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ATTACHMENT 2

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Revision 2

THE SIGNIFICANCE OF LACK OF PENETRATION/ LACK OF FUSION IN ASME CLASS 3 WELDS AT WATTS BAR NUCLEAR PLANT

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ABSTRACT

This report describes the results of analyses to determine the significance of lack of penetration (LOP) and lack of fusion (LOF) indications in ASME Class 3 welds at Tennessee Valley Authority's (TVA) Watts Bar Nuclear Plant.

Using a combined statistical and "worst-case" deterministic approach, it is shown that there is a better than 95% confidence that 95% of the affected weld population will meet the ASME Code acceptance criteria based on allowable stresses. The above analyses are based on fracture mechanics and limit load concepts and use as input data the upper bound flaw sizes, worst-case stresses, and Code-specified material properties (both carbon steel and stainless steel systems are affected).

The upper bound flaw size was established using a random sampling program to identify welds to be radiographed. The indication length data determined by radiography were supplemented by indication depth data derived from ultrasonic testing and destructive sectioning. A statistical analysis established that 95% of the population contained flaws with areas less than 18% of the section area. This was used as the bounding flaw size in the analysis. The confidence level for this bound was found to be 95%.

Worst-case stress data were established by reviewing TVA stress data for the systems which were anticipated to have the highest stresses. This resulted in a review of stress packages from two stainless steel systems and one carbon steel system. Stress data at highest stress locations (nodes) in the analyses were tabulated.

The analyses were performed using the above inputs to evaluate compliance with ASME Section III stress allowables for degraded pipe sections (due to LOP/LOF). Additionally structural integrity was assessed using the methods embodied in ASME Section XI.

These analyses included the highest stressed nodes and the bounding flaw size. In addition, the bounding flaw was placed at the worst location in the pipe section from the stress point of view. (This meant that the flaws were located in the positive part of the bending moment). Thus, the analysis method is conservative and resulted in 44 nodes that required further evaluation. Of the 44, only three required further radiography to ensure compliance with Code requirements. The remaining 41 were either previously radiographed or were not relevant welds.

It was concluded that there is high confidence (greater than 95%) that 95% of the affected welds will meet the design stress requirements.

A separate statistical analysis of welder attributes was performed to identity those welders that may have produced substandard workmanship. This analysis, along with further selective radiography, identified one substandard welder. All of the welds of this welder have been radiographed and, where necessary, corrective actions will be effected.

Section 1
INTRODUCTION

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code Section III requires that welds for all classes of nuclear construction meet certain standards. Several of these standards are for workmanship covering several weld discontinuities and lack of penetration (LOP) and lack of fusion (LOF). Class 1 and Class 2 fabrication and examination rules, embodied in Subsections NB/NC 4000 and 5000, specify radiographic examination (RT) for positive quality control of LOP/LOF. Class 3 fabrication and examination rules allow the owner a choice between surface examination or RT. By allowing a surface examination option for Class 3 construction, the code intends that the owner utilize adequate process control to minimize discontinuities such as LOP/LOF. Tennessee Valley Authority (TVA), Watts Bar Nuclear Plant (WBN) specified surface examination for its Class 3 welds.

Tennessee Valley Authority and the Nuclear Regulatory Commission (NRC) discovered ASME B&PV Code Section III, Class 3, piping welds with LOP and/or LOF at WBN. This report documents the results of a program to ascertain the extent of the problem and to demonstrate compliance with the ASME Code. In addition, methods to demonstrate suitability for service are described.

1.1 BACKGROUND

Tennessee Valley Authority previously conducted an extensive Weld Evaluation Project (WEP) reinspection to ensure the adequacy of welding at WBN. One issue addressed during the WEP was employee concerns regarding the potential for LOP/LOF. Ultrasonic testing (UT) of specifically implicated piping welds was used to determine that LOP/LOF was not a problem. Based on these results, the employee concerns were initially determined to be unfounded.

In July of 1990, an NRC inspection team checking for microbiologically-induced corrosion degradation radiographed welds in the essential raw cooling water (ERCW) system. Some of the welds checked by the NRC were those that were also evaluated during the WEP for LOP/LOF. The radiographs revealed LOP/LOF.

Subsequent additional RT by TVA and the NRC discovered LOP/LOF in systems other than the ERCW system.

Tennessee Valley Authority contracted with Aptech Engineering Services, Inc. (APTECH), to determine whether the ASME Class 3 allowables were satisfied for piping with LOP/LOF flaws and to determine the suitability for service of the Class 3 piping. This report describes the results of APTECH's work.

1.2 APPROACH

The objective of this project was to demonstrate by analysis that appropriate safety margins exist for the life of the plant for Class 3 piping with potential LOP/LOF weld imperfections. This was accomplished by two separate calculations that considered design basis loadings, including fatigue.

Calculation results are presented that demonstrate:

- Compliance to ASME Section III - Specifically that there is high confidence that the welds will meet the design stress allowables considering the maximum potential reduction in load carrying capacity due to LOP/LOF.
- Service suitability by structural integrity evaluations considering the behavior of the welds with LOP/LOF modeled as crack-like flaws.

There are two input parameters for these analyses - flaw size and stress. Given the large number of welds, a statistical approach was determined to be appropriate to establish the upper bounds on these parameters. The analysis strategy is outlined in further detail in Section 2.

Initially, the flaw data from the TVA and NRC examinations were reviewed, and these were augmented by further random samples. Flaw sizes were estimated very conservatively from inspections for each of 116 welds. These overstated flaw sizes were then treated with a statistical analysis to establish bounding values of flaw size in terms of flaw depths, flaw lengths, and flaw area based on the 95th percentile at 95% confidence. This "95-95" overstated flaw was modeled in each uninspected weld at the location that produces maximum reduction of load carrying capacity.

Next, stress data were reviewed for the highest stressed systems. Analyses were conducted for all affected piping sizes and materials utilizing worst-case stresses for each pipe size. The effect of LOP/LOF flaws on piping stresses was determined and compared with the stress requirements of ASME Section III. In addition, suitability-for-service calculations based on the methods embodied in ASME Section XI were performed.

A summary of the work performed on each task follows. The tasks are described in greater detail in subsequent sections of this report.

1.2.1 Task 1 - Review of Client Supplied Information

APTECH reviewed existing TVA nondestructive examination (NDE) data, stress data, and stress and fracture mechanics calculations to confirm WBN's initial assessment of the integrity of the ERCW system.

Previous work by EG&G (TVA's contractor for WEP) was also reviewed. It was determined that, due to differences in UT results on the ERCW welds, the potential existed for problems with other groups dispositioned by EG&G. The resolution of these issues is the subject of a separate report.

This task also included the development of two ASME Code interpretations which support the resolution strategy for this problem.

1.2.2 Task 2 - Development of Statistical Sample of Flaw Size

An upper bound flaw size was determined from a statistical random sample of welds developed by APTECH.

The WEP treated the population of all ASME Section III, B&PV welds as a homogeneous sample. However, since specific parameters of welding could affect the potential for LOP/LOF, we decided to test the hypotheses of homogeneity. The random sample was partitioned to assure coverage of base material, pipe diameter, pipe wall thickness, and other population variables. The hypothesis of homogeneity was determined to be conservative for the current problem.

Radiography was performed by TVA on the sample population to establish the extent of LOP/LOF. Indications were sized using UT procedures, radiographic imaging techniques, and limited destructive inspections. Physical limitations on flaw size from experience were considered. APTECH reviewed inspection procedures, summarized results of examinations, and determined an upper bound on flaw.size.

1.2.3 Task 3 - Development of Stress Data

In this task, maximum stress data were tabulated for all piping sizes and material combinations for the analyses. Four systems with anticipated worst loads (as determined from interviews with TVA piping analysis personnel) were selected for review.

Tennessee Valley Authority calculation packages were reviewed to identify those with the highest stresses for each piping size. Stress information was collected for the analysis at several of the nodes with the highest stresses in each of the selected calculation packages. Each node location may or may not correspond to a weld location and this was checked later in the program. Information required for subsequent analyses were tabulated.

1.2.4 Task 4 - Design and Flaw Evaluations

The analyses in this task perform two functions. The first is to evaluate compliance with the piping system design basis. The second is to determine whether the LOP/LOF flaws will have any impact on structural integrity or suitability for service.

Calculations using the maximum stress values identified above were made for each node that had a butt weld stress intensification factor, assuming a reduced net section due to the "95-95" overstated flaw. The reduced net section was determined by incorporating the maximum area loss as determined in Task 2. Compliance with the ASME Section III Code equations for Class 3 piping was determined for each relevant node by using these reduced areas and moments of inertia.

For all nodes checked with Section III equations, calculations were also made to determine flaw acceptability following the rules of ASME Section XI. Suitability for service was determined for design basis loadings including fatigue.

Individual nodes that failed the worst-case flaw analysis were identified. Those nodes that were determined to be within the scope of this project (e.g., TVA field welds, excluding those made with backing rings) were examined by TVA and the suitability for service was evaluated using actual flaw dimensions.

1.3 SCOPE

The ASME Class 3 piping at WBN ranges from ½ inch to 36 inches in outside diameter and is found in the following systems:

- Auxiliary feedwater
- Essential raw cooling water
- Component cooling
- Spent fuel cooling
- High pressure fire protection
- Control air
- Chemical volume and control
- Purge vent

APTECH determined the number of potentially affected welds in Unit 1 and common systems (required for licensing of Unit 1). A total of 7,120 welds were identified as ASME Class 3 including 3,908 stainless steel, 3,105 carbon steel, and 107 stainless steel to carbon steel welds.

Section 2
RESOLUTION STRATEGY

2.1 STRATEGY OVERVIEW

There are two distinct concerns that were addressed by APTECH in its evaluation of the significance of LOP/LOF. The first is whether the Class 3 piping at WBN complies with Section III of the ASME Code. The second is whether the flaws in the Class 3 piping have any impact on the structural integrity of the piping.

The primary aspect of Section III compliance is the presence of unacceptable indications in a piping system that has been previously accepted by a different inspection technique. The piping systems had been inspected by a surface inspection technique and were found acceptable, although subsequent volumetric inspection with radiography detected unacceptable indications. The ASME Code accounts for the possibility of undetected subsurface flaws when surface examination only is performed through the use of weld joint efficiency factors (Section III, Subparagraph NC-3611.1(a)(1) Ref. 2-1) that are less than unity for welds that do not receive a volumetric inspection. In order to ensure that this interpretation of the Code was correct, APTECH and TVA submitted the following two questions to Section III committee members to provide a Code interpretation:

Question 1: When an unacceptable indication is detected during a supplemental NDE of a piping weld (i.e., an examination performed for other than determination of Code acceptability) is it a requirement of the Code that the indication be repaired or removed if it is located in an area which was previously accepted by another permissible method of examination?

Reply 1: No.

Question 2: A Class 3 piping butt weld was accepted by the certificate holder and ANI based on the results of a permissible surface examination method in accordance with the code requirements. Subsequently, the weld was examined by radiography and found to have weld indications that would have been unacceptable if that method had been employed for acceptance of the weld in accordance with the subject code requirements (specifically, zones of incomplete fusion and penetration). Is it a requirement of the Code that the unacceptable radiographic indications be removed or repaired?

Reply 2: No.

The ASME code response (Item NI-90-41) is included in Ref. 2-2. The strategy for accepting the welds with LOP/LOF indications is to rely on these code interpretations and a structural integrity analysis to demonstrate that the welds are in compliance with Section III. The strategy for evaluating the impact of the LOP/LOF flaws on structural integrity is discussed below.

Nuclear piping design for Class 3 systems at WBN are governed by ASME Section III, Subsection ND (2-1). The ASME Class 3 piping criteria have been established to provide margin against failure under static loads encountered in normal service and dynamic loads associated with other events including low probability events such as earthquake. The design margins to be satisfied are embodied in the stress allowables provided in ASME Section III. Margins against fatigue failure, although not explicitly evaluated in Class 3 design, are handled in the Code rules in the evaluation of secondary stresses reducing the allowable stress range depending on the expected number of thermal expansion cycles. On this basis, the integrity of the piping design throughout the life of the piping system is assured at the start of operation.

Similarly, when flaws are detected during operation, ASME Section XI provides flaw evaluation rules for assessing the integrity of the piping and establishing the technical basis for continued operation. The margins against failure are demonstrated for the design basis loads as used in the original piping design employing fracture mechanics concepts. The Section XI flaw acceptance criteria contain appropriate safety factors for normal/upset and emergency/faulted loading conditions that are based on the original design safety margins from Section III. In addition, Section XI requires an evaluation of subcritical flaw growth to ensure that crack growth will not have an impact on structural integrity.

The presence of LOP/LOF in some Class 3 welds raises two integrity questions: will the net section properties of the weld, taking into account the area loss of the LOP/LOF, be sufficient to preserve the Code design safety margins, and will the fracture toughness and fatigue resistance properties of the weld be sufficient to prevent significant crack extension during service? The evaluation strategy, outlined in Figure 2-1, involves the definition of conservative bounding case LOP/LOF sizes and pipe stresses that can be used in the structural evaluation.

