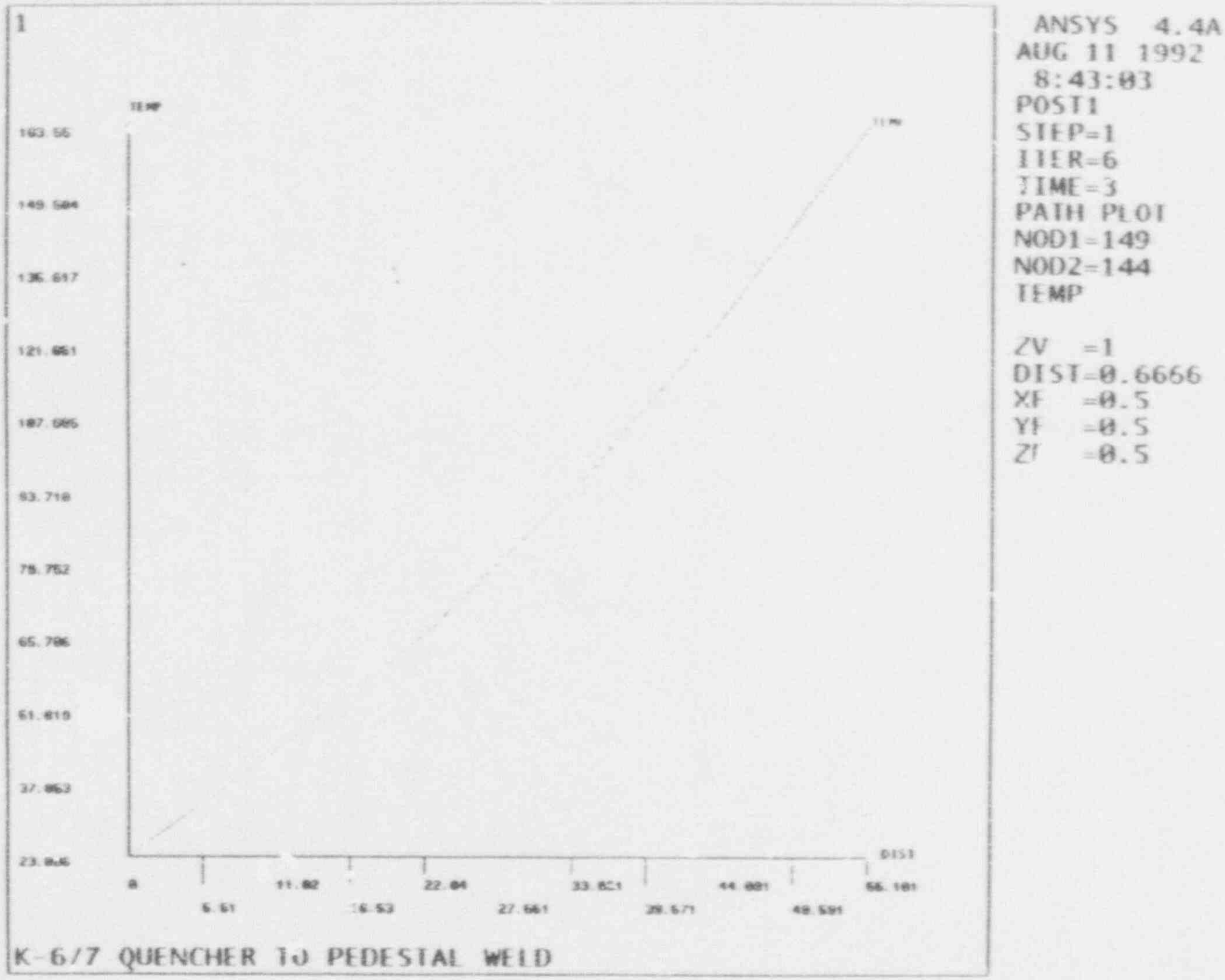



Figure 11 : Temperature distribution through section B-B
(nodes 149-144, 3.00 min after SRV blowdown)

the number of degrees of freedom are taken more than twice the number of modes with frequencies less than 33 Hz.

(2) Mass is lumped at any point where a significant concentrated weight is located (e.g., the motor in the analysis of pump motor stand, the impeller in the analysis of pump shaft, etc).

(3) If the equipment has free-end overhang span with flexibility significant compared to the center span, a mass is lumped at the overhang span.