The bounding LOP/LOF size was based on a statistical evaluation of inspection data to define the largest LOP/LOF size in the population of Class 3 welds with a 95% probability of occurrence at 95% confidence. This statistical criterion is a reasonably conservative tolerance limit to use in establishing a bounding LOP/LOF size and has been previously used and accepted in the resolution of other weld review issues at WBN. Bounding stress values were determined from a review of calculation packages for three piping systems that were determined by TVA engineers to be more highly stressed than the other piping systems. Seventeen of the calculation packages with the highest stresses were selected for further review. Because the various acceptance criteria involve several different combinations of stresses, it is difficult to determine by observation which node(s) provide the bounding stresses for all of the acceptance criteria. To ensure that the bounding case was selected, several of the highest stressed nodes were tabulated for each pipe size and material for each calculation package. This results in a database of the most highly stressed nodes in the three piping systems.

Demonstrating the structural adequacy of the Class 3 piping in the as-built condition was based on showing both Code acceptance to Section III design stress allowables and Section XI flaw acceptance criteria. Because Section XI flaw evaluation methods cover only Class I piping, the rules in IWB-3640 and IWB-3650 were used as guidance in evaluating Class 3 pipe. Additional details of the analysis methods are provided later in Section 6.

2.2 ANALYTICAL REPRESENTATION OF WELD CONDITION

The LOP/LOF in Class 3 weldments has been observed in RT film to run intermittently around the inside circumference of the weld. Lack of fusion is a weld condition where either improper heat input or poor welder technique in start/stop positioning of the weld rod can cause poor fusion between the deposited weld metal and parent pipe. Lack of fusion can occur anywhere through the thickness whenever the above welding deficiencies occur in the weld pass. Lack of penetration is generally a root condition where the first weld pass does not completely penetrate to the inside diameter of the pipe because of low heat input, inadequate weld preparation, and poor welder technique.

Although the fundamental reasons for LOP or LOF can be different, from a structural integrity view point, they can be represented by the same analytical model. The loss in load carrying area from LOP/LOF is modelled by the geometry detail shown in Figure 2-2. The LOP/LOF is represented by a flaw in the weld metal with a normalized circumferential angle, θ/π, and with a normalized through-wall penetration of a/t (Figure 2-2). The bounding flaw size from Section 4 of this report is a statistically based bound of the flaw area and a separate statistical bound of the through-wall extent. The bounding circumferential extent of the LOP/LOF flaws is determined by dividing the normalized flaw area by the normalized flaw depth.

2.3 REFERENCES

2-1 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, "Rules for Construction of Nuclear Power Plant Components", Section III, Division 1, 1971 Edition Through the Summer 1973 Addenda. Subsection ND, "Class 3 Components", Article ND-3000, Subparagraph ND-3611 (Piping Design Acceptability) Refers to NC-3600 (TVA Watts Bar Nuclear Plant Code of Record for ASME Piping).

2-2 Letter, Christian Sanna, Assistant Secretary, Boiler and Pressure Vessel Committee, ASME, to Rodney Dail, APTECH, dated January 25, 1991, APTECH External Document E-43.

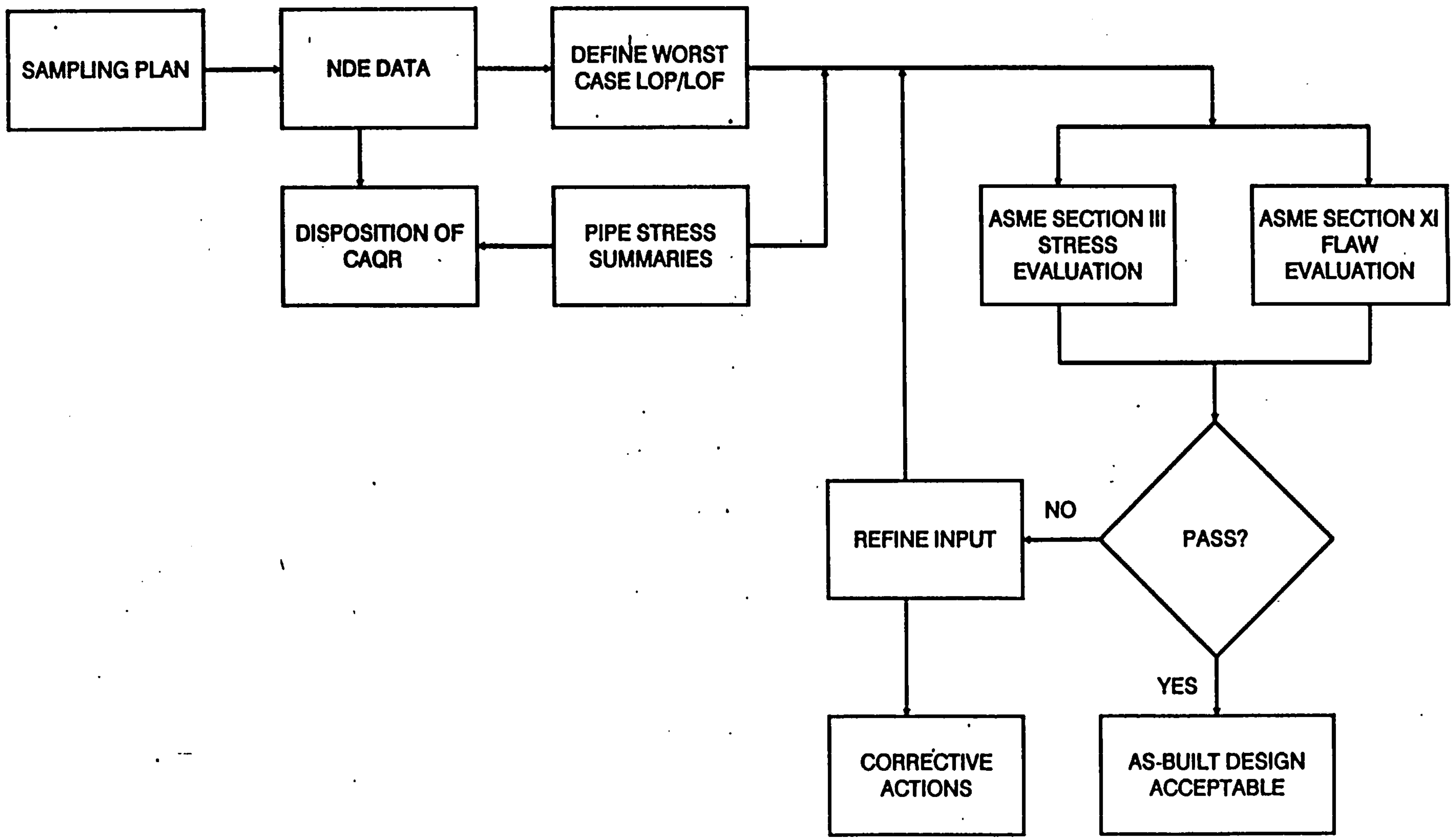

Figure 2-1 - Evaluation Strategy for LOP/LOF in Class 3 Welds.

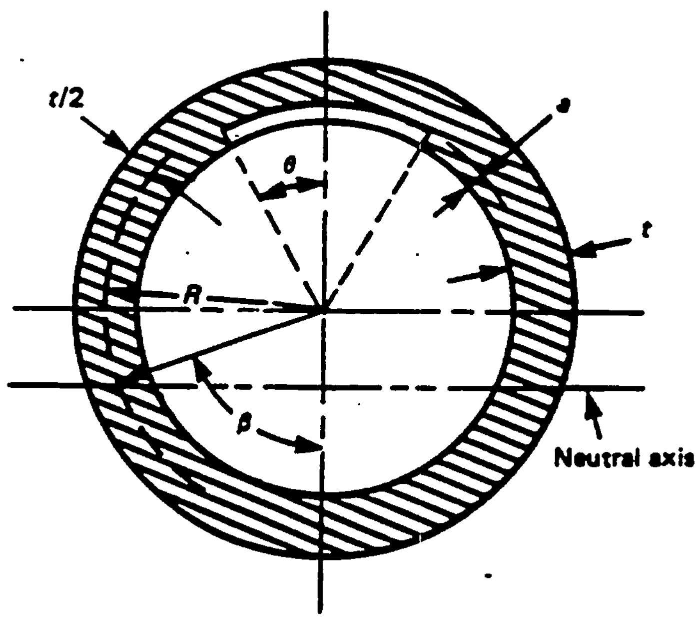

Figure 2-2 - Representation of LOP/LOF.

Section 3
ANALYSIS METHODS

In order to evaluate the significance of the LOP/LOF, the indications are evaluated based on strength (ASME Section III) and fracture (ASME Section XI) considerations. The Section III analysis addresses the existing design margins present when the LOP/LOF indications are taken into account. The Section XI evaluation addresses the potential for flaw growth and fracture during the life of the plant. Both of these approaches are discussed in detail in this section.

3.1 SECTION III ANALYSIS PROCEDURE

The TVA stress analyses are based on Eqs. 8 through 11 of ASME Section III, NC-3650 (3-1). These equations are reproduced below.

$$S_L = \frac{PD_o}{4t_n} + \frac{0.75IM_A}{Z} \leq 1.0S_h \quad (8)$$

$$S_{OL} = \frac{P_{max}D_o}{4t_n} + 0.75I\left(\frac{M_A + M_B}{Z}\right) \leq 1.2S_h \quad (9)$$

$$S_E = \frac{IM_C}{Z} \leq S_A \quad (10)$$

$$S_{TE} = \frac{PD_o}{4t_n} + 0.75I\left(\frac{M_A}{Z}\right) + I\left(\frac{M_C}{Z}\right) \leq (S_h + S_A) \quad (11)$$

where,

P = Internal design pressure, psi

P_{max} = Peak pressure, psi

D_o = Outside diameter of pipe, inches

t_n = Nominal pipe wall thickness, inches

M_A = Moment due to dead weight and other sustained loads, in-lb

M_B = Moment due to occasional loads, in-lb

M_C = Moment due to thermal expansion, in-lb

Z = Section modulus of pipe, in^3

i = Stress intensification factor

S_L = Stress due to sustained loads, psi

S_{OL} = Stress due to mechanical loads, psi

S_E = Stress due to thermal expansion, psi

S_{TE} = Stress due to pressure, dead weight and thermal expansion, psi

S_h = Basic material allowable stress (hot), psi

S_A = Allowable stress range for expansion stress, psi

The allowable stress range for expansion stress is defined as:

$$S_A = f(1.25S_c + 0.25S_h) \qquad (3\text{-}1)$$

where,

S_c = Basic material allowable stress (cold), psi

f = Stress range reduction factor.

The stress range reduction factor is determined from Table NC-3611.1(b)(3)-1 in Section III. For less than 7,000 cycles of thermal expansion, the factor f is equal to 1.0. Because the piping operates at relatively low temperatures, the hot and cold allowable stresses are assumed to be the same. Therefore,

$$S_A = f(1.25S_c + 0.25S_h) = 1.0(1.25S_h + 0.25S_h) = 1.5S_h \qquad (3\text{-}2)$$

Therefore, the right hand side of the inequalities in Eqs. 10 and 11 are $1.5S_h$ and $2.5S_h$ respectively.

In the resolution strategy discussed in Section 2, the LOP/LOF indication is statistically bounded on the basis of percent loss of area. It is also statistically bounded based on through-thickness extent (a/t). These bounds are described in detail in Section 4. Combining the two bounds results in a part-thickness flaw that extends around part of the circumference so that the total flaw area matches the bounding area.

The effect of loss of area is a linear increase in the axial stress, which is simply the pressure stress reaction divided by the pipe cross sectional area. The effect on bending stresses is nonlinear, as bending stress depends on the location of the centroid and the distribution of area around the centroid (i.e., the section modulus). The section modulus can be calculated for the geometry in Figure 3-1 using the following relations for a segment of a circle:

$$\text{Area} = r^2\alpha \qquad (3\text{-}3)$$

$$x_c = \frac{2}{3}\frac{r}{\alpha}\sin\alpha \qquad (3\text{-}4)$$

$$I_{yc} = \frac{r^4}{4}\left(\alpha + \frac{\sin 2\alpha}{2}\right) \qquad (3\text{-}5)$$

where α is half the included angle of the circular segment, x_c is the distance from the neutral axis to the center of the circle, and I_{yc} is the moment of inertia about the y axis (which goes through the center of the circle and not the neutral axis).

In order to evaluate the effect of the LOP/LOF on the total stress for each of the Code equations, the pressure and bending stress components must be separated. The summary of TVA stress analyses (3-2) provides the pressure stress and the ASME stress ratios for each of the four equations, except that Eq. 9 is evaluated for upset, emergency, and faulted conditions (denoted as Eqs. 9U, 9E, and 9F, respectively). The pressure stress is taken as the first term in Eqs. 8 and 11. The maximum pressure for the upset, emergency, and faulted conditions is assumed to be the design pressure. As a result, the first term in Eqs. 9U, 9E, and 9F is the same as the first term in Eqs. 8 and 11.

Therefore, the following process is used to calculate the Section III Code stress ratios for each equation:

1. The Code stress ratio is multiplied by the allowable stress for that equation to determine the magnitude of the stress.

2. The pressure stress is subtracted from the total stress to give the bending stress (except Eq. 10 where the pressure stress is not considered).

3. The pressure stress is divided by the ratio of the effective net section area with LOP/LOF to the nominal area, A'/A, to give the effective pressure stress.

4. The bending stress is divided by the ratio of the effective section modulus to the nominal section modulus, Z'/Z, to give the effective bending stress.

5. The effective pressure and bending stresses are combined.

6. The resulting total effective stress is divided by the allowable stress for that equation to give the effective stress ratio for each equation.

In addition to the Section III evaluation, a flaw evaluation is performed using the Section XI methodology. The Section XI procedure requires knowledge of three stress values:

P_m = Primary membrane stress at the flaw, ksi
P_b = Primary bending stress at the flaw, ksi
P_e = Pipe expansion stress, ksi

These values are determined from the as-designed stress ratios in Step 2 above. The value of P_m is assumed to be the same as the pressure stress term and the value of P_b is taken as the bending stress term, for Eq. 9 only. The Section XI procedure requires evaluation for two cases: normal/upset and emergency/faulted. No value is tabulated for normal conditions, so the upset condition stresses define the first case, whereas the greater of the emergency and faulted condition stresses defines the second case. The value of P_e is taken from Eq. 10.

3.2 FATIGUE ANALYSIS

Prior to performing a fracture evaluation, a fatigue evaluation must be performed for each flaw. The Section III methodology previously used assumes up to 7000 cycles of fatigue loading, so 7000 fatigue cycles are used here to conservatively account for fatigue crack growth. The crack growth per cycle is determined from:

$$da/dN = C\Delta K^m \tag{3-6}$$

where C and m are constants that depend on the material and environment, and ΔK is the cyclic range in the stress intensity factor, K. The methodology for calculating K is described later in the section on linear elastic fracture mechanics (LEFM). Appendix A of Section XI (3-3) provides guidance on the values of C and m for a water environment for carbon and low alloy steels. Neither Appendix C (3-4) (for austenitic piping) or Appendix H (3-5) (for ferritic piping) provides any guidance on the values to be used for surface flaws in piping. For ferritic material, the crack growth constants from Appendix A of Section XI are used, assuming an R-ratio (K_{min}/K_{max}) of 0.25. The ferritic crack growth constants used are:

$$C = 1.02 \times 10^{-12},\ m = 5.95 \text{ for } \Delta K < 19 \text{ ksi}\sqrt{\text{in}}$$
$$C = 1.01 \times 10^{-7},\ m = 1.95 \text{ for } \Delta K > 19 \text{ ksi}\sqrt{\text{in}}$$

where C and m are defined for units of ksi and inch. The constants for austenitic material were derived from Ref. (3-6):

$$C = 8.91 \times 10^{-11},\ m = 4.05$$

The cyclic loads are assumed to be the pressure stress and the expansion stress, as the bending stress is due to dead loads that do not cycle. The fatigue evaluation is performed by calculating ΔK for the assumed crack size and flaw geometry, determining da/dN from Eq. 3-6, and multiplying this by 100 cycles. The crack size is incremented in the through-thickness direction and the procedure is repeated a total of 70 times, for a total of 7000 cycles of loading. The flaw size at the end of the 7000 cycles is used as the basis for the flaw evaluation.

The flaw evaluation procedures in Section XI specify different procedures for austenitic and ferritic materials. Each of these procedures will be described below.

3.3 SECTION XI ANALYSIS PROCEDURE FOR AUSTENITIC MATERIALS

For austenitic materials that are not welded with a flux process the evaluation procedure is specified in Appendix C of Section XI (3-4) and is based solely on limit load considerations. For a circumferential flaw, the critical membrane and bending stresses, P_m' and P_b', corresponding to plastic collapse can be determined from:

$$P_b' = \frac{2}{\pi}\sigma_f\,[2\sin\beta - (a/t)\sin\theta] \qquad \text{(3-7A)}$$

where

$$\beta = \frac{1}{2}\left[(\pi - \theta\, a/t) - (P_m'/\sigma_f)\pi\right] \qquad \text{(3-8A)}$$

or, if $(\theta + \beta) > \pi$, then

$$P_b' = \frac{2}{\pi}\sigma_f\,[(2 - a/t)\sin\beta] \qquad \text{(3-7B)}$$

where

$$\beta = \frac{\pi\left[1 - a/t - P_m'/\sigma_f\right]}{[2 - a/t]} \qquad \text{(3-8B)}$$

The geometric variables for these equations are shown in Figure 2-2. The flow stress, σ_f, is assumed by the Code to be equal to $3S_m$.

Eq. 3-7 is solved iteratively with different crack sizes, assuming $P_m = P_m'$ until the critical bending stress, P_b', converges on the value:

$$P_b' = SF(P_m + P_b) - P_m \qquad \text{(3-9)}$$

where SF is the factor of safety (2.77 for normal and upset conditions or 1.39 for emergency and faulted conditions). The flaw size thus derived is the allowable flaw size for limit load failure in austenitic materials.

3.4 SECTION XI ANALYSIS PROCEDURE FOR FERRITIC MATERIALS

The evaluation procedure for ferritic materials is contained in Appendix H of Section XI (3-5) and is considerably more complex, as it includes elastic and elastic plastic failure criteria as well as limit load. In order to establish the correct failure criteria, a screening evaluation is performed.

3.4.1 Screening Procedure

For seamless or welded wrought carbon steel pipe operating on the material's lower shelf, the material toughness, J_{Ic}, is specified as 45 lb/in. The yield stress is specified as 27.3 ksi, and the flow stress is taken as $2.4S_m$. The screening criterion is the ratio of K'_r/S'_r, where

$$K_r = \left[\frac{1000K_I^2}{E'J_{Ic}}\right]^{0.5} \qquad (3\text{-}10)$$

and

$$S_r = \frac{P_b + P_e}{\sigma'_b} \qquad (3\text{-}11)$$

In Eq. 3-10, E' is the modulus of elasticity divided by $(1-\nu^2)$, where ν is Poisson's ratio. The stress intensity factor, K_I, is calculated from

$$K_I = K_{Im} + K_{Ib} \qquad (3\text{-}12)$$

where

$$K_{Im} = \left[\frac{P}{2\pi Rt}\right](\pi a)^{0.5}F_m$$

$$K_{Ib} = \left[\frac{M}{\pi R^2 t} + P_e\right](\pi a)^{0.5}F_b$$

and

$$F_m = 1.10 + x\left[0.15421 + 16.772(x\theta/\pi)^{0.855} - 14.944(x\theta/\pi)\right]$$

$$F_b = 1.10 + x\left[-0.09967 + 5.0057(x\theta/\pi)^{0.565} - 2.8329(x\theta/\pi)\right]$$

In these equations, $x = a/t$, θ/π = ratio of crack length to pipe inner circumference, and P and M are the applied axial load and bending moment, respectively.

In Eq. 3-11, the reference bending stress, σ'_b is calculated from

$$\sigma'_b = \frac{2\sigma_y}{\pi}\left[2\sin\beta - \frac{a}{t}\sin\theta\right] \qquad (3\text{-}13A)$$

where

$$\beta = \frac{1}{2}\left[\pi - \frac{a}{t}\theta - \pi\frac{P_m}{2.4S_m}\right]$$

or, if $(\theta + \beta) > \pi$, then

$$\sigma'_b = \frac{2\sigma_y}{\pi}\left[\left(2 - \frac{a}{t}\right)\sin\beta\right] \qquad (3\text{-}13B)$$

where

$$\beta = \frac{\pi}{2 - a/t}\left[1 - \frac{a}{t} - \frac{P_m}{2.4S_m}\right] \qquad (3\text{-}14B)$$

As mentioned above, the screening criterion is based on the ratio of K'_r over S'_r. When this ratio is less than 0.2, the limit load procedure is applied. When the ratio is greater than or equal to 1.8, then the LEFM procedure is applied. When the ratio takes on an intermediate value, the elastic plastic fracture mechanics (EPFM) procedure is applied.

3.4.2 Limit Load Analysis Procedure

The allowable bending stress in the limit load procedure is defined as

$$S_c = \frac{P'_b}{SF} - P_m\left[1 - \frac{1}{SF}\right] \qquad (3\text{-}15)$$

where SF is the factor of safety (defined as 2.77 for normal and upset conditions, and 1.39 for emergency and faulted conditions). The bending stress at incipient plastic collapse is defined using Eqs. 3-13 and 3-14. Eq. 3-15 is solved iteratively with different crack sizes until the allowable bending stress converges on the applied bending stress, P_b. The flaw size thus derived is the allowable flaw size for limit load.

3.4.3 Elastic Plastic Fracture Mechanics Analysis Procedure

The EPFM procedure is similar to the limit load procedure, except that the allowable bending stress is defined as

$$S_c = \frac{1}{SF}\left(\frac{P_b'}{Z} - P_e\right) - P_m\left(1 - \frac{1}{Z(SF)}\right) \qquad (3\text{-}16)$$

where Z is an elastic plastic correction factor defined as

$$Z = 1.20\ [1 + 0.021A(NPS - 4)]$$

where A is a nondimensional term relating to the pipe geometry

$$A = [0.125(R/t) - 0.25]^{0.25} \qquad \text{for } 5 \le R/t \le 10$$

$$A = [0.4(R/t) - 3.0]^{0.25} \qquad \text{for } 10 \le R/t \le 20$$

and NPS is the nominal pipe size in inches. Although no guidance is given in the Code for pipe sizes less than four inches, Z is assumed here to be equal to 1.20 for all pipe sizes less than four inches.

3.4.4 Linear Elastic Fracture Mechanics Analysis Procedure

The LEFM procedure is to evaluate the following equations, solving for the crack size, a, for a given circumferential extent, θ:

$$K_I = (J_{Ic}E'/1000)^{0.5} \qquad (3\text{-}17)$$

The applied stress intensity factor for a part-through, part-circumferential flaw is:

$$K_I = K_{Im} + K_{Ib} + K_{Ir} \tag{3-18}$$

where

$$K_{Im} = SF\left[\frac{P}{2\pi Rt}\right](\pi a)^{0.5}F_m$$

$$K_{Ib} = SF\left[\frac{M}{\pi R^2 t} + P_e\right](\pi a)^{0.5}F_b$$

F_m and F_b are defined in Eq. 3-12 and K_{Ir} is the stress intensity factor for residual stress. Residual stresses are ignored in the analysis procedure.

3.5 REFERENCES

3-1 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, "Rules For Construction of Nuclear Power Plant Components", Division 1, 1971 Edition Through the Summer 1973 Addenda. Subsection ND, "Class 3 Components", Article ND-3000, Subparagraph ND-3611 (Piping Design Acceptability) Refers to NC-3600 (TVA Watts Bar Nuclear Plant Code of Record for ASME Piping).

3-2 Internally generated controlled document I-8 "Highest Stresses by Pipe Size in Selected Analyses".

3-3 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", Appendix A, "Analysis of Flaws", 1989 Edition.

3-4 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", Appendix C, "Evaluation of Flaws in Austenitic Piping", 1989 Edition.

3-5 American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", Appendix H, "Evaluation of Flaws in Ferritic Piping", 1989 Edition, 1989 Addenda.

3-6 Bamford, W.H., "Fatigue Crack Growth of Stainless Steel Piping in a Pressurized Water Reactor Environment", ASME Paper 77-PVP-34.

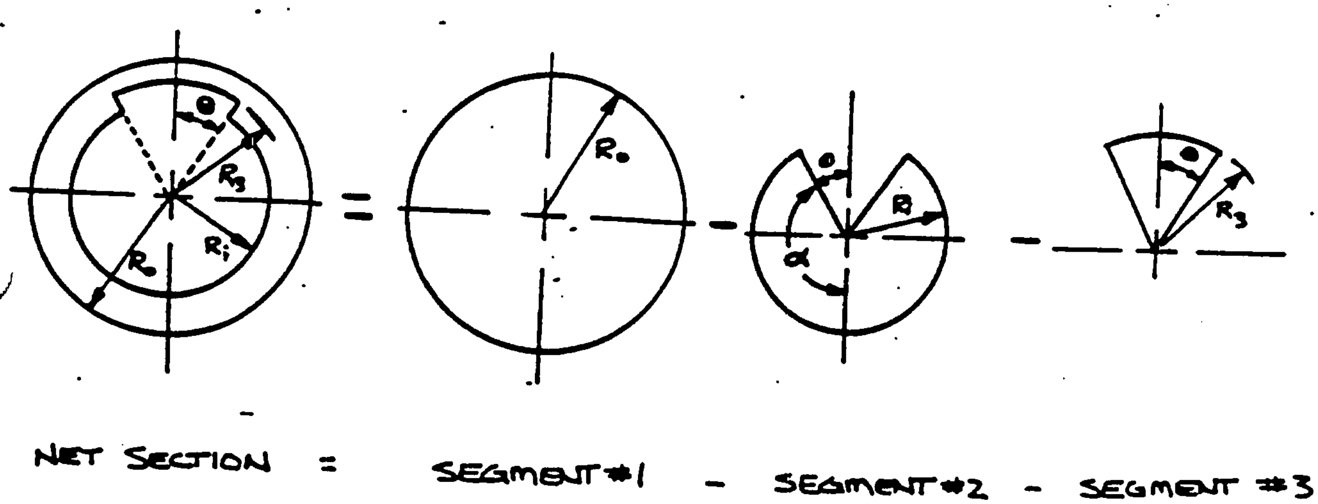

Figure 3-1 - Geometry Used to Calculate Section Modulus of Part-Through, Part-Circumferential Flaw.