(4) When a mass is lumped between two supports, it is located at a point where the maximum displacement is expected to occur. This tends to lower the natural frequencies of the equipment because the equipment frequencies are in the higher spectral range of the response spectra. Similarly, in the case of live loads (mobile) and a variable support stiffness, the location of the load and the magnitude of support stiffness are chosen to yield the lowest frequency content for the system. This ensures conservative dynamic loads since the equipment frequencies are such that the floor spectra peak is in the lower frequency range. If not, the model is adjusted to give more conservative results.

### 3.7.3.3.3 Field Location of Supports and Restraints

The field location of seismic supports and restraints for Seismic Category I piping and piping systems components is selected to satisfy the following two conditions:

(1) the location selected must furnish the required response to control strain within allowable limits; and

(2) adequate building strength and stiffness for attachment of the component supports must be available.

The final location of seismic supports and restraints for Seismic Category I piping, piping system components, and equipment, including the placement of snubbers, is checked against the drawings and instructions issued by the engineer. An additional examination of these supports and restraining devices is made to assure that their location and characteristics are consistent with the dynamic and static analyses of the system.

### *3.7.3.3.4 Analysis of Frame Type Pipe Supports*

*The design loads on frame type pipe supports include (a) loads transmitted to the support by the piping response to thermal expansion, dead weight, and the inertia and anchor motion effects, and (b) support internal loads caused by the weight, thermal and inertia effects of loads of the structure itself, and (c) friction loads caused by the pipe sliding on the support. To calculate the frictional force acting on the support, dynamic loads that are cyclic in nature need not be considered. ~~The coefficient of friction used will be static coefficients and~~ will be substantiated by actual test data covering the range of materials, geometry and loading condition. To determine the response of the support structure to applied dynamic loads, the equivalent static load method of analysis described in Paragraph 3.7.3.8.1.5 may be used. The loads transmitted to the support by the piping will be applied as static loads acting on the support.*

*As in the case of other supports, the forces the piping places on the frame-type support are obtained from an analysis of the piping. In the analysis of the piping the stiffness of the frame-type supports shall be included in the piping analysis model, unless the support can be shown to be rigid. The frame type supports may be modeled as rigid restraints providing they are designed so the maximum* Service Level D *deflection in the direction of the applied load is less than 1/16 inch and providing the total gap or diametrical clearance between the pipe and frame support is between 1/16" and 3/16" when the pipe is in either the hot or cold condition.* ← Add insert AA

### 3.7.3.4 Basis of Selection of Frequencies

Where practical, in order to avoid adverse resonance effects, equipment and components are designed/selected such that their fundamental frequencies are outside the range of 1/2 to twice the dominant frequency of the associated support structures. Moreover, in any case, the equipment is analyzed and/or tested to demonstrate that it is adequately designed for the applicable loads considering both its fundamental frequency and the forcing frequency of the applicable support structure.

210.27

## 3.7.3.12 Buried Seismic Category I Piping and Tunnels and Exterior Piping

All underground Category I piping systems are installed in tunnels. The following items are considered in the analysis:

(1) The inertial effects due to an earthquake upon underground systems and tunnels will be adequately accounted for in the analysis. In case of buried systems sufficiently flexible relative to the surrounding or underlying soil, it is assumed that the systems will follow essentially the displacements and deformations that the soil would have if the systems were absent. When applicable, procedures, which take into account the phenomena of wave travel and wave reflection in compacting soil displacements from the ground displacements, are employed.

(2) The design response spectra for the underground piping are the horizontal and vertical design spectra at the ground surface given in Figures 3.7-1 and 3.7-2. These design spectra are constructed in accordance with Regulatory Guide 1.60. The piping analysis is performed using one of the methods described in Subsection 3.7.3.1.

(3) When applicable, the effects due to local soil settlements, soil arching, etc., are also considered in the analysis.

3.7.3.12 (cont'd)

All above grade level Category I piping outside the Reactor building, Control building and the Turbine building is enclosed within structures. The design response spectra for this enclosed piping are the horizontal and vertical design spectra at the ground surface given in Figures 3.7-1 and 3.7-2. The piping analysis is performed using one of the methods described in Subsection 3.7.3.1.

New third para. in section 3.9.3.1

SER 5.18

Piping loads due to the thermal expansion of the piping and thermal anchor movements at supports are included in the piping load combinations. All operating modes are evaluated and the maximum moment ranges are included in the fatigue evaluation. Piping systems with maximum operating temperatures of less than or equal to 150°F are not required to be analyzed for thermal expansion loading.

SSAR page 3.9-18