Section 4
CHARACTERIZATION OF LACK OF PENETRATION/LACK OF FUSION FLAWS

4.1 INTRODUCTION

In order to evaluate the significance of LOP/LOF flaws, it is necessary to characterize the extent of LOP/LOF. In this context, "extent" means not only the size of flaws but also what populations of welds (e.g., piping systems, materials, thicknesses, welders) are affected by the LOP/LOF. Three types of statistical analysis are used to characterize the LOP/LOF flaws. They are listed in Table 4-1 (page 4-15).

The first type of analysis performed in this project is to bound the flaw size for use in the structural integrity evaluations of Section 6. Three steps to obtain this bound are:

- Selection of welds in sample
- Examination and inspection of welds
- Statistical analysis of the inspection results.

4.2 SELECTION OF WELDS IN SAMPLE

A random sample of welds was selected for RT. APTECH obtained computer printouts of all ASME Class 3 welds at the WBN, and a "random number generator" was used to select welds from this population to be inspected. Results from this examination were supplemented by UT and limited destructive examination (DE).

A set of 59 welds was chosen as a minimum number for the sample of the total population. Under a broad range of statistical assumptions, a sample size of 59 has significance. For example, under broad assumptions the maximum flaw size in 58 to 60 welds estimates the 95th percentile size with 95% confidence. (Percentiles and confidence bounds are defined in the subsection on statistical analysis.)

The random sample did not specifically identify enough welds from a given subpopulation to perform the weld and welder comparisons discussed later in this section. Additional welds were selected to fill minimum subpopulation requirements. These criteria are listed in Table 4-2.

These sample sizes were selected from many discussions and a consensus. We considered:

- Preliminary statistical calculations based on sequential sampling methods
- The perceived greater difficulty to weld stainless steel
- The perceived greater difficulty to weld thicker cross sections
- The major effect of sample size and minor effect of total subpopulation size upon statistical comparisons

Initially over 100, rather than 59, welds were selected randomly and ranked according to the order of selection. Extra welds were selected in case initial inspection results or access problems suggested more weld inspections were needed.

All weld numbers selected were submitted to TVA quality assurance (QA) for determination of accessibility, drainage attempts if full, or other factors that would hinder RT. If a selected weld could not be radiographed the next number on the list was selected. After the first 59, additional welds were selected to meet the various subpopulation requirements in Table 4-2.

Of those selected initially; 82 were eventually inspected. Inadvertently, two inspected welds, identified as Welds 2-067G-T047-15 and 1-070B-0172-20C, were not from the initial random selection. They were next to randomly sampled welds and were included in the RT image of the randomly selected welds. Both had flaws and Weld 2-067G-T047-15 had a somewhat large flaw. For conservatism, they were included as if they had been selected randomly. Thus, in all that follows, we refer to "84 random welds."

Besides the APTECH random sample program, 32 welds were radiographed by TVA due to other concerns. In all that follows we call these "32 original welds."

4.3 INSPECTION

The first objective of inspection was to quantify the length of LOP/LOF indications along the girth welds in the sample population. Radiography provided an accurate measurement of flaw length.

The next objective was to quantify flaw depth, an even more critical input to structural integrity evaluation. "Ordinary" RT cannot do this. Thus, our choices were UT or enhanced RT or both. Tennessee Valley Authority indicated that it was impractical to size manually every one of the identified LOP/LOF indications with UT. Thus we rely on enhanced RT, as calibrated against both UT and DE of some flaws.

The following sections summarize the RT efforts of TVA as reviewed by APTECH, the RT image enhancement work of APTECH, and the calibration of flaw depth estimates.

4.3.1 Tennessee Valley Authority Radiography Examination of Sampled Welds

The 84 random and 32 original welds were radiographed by TVA according to a modification of TVA Procedure N-RT-2. This procedure was designed to quantify microbiologically-induced corrosion damage and has been modified to size LOP/LOF defects in piping welds.

All radiographs were interpreted by a TVA NDE Level III inspector to identify areas of LOP/LOF. These radiographs and interpretations were then reviewed by APTECH's NDE Level III to confirm the LOP/LOF indications called by TVA.

Tennessee Valley Authority sent a Level III inspector, to Houston on November 13, 1990. He brought the last remaining radiographs and provided QA oversight of APTECH's work in Houston. Through these QA efforts, all major differences in interpretation were resolved (during the visit the TVA Level III inspector also observed APTECH's imaging system described below).

The results of the RT examinations by TVA are listed in Appendix A.

4.3.2 Image Analysis by APTECH

Digital image analysis of radiograph density was used to estimate the depth of all LOP/LOF indications. An APTECH procedure, backed by ten years of development, was employed.

Depth information of the flaws was obtained by comparing two dimensions. One is the density difference on the radiograph between the flaw and adjacent weld area. The second is the density difference of a known thickness difference caused by the penetrameter and shim placed on the base metal next to the weld.

The image of a radiograph is captured and digitized in a 512 x 512 matrix of pixels. Each pixel is given a light value from 0 to 255 corresponding with the transmitted light through the radiograph at that minute area. The areas containing the flaws are interrogated through computer manipulation to find the deepest point (minimum light value).

After this screening process, four digital density light value measurements are taken: minimum light value of (1) flaw, (2) area adjacent to worst flaw, (3) penetrameter plus shim area, and (4) base metal next to penetrameter measurement. These light value measurements are converted to film density values by interpolation of readings from a density strip chart. This chart is traceable to National Institute of Standards and Technology (NIST - formerly the National Bureau of Standards) standards. This process eliminates any measurement variation due to the light source, camera adjustments, distance, etc. These film measurements are used to estimate flaw depth via a logarithmic relationship between film density and specimen thickness. Refer to Ref. (4-1) for this relationship and other details.

The imaging LOP/LOF depth measurement procedure was qualified on a one-inch test block with notches cut in it to simulate flaws. This block was radiographed and the resulting x-ray film was imaged to reproduce these depths and confirm the procedure.

4.3.3 Ultrasonic Sizing By Tennessee Valley Authority

Ten welds were selected for UT sizing according to TVA's NDE Procedure N-UT-39. The weld crowns were ground flush to help this sizing. The welds examined were:

- 0-067J-T145-09
- 2-067J-T349-01B
- 1-067J-T526-01
- 0-026H-T010-06A
- 1-067C-T613-07
- 2-067G-T047-15

From the random sample population and

- 0-078A-D196-05B
- 1-067J-T608-02
- 1-067J-T608-03
- 1-067J-T635-06

From the original 32 welds radiographed by TVA.

The results of this UT sizing are listed in the UT Depth column of the first table in Appendix A (UT sizing was attempted during August, 1990, on Welds 1-067J-T608-02 and 1-067J-T608-03 previously with maximum flaw depths of 0.140 and 0.136, respectively). These measurements were limited to four places on the weld crown (six inches out of a 27-inch circumference) and are deemed not as valid as the later measurements in Appendix A. Also, UT sizing was done on Welds 0-078A-D196-05B and 1-067J-T635-06 during September, 1990, with flaw depth measurements of 0.100 and 0.150, respectively.)

4.3.4 Destructive Analysis and Measurement

Weld 0-078A-D196-05B was cut and sectioned in five places with the results in Table 4-3. Note that the flaws had both LOP and LOF. Table 4-3 lists results from the measurements of both RT imaging depths and UT sizing depths.

Given the limited DE sample tabulated in Table 4-3, we developed a simple but workable estimate of flaw depth "a." The estimate is based on the following observations.

- Ultrasonic testing was either accurate or significantly overstated flaw depth.
- Enhanced RT was either accurate or significantly understated flaw depth.
- Based on the physical principles behind enhanced RT, we expect this result. We believe the error "ϵ" should be expressed in length units (e.g., $a + \epsilon$), not as a factor (e.g., ϵa).
- From these five readings, the worst error of enhanced RT is bounded by $\epsilon \leq 0.060$ inch.

From these observations, in the statistical evaluation below we assume the maximum flaw depth "a" is the lesser of:

- The largest measured with UT where available (a_{UT})
- The largest measured with RT (a_{RT}) plus 60 mils (0.060 in.)

In equation notation,

$$a = \text{minimum}[a_{UT}, (a_{RT} + 0.060)]$$

4.4 STATISTICAL ANALYSIS OF THE INSPECTION RESULTS

4.4.1 Formulation of the Statistics Problem

The mathematical details of the employed methods are included in Appendix B and have been given elsewhere. References include several applications to Nuclear equipment. This past work was done under the APTECH QA program for TVA (4-2) and (4-3) and other clients (e.g., (4-4)).

Many of the assumptions also have detailed mathematics. These are listed in Appendix B.

Most of the "textual" assumptions (i.e., without complex math and statistics terminology) have been given previously. For example, we have documented the assumptions used to estimate flaw depth "a" from inspection data. Two remaining assumptions to express here are:

- Defect area Y = PAR is calculated by multiplying flaw length by its maximum depth

  $$Y = \%L/C \text{ times } a/t$$

  As defined above, Y = PAR is expressed as a percent of the cross section removed. This product is very conservative because it assumes that the defect will be at maximum depth "a" over its entire length.

- No leaks from LOP/LOF defects have ever resulted in any of the existing 7120 TVA WBN Class 3 welds. Therefore, Y < 100% (and so is a/t) for all 7120 welds. For large groups we rely on this assumption in a conservative way. We input one leak and 7119 "no-leaks" into the computer program described in Appendices B and C.

For uninspected welds, a "no-leak" is input simply by telling the program that Y < 100% or a/t < 1. A big advantage of the statistical methods used here is their ability to handle input bounds like Y < 100% as rigorously as they handle explicit values of Y.

A statistical analysis was applied to the key inspection results listed earlier in this section. The scatter in these flaw size data is apparent. It suggests strongly that for a structural integrity analysis, a value of flaw area based on the largest flaws in our weld sample should be used. It is intended that the structural analyst assume this flaw area is in each uninspected Class 3 weld.

A standard "95-95" statistical definition was chosen to establish these values. Here, the first "95" refers to a 95% probability of "doing better" than the value quoted. The second "95" refers to the use of a 95% confidence bound. This bound compensates for the lack of an infinite sample size. It limits the chance to 5% that our estimates are too optimistic.

4.4.2 Flaw Areas

Figure 4-1 is a plot of F(x) for the "baseline data group sample BASEL." The 95-95 flaw area is 18% of the cross section. The 18% value is the key input from this section to the structural integrity evaluation of Section 6.

This is the largest group considered and is featured in this report. It includes all 116 welds except eight produced by a substandard welder identified by the TVA code, "6EL."

The excluded eight welds are analyzed here using the Symbol "6ELOR." See the subsections comparing welds and welders for the appropriate tests. These tests show that Welder 6EL produces larger defects than TVA welders in general. On this basis and similar preliminary analyses, we have recommended that all 6ELs welds be inspected, repaired as needed, and eliminated from the 95-95 statistical evaluation. By all, we mean every weld 6EL has made, original or not.

Table 4-4 focusses on the 95th percentile flaw estimates for BASEL. It includes some language to help people unfamiliar with statistics to understand the meaning of confidence limits.

4.4.3 Flaw Depths

To handle future weld inspections with no information on flaw depth, a 95-95 estimate of a/t is useful. Figure 4-2 summarizes the analysis. With 95% confidence, no more than 5% of the welds will have LOP/LOF flaws exceeding 45% wall thickness.

4.5 WELD COMPARISONS

APTECH was asked by TVA to test whether certain variables affect flaw size. These variables include weld material, thickness, origin, and welder. By testing the variables, two purposes are achieved. First, we allow the structural integrity analysis to account for significant differences, if any, among weld flaws. Second, we help seek root causes for atypical weld flaws.

4.5.1 General Approach

There are several statistical analysis approaches to do this. Here, we evaluate the statistical significance of differences in the 95th percentile flaw area among the various groups of the subject welds. Later, under "Welder Comparisons," we test differences in the proportion of flawed welds among several welders.

Here, as above, the 95% flaw area Y_{95} denotes flaws so large that only 5% of the welds exceed them. Flaw area is defined and computed as above. Also, the weld groups are specified completely in the calculation (4-3) and summarized below. Finally, for each weld group and sample considered, Ref. (4-2) gives best estimates $\hat{Y}_{958}$ and upper 95% ($Y_{95\text{-}95}$) and lower 5% ($Y_{95\text{-}5}$) confidence bounds of flaw area.

As in Appendix B, we deal mainly with the transformed variable

$$X_{95} = 1/(10\% + Y_{95}).$$

We use an approximate technique analogous to Section 13.64 in Burlington and May (4-5). We investigate the difference "D" in the best estimate of X_{958} between a baseline sample "b" and the sample to be compared with "c." Specifically,

$$D = X_{958b} - X_{958c}$$

The problem is set up as a one-sided hypothesis test. The "null" hypothesis is that each weld sample comes from the same statistical population of weld flaw area Y as a baseline sample used for comparison. The alternative hypothesis is that the two flaw area samples were drawn from different populations.

We reject the null hypothesis only if the difference D in best estimates $Y_{95\%}$ from the two samples is large. The criterion for "large" is that if the null hypothesis is correct, the observed difference could be exceeded randomly with small chance $\alpha(D) < \alpha_{SPECIFIED}$. Here, $\alpha_{SPECIFIED}$ is called the significance level. Because the test is one sided, $\alpha(D)$ can never exceed 1/2 or be less than zero. In math notation,

$$0 = \alpha(\infty) \leq \alpha(D) \leq \alpha(0) = 1/2.$$

Thus, if there is precisely zero difference between the groups, α is 1/2.

Depending on the application, analysts use $\alpha_{SPECIFIED}$ values ranging from 0.15 to as low as 0.001. The values 0.01, 0.05 and 0.10 are seen most often. Low values are used when it is not a critical error to accept an incorrect hypothesis. Larger values are used when it is more important to avoid this error and reject an incorrect hypothesis. Following some early preliminary work, we chose $\alpha_{SPECIFIED} = 0.10$, a 10% level of significance. As will be shown below, our conclusions under "Weld Comparisons" are not affected by the choice of any significance level between 0.05 and 0.2.

Three general comparisons were made in Table 4-5. See the results in Tables 4-6 through 4-8 and Ref. (4-4) for complete definition of the five-digit group symbols denoting the weld group samples.

4.5.2 Random Versus Original Welds

Table 4-6 shows clearly that the difference between the random and original welds is insignificant if the eight original welds of 6EL are excluded. The $\alpha(D) = 0.41$ is much larger than the chosen critical value 0.1. Also, the 0.41 value is close to its theoretical maximum for zero difference of $\alpha(0) = 1/2$.

These excluded eight welds lead to a best estimate 95th percentile flaw area of 34%. The difference between this large flaw and the 12% baseline flaw area is significant since $\alpha(D) = 0.04 < 0.10$.

4.5.3 Material Effect on Flaw Area

Table 4-7 shows the negligible difference between the 95th percentile flaw areas observed in carbon steel and non-carbon steel welds. The non-carbon welds include 63 stainless steel and five dissimilar metal welds. The small sample of dissimilar metal welds looks slightly worse than the rest (one weld with Y = 19% and four clean welds). From Table 4-8 we see that the single flaw found in five dissimilar metal welds is small enough to pass the hypothesis test.

We conclude from Tables 4-7 and 4-8 that no weld material influence on flaw area is apparent.

4.5.4 Other Effects on Flaw Area

Table 4-8 compares the smallest samples against the much larger baseline, BASEL. Again, only Welder 6EL is different. We find no other influence of weld material, thickness, or origin on LOP/LOF flaw area.

4.6 WELDER COMPARISONS

In December of 1990, a memo and related viewgraph material were prepared to document this analysis. These documents are revised in Appendix D to include all data received in 1990 and any modifications from our QA efforts.

There are four major differences between this work and the "Weld Comparisons" above:

- We focussed solely on welders instead of many variables.
- We focused on flaw length rather than depth or area. Flaw length data are more complete and are felt to be good indicators of workmanship.
- Instead of analyzing the entire flaw size distribution, we considered only two statistics. These were the proportion of welds with LOP/LOF flaws of more than (1) 10% circumference and (2) 50% circumference.
- The carbon steel and stainless steel databases were treated separately in this analysis. This is because of an early suspicion, never confirmed, that the lengths of LOP/LOF flaws might be greater in stainless steel welds. Unlike the previous work, we have

not done a formal analysis of material effects on flaw length. The study on flaw area is sufficient for purpose of structural integrity.

The conclusions of this analysis are given in Appendix D and above. For convenience, the "suspect" welders mentioned in Appendix D are listed below:

Category	TVA Welder Code(s)
Major Suspect(s)	6EL
Minor Suspect(s)	6AAI, 6RS, 6NM, 6NU, 6GR, 6PFF
Additional Minor Suspect(s) if $\alpha_{specified}$ = 15%	6SV, 6TTC, 6RSS

We recommend that TVA investigate the first two categories of suspects with inspections. The third category could be added for extra conservatism but is not recommended. Figures 4-3 and 4-4 contain flow charts from Appendix D of the inspection procedure. They may be used to evaluate with these suspects.

This list of suspects is based on weld inspection measurement only. As stated in Appendix D, if there is other strong evidence for suspecting the workmanship of a welder, that welder should be added to the list by TVA.

These inspections could turn up welds that are candidates for rework. Our recommended criteria for weld rework have been given previously in this section. Recall that they apply to both past and future inspections and depend only on the weld, not the welder.

4.7 MAJOR CONCLUSIONS AND RECOMMENDATIONS

We draw the following three major conclusions from the analysis of flaw size distributions:

1. With 95% confidence, the chance is less than 5% that a randomly selected TVA Class 3 weld will lose more than 18% of its cross section to an LOP or LOF flaw.

2. With 95% confidence, the chance is less than 5% that a randomly selected TVA Class 3 weld LOF or LOP flaw will be deeper than 45% of the pipe wall thickness.

3. Conclusions 1 and 2 suggest the following criteria for reworking the largest weld flaws:

   - Limit total flaw area to 18% of the cross section.

   - Unless flaw depth data as reliable are presented in this section is available, limit LOP/LOF flaw length to 40% of the girth weld circumference. Here, 40% = 18%/(0.45).

   - Without flaw depth data and under worst-case assumptions for microbiologically-induced corrosion in the same cross section, use the following:

$$\ell_{MIC} + [(\ell_{LOP/LOF} \times 0.45)] \leq 18\%$$

   where,

   ℓ_{MIC} = circumferential extent of MIC in %

   $\ell_{LOP/LOF}$ = %L/C = circumferential extent of LOP/LOF in %

With the weld comparisons, three more major conclusions are added:

4. With one exception, there is no reason to doubt that flaw area data in all weld groups investigated were drawn from the same population.

5. The exception is the sample of eight original welds by Welder 6EL. This sample had larger defects than the other groups.

6. Based on Conclusion 4, and always excluding Welder 6EL, we find no statistical significance of flaw area differences among welds of different

   - Material

   - Pipe wall thickness

   - "Origin" (i.e., original versus random welds)

With the welder comparisons, several more major conclusions are added:

7. Using a different statistical method, and with or without adding the most recent data on ten more welds from Welder 6EL, we confirmed Conclusion 5. The work product of Welder 6EL is an outlier. Thus, we classify Welder 6EL as the only "major suspect" of

atypical workmanship. "Major" means that additional samples are unlikely to change our adverse conclusion.

8. Using a more conservative approach here than in the Weld Comparisons, we produced a list of welders classified as "minor suspects." Minor means the database is very small or the welder almost passed our test or both. More samples are likely to pass the welder.

9. For all "suspects" we recommend a detailed remedy calling for more inspection and statistical analysis based on "sequential sampling." In essence, the remedy amounts to the following:

   Start with at least four new randomly selected welds made by each suspect. Inspect the welds and analyze the results. Repeat this until either the suspect is shown to be indistinguishable from the general population or there are no more of the suspect's welds to check.

10. If this remedy is followed, the most likely results are:

    - All Welder 6EL's welds will need to be inspected

    - For most if not all minor suspects, only the first four welds will need to be sampled

4.8 REFERENCES

4-1 "Detection and Measurement of Internal Undercut in Pipeline Girth Welds", Southwest Research Institute Project 17-5175 Draft Final Report, American Gas Association Contract PR-15-95 (February 1979).

4-2 Egan, G. R., P. M. Besuner, M. J. Cohn, and S. R. Paterson, "Analysis of HVAC Ducts in Tennessee Valley Authority's Watts Bar Nuclear Plant, Units 1 and 2, APTECH Report AES 90041243-1Q-1.

4-3 Calculations 3 and 4, APTECH Project AES 90041243-1Q.

4-4 Cipolla, R. C., "Statistical Analysis of Hole Depth Data", APTECH Project AES 89121166-1Q, Calculation 1166-1Q-6 (Document I-7).

4-5 Cipolla, R. C., J. L. Grover, and P. M. Besuner, "Significance of Over-Drilled Oil Holes on Fatigue Life of the KSV-4-2A Connecting Rod in the Standby Diesel Engines at South Texas Project", APTECH Report AES 89121166-1Q-1 (March, 1990) (See Section 3 especially).

Table 4-1

THREE STATISTICAL ANALYSES OF WELD FLAWS

Type of Analysis	Purpose	Short Label
Best estimates and confidence bounds of cumulative probability distributions F(x) of flaw area PAR, and depth, a/t.	Estimate flaw sizes for structural analyses and rework criteria.	Flaw Size Distributions
Statistical hypothesis and significance tests of F(PAR) distributions for several weld groups.	Decide flaw sizes that go with each weld group.	Weld Comparisons
Statistical hypothesis and significance tests of welders' "flaw hit rates" and ability to avoid long and medium flaws.	Root cause study of substandard weld workmanship.	Welder Comparisons

Notes:

PAR = percent of cross section area removed by flaw

a/t = flaw depth divided by thickness

Table 4-2

MINIMUM SAMPLE SIZE FOR SUBPOPULATIONS

Material	Thickness, t (In)	Other	Number
CS	t < 0.25		8 of 676
CS	0.25 < t < 0.375		7 of 3025
CS	t > 0.375		8 of 207
SS	t < 0.25		15 of 1774
SS	t > 0.25		15 of 1331
All	All	Backing ring	Not specified
SS-CS	All		5 of 107

Table 4-3

COMPARING THREE FLAW DEPTH MEASUREMENTS AT FIVE FLAW LOCATIONS

Location L=0"=TDC (Inch)	Destructively Measured Flaw LOP/LOF (mils)	RT Imaging (mils)	UT Sizing (mils)
8.25	28	34	80
16	94	35*	110
18.25	88	34	110
25.25	31	37	130
32.25	38	36	100

*This figure is low because distance between shim area and flaw area was too large. The measurement was repeated using a shim area closer to flaw area and it revealed a flaw depth of 58 mils.

Table 4-4

95TH PERCENTILE FLAW ESTIMATES FOR BASELINE WELDS

Type of Estimate	Flaw Area (%)	Statement that has C% Chance of Being Conservative	Confidence Level = C
95% Confidence Interval Estimate	18	Five percent of the welds have flaws removing more than 18% of their cross section.	95%
Best (Point) Estimate	11	Five percent of the welds have flaws removing more than 11% of their cross section.	About 50%
5% Confidence Interval Estimate	6	Five percent of the welds have flaws removing more than 6% of their cross section.	5%

Table 4-5

THREE CATEGORIES OF STATISTICAL SIGNIFICANCE TESTS

Comparison Type	Baseline Sample	Table Number	Compared Samples
Random Versus Original Welds	RANDM	4-6	ORIGL (All originals except Welder 6EL) and 6ELOR
Carbon Steel Versus Non-Carbon-Steel Welds	NOCAR including 5 dissimilar metal welds	4-7	CARBN
Baseline Versus Smallest Groups	BASEL	4-8	Several, using our smallest subdivisions.

Table 4-6

COMPARING THE RANDOM GROUP WITH TWO ORIGINAL GROUPS

Sample of Welds Inspected	Best Estimate of Flaw Area Y_{95} (%)	Same as Baseline?	Significance Level α(D)
Baseline 84 random welds [RANDM]	11.74	N/A	N/A
24 original welds (without 6EL) [ORIGL]	14.1	Same	0.4122
8 original welds from 6EL [6ELOR]	34.44	Worse	0.0421

Note: RANDM + ORIGL = BASEL

Table 4-7

COMPARING THE CARBON WELDS WITH NON-CARBON WELDS

Sample of Welds Inspected	Best Estimate of Y_{95} Area (%)	Same as Baseline?	Significance Level
Baseline 68 non-carbon welds [NOCAR]	13.26	N/A	N/A
35 carbon welds [CARBN]	11.28	Same	0.4098

NOTES:

- See next table to define symbols used in the following notes.
- CARBN = THINC + MEDIC + THCKC + (one carbon weld from ORIGL)
- NOCAR = THINS + THCKS + DISSR + ORIGL - (one carbon weld from ORIGL)
- Equivalently, NOCAR = BASEL - CARBN - 5 backing-bar welds in RANDM

Table 4-8

COMPARING THE BASELINE GROUP WITH THE SMALLEST SAMPLES CONSIDERED

Sample of Welds Inspected	Best Estimate of Flaw Area Y_{95} (%)	Same as Baseline?	Significance Level
Baseline 84 random plus 24 of 32 original welds [BASEL]	11.05	N/A	N/A
9 carbon steel welds of thickness .LE. 0.25 inch [THINC]	6.13	SAME	0.2472
17 carbon steel welds of 0.25" < T .LE. 0.375" [MEDIC]	16.32	SAME	0.3520
8 carbon steel welds of thickness > 0.375 inch [THCKC]	7.54	SAME	0.3141
15 stainless steel welds of T .LE. 0.25 inch [THINS]	19.41	SAME	0.3089
25 stainless steel welds of T > 0.25 inch [THCKS]	15.00	SAME	0.3505
5 welds of dissimilar mtl (SS/CS) -- any T [DISSR]	27.04	SAME	0.2034
8 original welds of Welder 6EL [6ELOR]	34.44	WORSE	0.0346

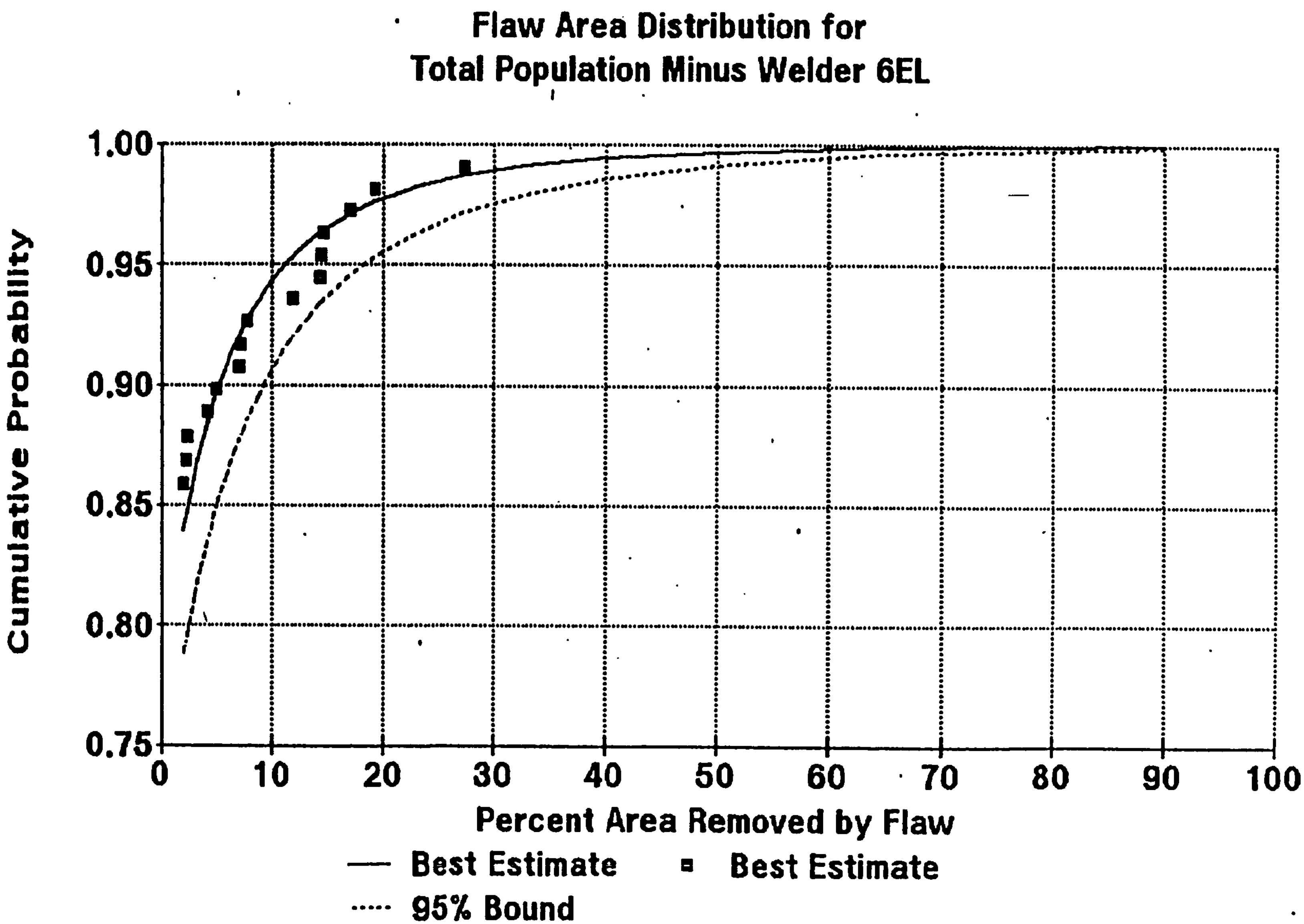

Figure 4-1 - Flaw Area Distribution For Total Population Minus Welder 6EL.

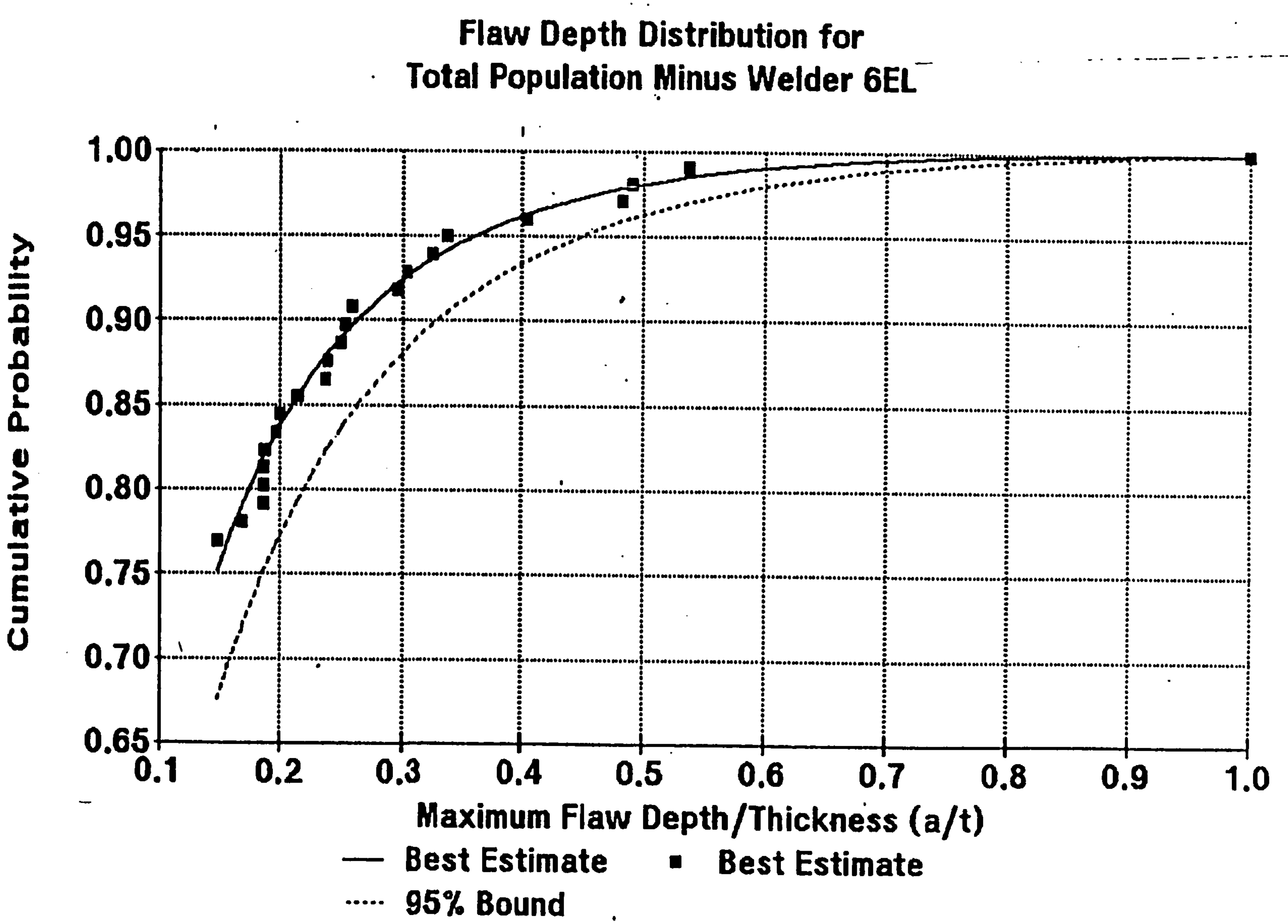

Figure 4-2 - Flaw Depth Distribution for Total Population Minus Welder 6EL.

Section 5
BOUNDING STRESSES

The resolution strategy for evaluation of the significance of the LOP/LOF indications is based on a bounding stress level. However, the analysis methodology described in Section 3 utilizes several different stress levels, in different combinations, to perform the ASME Section III and Section XI evaluations. As a result, it is not clear how to define the bounding stress level as the highest stress level for a Section III evaluation may not provide the worst-case for a Section XI evaluation, especially when fatigue is considered. Therefore, a screening procedure was used to identify the piping systems and calculation packages within each system that provided a likely upper bound, and several of the most highly stressed nodes in each package were identified for detailed analysis. The complete screening procedure is described in detail below.

5.1 SELECTION OF CLASS 3 SYSTEMS FOR ANALYSIS

Review of the lists of TVA field welds indicated that the Class 3 welds were limited to the following systems:

- Auxiliary feedwater
- Essential raw cooling water
- Component cooling
- Spent fuel pit cooling
- High pressure fire protection
- Control air
- Chemical volume and control
- Purge vent

The resolution strategy discussed in Section 3 of this report was based on sample of four of these systems. Tennessee Valley Authority engineers told APTECH that their experience indicated that analysis results for the carbon steel auxiliary feedwater system contain relatively high stresses. This system was, therefore, selected for flaw analysis. To ensure an adequate sample of carbon steel welds, the component cooling water system was also initially selected. Similarly, the ERCW and spent fuel pit cooling systems were selected to provide an adequate sample of stainless steel welds.

5.2 IDENTIFICATION OF CLASS 3 ANALYSIS PROBLEMS FOR DETAILED ANALYSIS

Within each of the selected systems, TVA analysis problems associated with Class 3 piping were identified on flow diagrams that had been marked with analysis problem numbers by TVA engineers. The latest revisions of the analysis problems were located in the TVA RIMS records system. Successor calculations were obtained for three calculations which had been superseded.

One hundred thirty six analysis problems were reviewed. The results of the review are given in Appendix E. Materials, pipe sizes and pipe thicknesses were tabulated as a complete list of those used in an analysis problem. Stress ratios and node identifications were recorded only for the most highly stressed node for each combination of pipe size, thickness, and material as identified in the stress summary for each analysis problem.

Tennessee Valley Authority piping analysis procedures do not necessarily consider the physical location of welds in the structure during the assignment of nodal locations in the analysis problem. Thus, a node may or may not coincide with a weld, and a weld may or may not be located physically close to a node. From this, it follows that some of the maximum stress values may not represent Class 3 piping welds. In addition, some maximum stress points may represent piping of less than two inch nominal size. These aspects were initially ignored for the purpose of searching out the most highly stressed systems but were considered during the detailed evaluation.

It should also be noted that several of the stress ratios in Appendix E violate ASME Section III requirements. A review of the calculation packages associated with the analysis problems indicated that the calculated stresses at these locations had been reduced using alternate analyses. For the analyses herein, however, the computer output values were used to provide a uniform standard for comparison of stresses.

Based on the above review, 17 analysis problems were selected for more detailed review. The primary selection criteria included high stresses, a range of pipe sizes, and the inclusion of representative samples of carbon steel and stainless steel welds. The selected analysis problems are in the auxiliary feedwater, spent fuel cooling, and ERCW systems.

5.3 EXTRACTION OF BOUNDING STRESSES

The 17 selected analysis problems were reviewed to extract the highest nodal stresses for ASME Code Eqs. 8, 9, 10, and 11 for upset, emergency, and faulted conditions for each pipe size, each pipe thickness, and type of material (carbon or stainless steel). The nodal stresses were extracted as sets: a high stress value for any one of the equations resulted in the tabulation of all six values for that node.

As discussed previously, TVA piping analysis procedures do not provide for a direct correlation between the locations of nodes (in the analysis problem) and welds (in the physical structure). Therefore, when a high nodal stress was obviously not at a butt weld (e.g., nodes denoted as CENTR are in the middle of bends), sets of stresses for nearby nodes clearly corresponding with butt welds (such as a node adjacent to a CENTR node) were also extracted. Several sets of stresses were extracted for each combination of pipe size, thickness, and material in each analysis problem with the number of sets being chosen in view of the number of members involved and the magnitude of the stresses. Approximately 10,000 locations were reviewed to extract the data.

The result of this task was a compilation of the Section III stress ratios for 664 nodes. This compilation was converted to a computer database in order to facilitate the evaluation described in the following section. Appendix F summarizes all of the data contained within this database.

Section 6
STRUCTURAL INTEGRITY EVALUATIONS

Because of the complexity of the analysis methodology used in this project, a single bounding node cannot easily be identified that will bound all aspects of code compliance, fatigue crack growth, and fracture that were considered. In addition, it was recognized that the most highly stressed welds may not be acceptable assuming the worst-case flaw size, and inspection would, therefore, be required to disposition a few specific welds. This would require evaluation of a group of the next most highly stressed welds. In order to ensure that the worst-case conditions were identified and to allow for evaluation of the next most severe cases, the analysis methodology was incorporated into a computer program that utilizes the bounding flaw size from Section 4 and the entire database of bounding stresses from Section 5 to evaluate the acceptability of each node in the database from an ASME Section III and Section XI point of view.

The database of bounding stresses contains information on 664 of the most highly stressed nodes (based on the TVA stress reports). In many cases, however, those nodes were not at TVA field welds but were at other locations, such as valves, fittings, and anchors. The TVA pipe stress analysis guidelines (6-1) indicate that all butt weld nodes in the piping analyses should have a stress intensification factor (SIF) of 1.8 for piping less than 0.322 inch thick, or an SIF of 1.0 for piping greater than or equal to 0.322 inch in thickness. However, if the butt welds were not identified on the walkdown isometric, then all of the data points on straight sections of pipe should have an SIF equal to the relevant butt weld value.

This definition of SIFs was used to screen out nodes that were definitely not welds because they had some other value for the SIF. This reduced the database of bounding stress nodes from 664 to 181, including 123 carbon steel nodes and 58 stainless steel nodes. However, not all of these remaining nodes are necessarily welds because straight runs of pipe may have butt weld SIFs.

The analysis was performed using this reduced database of nodes with butt weld SIFs. The database included values for the allowable stress, S_h, but not for any other material properties. Tables I-1 and I-7 of Section III of the ASME Code were used to define S_m values that matched the S_h values in the database. When fracture toughness values were required, the minimum value specified in Appendix H of Section XI was used. Fatigue crack growth properties are defined in Section 3 of this report.

The results of the Section III analysis showed that nine of the 181 nodes that have butt weld SIFs failed to meet the Section III acceptance criteria. Nine additional nodes failed the Eq. 10 acceptance criteria but passed Eq. 11, and the Code requires that either Eq. 10 or Eq. 11 is satisfied. Table 6-1 shows the complete results of the Section III analysis for all nodes with butt weld SIFs.

The Section XI analysis showed that 44 of the 181 nodes that have butt weld SIFs had an allowable flaw size for either normal and upset conditions (N/U) or emergency and faulted conditions (E/F) that was smaller than the size of the bounding flaw after 7000 cycles of fatigue loading. Twenty-six of these nodes had allowable flaw sizes smaller than the bounding flaw neglecting fatigue crack growth. Table 6-2 summarizes the results of the Section XI analyses for all nodes with butt weld SIFs. Table 6-3 lists the 44 nodes that failed the Section XI criteria (all of the nodes that failed Section III also failed Section XI).

This list of nodes was compared against TVA weld maps to determine which nodes, if any, were welds. Sixteen welds were identified to be at or near these nodes. Six of these welds are ASME Class 2 welds and were radiographed and accepted as part of the Class 2 acceptance criteria. Five of the welds were vendor shop welds and two of the welds were determined to have backing rings where the potential for LOP/LOF is considered to be small. Only three of the welds required further evaluation. These are a carbon steel node in the auxiliary feedwater system (Node N3-03-05A-729) and two stainless steel nodes in the ERCW system (Nodes N3-67-24A-E48 and N3-67-43A-B06E).

It is highly unlikely that the three nodes with the worst stresses also have worst-case flaws. A radiographic examination was performed on these three welds to determine the extent of any LOP in these welds. In order to determine whether any observed LOP defect was acceptable, the analysis methodology described previously was used on an iterative basis to determine what flaw size would precisely meet the Section XI acceptance criteria.

Two bounding flaw models were evaluated for these three welds. Because RT primarily provides information on flaw length, the first flaw model used the worst-case flaw depth to solve for the allowable flaw length, as a percentage of the circumference. The second flaw model solves for the allowable depth, assuming a fully circumferential flaw. The results of these analyses are summarized below:

ALLOWABLE FLAW SIZES

Node	Crack Depth, a/t	Circumferential Extent, %
N3-03-05A-729	0.45	<1
	0.02	100
N3-67-24A-E48	0.45	2
	0.16	100
N3-67-43A-B06E.	0.45	25
	0.26	100

From these results, the following conclusions can be made regarding the acceptability of these three welds: -

1. Weld N3-03-05A-729 cannot tolerate flaws as deep as the bounding flaw.
2. If the LOP/LOF is shorter than 25% of the circumference in Weld N3-67-43A-B06E, it is acceptable.
3. If LOP/LOF is shorter than 2% of the circumference in Weld N3-67-24A-E48, it is acceptable.
4. If the LOP/LOF flaw is determined to be shallower than a/t=0.02 for Weld N3-03-05A-729 or shallower than a/t=0.16 for Weld N3-67-24A-E48 or shallower than a/t=0.26 for Weld N3-67-43A-B06E, it is acceptable.
5. If the flaw depth or length exceeds the limits as described above, then further analysis may be required to determine if the weld is acceptable.

Radiographic examination was subsequently performed on each of these welds. Interpretation of the radiographs by TVA Level III radiographers showed no LOP/LOF indications on Weld N3-03-05A-729 and this weld was accepted as-is. Weld N3-67-43A-B06E was found to have a ¼-inch long LOP/LOF indication which is acceptable to the allowable flaw sizes discussed previously. Weld N3-67-24A-E48 contained a LOP/LOF indication ⅜ inch long, or approximately 1.4% of the circumference. This indication is also acceptable to the allowable flaw sizes.

The above evaluation was performed based on the 95%-95% bounding flaw area of 18% as developed in Section 4. In order to evaluate the adverse quality associated with the welds (including 6EL welds) having observed flaw areas greater than 18%, another assessment was performed employing the observed flaw size information with location-specific stresses. This evaluation is necessary to address the CAQR as shown in Figure 2-1. Three welds had observed flaw areas greater than 18%; namely, 1-067J-T608-03, 2-067G-T046-07, and 2-067G-T047-15. All three welds passed the ASME Section III and Section XI evaluations. Therefore, the observed LOP/LOF would not have resulted in an unsafe situation if the condition had gone undetected.

6.1 REFERENCES

6-1 Tennessee Valley Authority, "Pipe Stress Analysis Guidelines", WBN-RAH-Appendix A, Revision 2 (August 8, 1989).

Table 6-1

RESULTS OF SECTION III ANALYSIS FOR NODES WITH WELD SIFs

System	Calc package	O.D.	Mat'l	Node	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
AUXFW	0600200-02-05	2.375	CS	646	.304	.704	.472	.455	.383	.353
AUXFW	0600200-02-05	2.375	CS	646X	.319	.677	.454	.433	.425	.382
AUXFW	0600200-02-05	2.375	CS	647Z	.293	.691	.464	.452	.315	.307
AUXFW	0600200-02-05	4.500	CS	125	.337	.372	.253	.378	.718	.565
AUXFW	0600200-02-05	4.500	CS	125Y	.355	.385	.264	.361	.667	.543
AUXFW	0600200-02-05	4.500	CS	127	.284	.293	.201	.257	.699	.532
AUXFW	0600200-02-05	4.500	CS	127B	.284	.294	.200	.263	.713	.541
AUXFW	0600200-02-05	4.500	CS	128	.289	.333	.223	.358	1.118	.787
AUXFW	0600200-02-05	4.500	CS	13P	.388	.434	.291	.437	.666	.554
AUXFW	0600200-02-05	4.500	CS	13Q	.388	.433	.291	.443	.673	.558
AUXFW	0600200-02-05	4.500	CS	164A	.268	.431	.318	.252	.779	.575
AUXFW	0600200-02-05	4.500	CS	195	.510	.860	.579	.531	.092	.259
AUXFW	0600200-02-05	4.500	CS	196	.488	.826	.555	.509	.081	.244
AUXFW	0600200-02-05	4.500	CS	19X	.456	.781	.524	.482	.068	.223
AUXFW	0600200-02-05	4.500	CS	86	.498	.783	.524	.476	.015	.209
AUXFW	0600200-02-05	4.500	CS	90	.310	.312	.208	.168	.228	.260
AUXFW	0600200-02-05	6.625	CS	13	.382	.540	.375	1.075	.231	.292
AUXFW	0600200-02-05	6.625	CS	44	.437	.489	.327	.676	.302	.356
AUXFW	0600200-02-05	6.625	CS	55	.329	.532	.366	1.128	.284	.301
AUXFW	0600200-02-05	6.625	CS	55A	.309	.398	.278	.909	.297	.301
AUXFW	0600200-02-05	6.625	CS	8	.354	.598	.400	.660	.356	.355
AUXFW	0600200-02-05	6.625	CS	93A	.382	.365	.247	.194	.074	.197
AUXFW	0600200-02-05	6.625	CS	B13	.337	.562	.387	1.171	.284	.305
AUXFW	0600200-02-05	16.000	CS	2A	.010	.007	.005	.004	0.000	.004
AUXFW	0600200-02-05	16.000	CS	2AC	.047	.092	.062	.108	.063	.056
AUXFW	0600200-02-05	16.000	CS	2E	.020	.063	.042	.049	.107	.072
AUXFW	0600200-02-05	16.000	CS	2EA	.023	.035	.024	.036	.087	.061
AUXFW	0600200-02-05	16.000	CS	2F	.038	.101	.066	.083	.122	.088
AUXFW	0600200-02-05	16.000	CS	ZZ	.018	.062	.041	.056	.074	.052
AUXFW	0600200-02-05	16.000	CS	ZZA	.022	.037	.025	.029	.027	.025
AUXFW	0600200-02-08	4.500	CS	222	.193	.337	.225	.233	1.227	.814
AUXFW	0600200-02-08	4.500	CS	222A	.193	.338	.225	.234	1.157	.771
AUXFW	N3-03-05A	4.500	CS	717	.269	1.049	.704	.720	.174	.213
AUXFW	N3-03-05A	4.500	CS	729	.263	1.111	.745	.753	.525	.419
AUXFW	N3-03-05A	4.500	CS	729Z	.263	1.107	.742	.749	.444	.371
AUXFW	N3-03-05A	4.500	CS	A20	.268	.655	.439	.428	.139	.191
AUXFW	N3-03-05A	4.500	CS	A24	.268	.869	.583	.585	.135	.188
AUXFW	N3-03-05A	4.500	CS	A48	.263	1.077	.722	.727	.423	.358
AUXFW	N3-03-05A	4.500	CS	A50	.263	1.058	.709	.713	.457	.379
AUXFW	N3-03-05A	4.500	CS	A52	.263	1.038	.696	.698	.432	.365
AUXFW	N3-03-05A	8.625	CS	23Y	.130	.259	.172	.165	.169	.153
AUXFW	N3-03-05A	8.625	CS	IN22	.053	.401	.268	.289	.012	.029
AUXFW	N3-03-05A	8.625	CS	IN23	.053	.417	.279	.299	.015	.030
AUXFW	N3-03-05A	8.625	CS	IN24	.051	.393	.263	.282	.012	.028
AUXFW	N3-03-05A	8.625	CS	IN25	.057	.373	.249	.266	.025	.038

(Table 6-1, Continued)

System	Calc package	O.D.	Mat'l	Node	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
AUXFW	N3-03-05A	8.625	CS	IN26	.057	.332	.221	.235	.029	.040
AUXFW	N3-03-13A	3.500	CS	153	.599	.927	.619	.673	.065	.279
AUXFW	N3-03-13A	3.500	CS	154	.555	.844	.565	.608	.074	.266
AUXFW	N3-03-13A	4.500	CS	100	.286	.371	.252	.283	.440	.379
AUXFW	N3-03-13A	4.500	CS	106	.262	.453	.344	.340	.118	.177
AUXFW	N3-03-13A	4.500	CS	148	.516	.566	.379	.353	.043	.232
AUXFW	N3-03-13A	4.500	CS	158	.395	.442	.301	.279	.105	.221
AUXFW	N3-03-13A	4.500	CS	356	.351	.475	.343	.365	.087	.193
AUXFW	N3-03-13A	4.500	CS	368	.291	.406	.277	.320	.547	.444
AUXFW	N3-03-13A	4.500	CS	PK	.301	.434	.299	.352	.621	.493
AUXFW	N3-03-13A	4.500	CS	PW1	.312	.489	.336	.410	1.028	.741
ERCW	N3-67-01A	8.625	CS	449Y	.091	.147	.099	.102	.675	.442
ERCW	N3-67-01A	8.625	CS	475E	.129	.197	.133	.134	.133	.132
ERCW	N3-67-01A	8.625	CS	IEB	.093	.139	.092	.094	.635	.418
ERCW	N3-67-01A	8.625	CS	LYH	.098	.146	.097	.098	.314	.228
ERCW	N3-67-01A	8.625	SS	737X	.088	.183	.123	.146	.332	.234
ERCW	N3-67-01A	8.625	SS	L17	.114	.195	.131	.148	.204	.168
ERCW	N3-67-01A	18.000	CS	224	.284	.356	.238	.235	.040	.138
ERCW	N3-67-01A	18.000	CS	224A	.293	.358	.238	.232	.040	.142
ERCW	N3-67-01A	18.000	CS	FL20	.162	.214	.142	.140	.116	.135
ERCW	N3-67-01A	18.000	CS	WP14A	.203	.249	.165	.162	.024	.115
ERCW	N3-67-01A	24.000	CS	48Y	.291	.377	.250	.249	.085	.167
ERCW	N3-67-01A	24.000	CS	54X	.268	.409	.273	.296	.207	.231
ERCW	N3-67-01A	24.000	CS	WP4	.266	.405	.270	.292	.203	.228
ERCW	N3-67-01A	30.000	CS	26E	.258	.294	.196	.186	.223	.237
ERCW	N3-67-01A	30.000	CS	37	.452	.598	.399	.408	.405	.424
ERCW	N3-67-02A	8.625	CS	646	.170	.467	.310	.377	.324	.262
ERCW	N3-67-02A	8.625	CS	646A	.162	.444	.296	.358	.344	.272
ERCW	N3-67-02A	8.625	CS	124	.098	.407	.270	.366	.402	.281
ERCW	N3-67-02A	8.625	CS	P21	.095	.446	.297	.407	.465	.317
ERCW	N3-67-02A	18.000	CS	1298	.162	.184	.122	.115	.129	.142
ERCW	N3-67-02A	18.000	CS	95	.253	.410	.274	.305	.019	.112
ERCW	N3-67-02A	18.000	CS	M40A	.273	.397	.265	.283	.024	.123
ERCW	N3-67-02A	18.000	CS	M40B	.286	.446	.297	.326	.019	.126
ERCW	N3-67-02A	18.000	CS	M40C	.281	.452	.301	.334	.018	.122
ERCW	N3-67-02A	20.000	CS	449	.247	.275	.185	.169	.026	.114
ERCW	N3-67-02A	20.000	CS	I142	.232	.257	.171	.157	.023	.106
ERCW	N3-67-02A	24.000	CS	187	.312	.463	.310	.323	.616	.495
ERCW	N3-67-02A	24.000	CS	188	.311	.460	.307	.321	.609	.490
ERCW	N3-67-02A	24.000	CS	196	.339	.713	.476	.538	.051	.166
ERCW	N3-67-02A	24.000	CS	202	.368	.659	.439	.482	.032	.166
ERCW	N3-67-09A	4.500	CS	KK5	.096	.350	.232	.303	1.164	.738
ERCW	N3-67-09A	4.500	SS	88Y	.092	.382	.255	.341	.762	.493
ERCW	N3-67-09A	6.625	CS	553Z	.194	.234	.156	.150	.547	.407
ERCW	N3-67-09A	6.625	CS	JJ2	.133	.246	.163	.184	.550	.383
ERCW	N3-67-09A	12.750	CS	V2	.232	.380	.253	.273	.449	.362

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(Table 6-1, Continued)

System	Calc package	O.D.	Mat'l	Node	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-09A	12.750	CS	V3	.155	.285	.190	.211	.264	.221
ERCW	N3-67-09A	12.750	CS	V3A	.156	.280	.186	.206	.256	.216
ERCW	N3-67-09A	12.750	SS	V13	.247	.540	.360	.417	.062	.135
ERCW	N3-67-09A	12.750	SS	V14	.287	.664	.443	.519	.043	.140
ERCW	N3-67-09A	14.000	CS	Q24	.172	.284	.189	.206	.048	.098
ERCW	N3-67-09A	14.000	SS	Q21	.259	.426	.283	.309	.070	.145
ERCW	N3-67-09A	16.000	CS	306Y	.214	.258	.171	.164	.231	.225
ERCW	N3-67-09A	18.000	CS	536	.228	.339	.226	.237	.156	.185
ERCW	N3-67-09A	18.000	CS	Q906	.393	.349	.232	.184	.015	.166
ERCW	N3-67-09A	20.000	CS	275A	.279	.347	.232	.222	.036	.133
ERCW	N3-67-09A	20.000	CS	277	.219	.305	.203	.206	.027	.104
ERCW	N3-67-09A	24.000	CS	172	.293	.325	.216	.196	.088	.170
ERCW	N3-67-09A	24.000	CS	223	.266	.292	.195	.178	.476	.391
ERCW	N3-67-09A	30.000	CS	493A	.293	.320	.213	.193	.035	.138
ERCW	N3-67-09A	36.000	CS	49	.349	.516	.344	.399	.297	.318
ERCW	N3-67-09A	36.000	CS	595	.351	.342	.228	.192	.202	.262
ERCW	N3-67-09A	36.000	CS	598	.358	.342	.228	.191	.382	.373
ERCW	N3-67-09A	36.000	CS	598A	.355	.334	.223	.184	.249	.292
ERCW	N3-67-09A	36.000	CS	652	.263	.543	.362	.434	.150	.195
ERCW	N3-67-23A	4.500	CS	A36	.151	.302	.202	.232	.037	.083
ERCW	N3-67-24A	3.500	SS	B08	.124	.326	.217	.279	.173	.153
ERCW	N3-67-24A	3.500	SS	B08	.140	.326	.217	.271	.174	.160
ERCW	N3-67-24A	4.500	SS	759	.236	.285	.190	.184	.082	.143
ERCW	N3-67-24A	6.625	CS	702	.236	.401	.268	.300	.044	.121
ERCW	N3-67-24A	6.625	CS	702A	.224	.421	.281	.321	.023	.104
ERCW	N3-67-24A	6.625	CS	705	.289	.488	.326	.359	.045	.142
ERCW	N3-67-24A	6.625	CS	710	.136	.436	.290	.361	.013	.061
ERCW	N3-67-24A	6.625	CS	711	.120	.416	.277	.348	.012	.055
ERCW	N3-67-24A	6.625	CS	720	.294	.575	.384	.436	.020	.130
ERCW	N3-67-24A	6.625	CS	X710	.114	.420	.279	.353	.013	.053
ERCW	N3-67-24A	6.625	CS	Z705	.265	.478	.319	.359	.048	.134
ERCW	N3-67-24A	6.625	SS	C1	.094	.181	.120	.141	.654	.431
ERCW	N3-67-24A	6.625	SS	C37	.313	.559	.373	.414	.029	.142
ERCW	N3-67-24A	6.625	SS	C38	.370	.648	.432	.478	.036	.169
ERCW	N3-67-24A	6.625	SS	C41	.152	.427	.285	.348	.566	.400
ERCW	N3-67-24A	8.625	SS	B05	.103	.144	.096	.102	.017	.051
ERCW	N3-67-24A	8.625	SS	E48	.074	.062	.041	.032	1.389	.863
ERCW	N3-67-39A	2.875	SS	14C	.123	.223	.168	.179	.027	.065
ERCW	N3-67-39A	2.875	SS	B05	.164	.273	.207	.194	.051	.097
ERCW	N3-67-39A	2.875	SS	C20B	.064	.096	.068	.067	.290	.200
ERCW	N3-67-39A	2.875	SS	C20E	.063	.097	.068	.069	.275	.190
ERCW	N3-67-39A	3.500	SS	190	.070	.160	.110	.087	.185	.139
ERCW	N3-67-39A	4.500	CS	C12B	.071	.094	.069	.067	.617	.399
ERCW	N3-67-39A	4.500	CS	C12E	.060	.085	.058	.059	.585	.375
ERCW	N3-67-39A	4.500	CS	C17B	.136	.393	.304	.349	.079	.101
ERCW	N3-67-39A	6.625	CS	99	.080	.097	.066	.064	.158	.128

(Table 6-1, Continued)

System	Calc package	O.D.	Mat'l	Node	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-39A	6.625	SS	131	.103	.099	.066	.056	.836	.543
ERCW	N3-67-39A	6.625	SS	137	.082	.082	.054	.048	.516	.343
ERCW	N3-67-39A	6.625	SS	145	.261	.293	.196	.193	.045	.130
ERCW	N3-67-39A	6.625	SS	146	.166	.172	.115	.106	.138	.149
ERCW	N3-67-39A	6.625	SS	P15M	.067	.062	.041	.033	.535	.347
ERCW	N3-67-43A	2.875	SS	40	.039	.169	.137	.159	.227	.151
ERCW	N3-67-43A	2.875	SS	62	.056	.158	.109	.133	.232	.162
ERCW	N3-67-43A	2.875	SS	C02B	.056	.158	.109	.132	.234	.163
ERCW	N3-67-43A	2.875	SS	C02E	.043	.144	.105	.125	.247	.166
ERCW	N3-67-43A	3.500	CS	490	.206	.351	.234	.258	.432	.342
ERCW	N3-67-43A	3.500	CS	500M	.246	.400	.267	.290	.464	.376
ERCW	N3-67-43A	3.500	SS	24	.056	.092	.061	.067	1.410	.867
ERCW	N3-67-43A	3.500	SS	B03B	.093	.372	.255	.204	.671	.439
ERCW	N3-67-43A	3.500	SS	B04E	.077	.291	.201	.166	.597	.389
ERCW	N3-67-43A	3.500	SS	B05B	.049	.156	.106	.084	1.241	.764
ERCW	N3-67-43A	3.500	SS	B06B	.077	.102	.072	.071	1.304	.812
ERCW	N3-67-43A	3.500	SS	B06E	.066	.101	.068	.072	1.530	1.010
ERCW	N3-67-43A	4.500	CS	C158	.070	.141	.103	.116	.537	.349
ERCW	N3-67-43A	4.500	CS	FL02	.080	.163	.108	.126	.705	.454
ERCW	N3-67-43A	4.500	SS	100L	.062	.106	.081	.076	.041	.050
ERCW	N3-67-43A	4.500	SS	100M	.092	.215	.110	.097	.098	.096
ERCW	N3-67-43A	6.625	CS	500N	.099	.115	.076	.072	.281	.209
ERCW	N3-67-43A	6.625	SS	750	.143	.153	.102	.089	.230	.196
ERCW	N3-67-43A	6.625	SS	770	.099	.112	.075	.069	.202	.161
ERCW	N3-67-43A	6.625	SS	P123	.171	.238	.159	.157	.029	.087
ERCW	N3-76-34A	4.500	CS	40	.078	.072	.048	.039	.171	.134
SFC	N3-78-01A2	8.625	SS	577	.174	.360	.239	.275	.059	.104
SFC	N3-78-01A2	10.750	SS	80	.092	.141	.095	.101	.016	.045
SFC	N3-78-01A3	3.500	SS	502	.081	.332	.221	.300	.681	.447
SFC	N3-78-01A3	3.500	SS	512	.115	.139	.093	.091	.781	.522
SFC	N3-78-01A3	3.500	SS	622	.043	.487	.324	.467	.048	.046
SFC	N3-78-01A3	3.500	SS	906	.050	.058	.039	.037	.536	.348
SFC	N3-78-01A3	3.500	SS	908	.081	.109	.073	.075	1.169	.746
SFC	N3-78-01A3	3.500	SS	909	.070	.086	.058	.057	.807	.520
SFC	N3-78-01A3	4.500	SS	383	.155	.191	.127	.125	.022	.074
SFC	N3-78-01A3	10.750	SS	120A	.080	.139	.093	.105	.281	.204
SFC	N3-78-01A3	10.750	SS	120B	.090	.144	.097	.107	.268	.199
SFC	N3-78-01A3	10.750	SS	331	.076	.109	.072	.076	.199	.151
SFC	N3-78-01A4	10.750	SS	182	.082	.392	.262	.340	.020	.044
SFC	N3-78-12A	3.500	SS	255	.035	.046	.031	.032	.613	.388
SFC	N3-78-12A	3.500	SS	30	.038	.046	.030	.029	1.081	.675
SFC	N3-78-12A	3.500	SS	36	.037	.044	.029	.026	.993	.621
SFC	N3-78-12A	3.500	SS	37	.035	.040	.026	.024	.871	.545
SFC	N3-78-12A	3.500	SS	55	.071	.069	.046	.038	.311	.218

Table 6-2

RESULTS OF SECTION XI ANALYSIS FOR NODES WITH WELD SIFs

System	Calc package	O.D.	Mat'l	Node	a/t (N/U)	theta/pi (N/U)	a/t (E/F)	theta/pi (E/F)	a/t (fatigue)	theta/pi (fatigue)	mode (N/U)	mode (E/F)
AUXFW	0600200-02-05	2.375	CS	646	.437	.400	.729	.400	.481	.400	EPFM	EPFM
AUXFW	0600200-02-05	2.375	CS	646X	.447	.400	.733	.400	.509	.400	EPFM	EPFM
AUXFW	0600200-02-05	2.375	CS	647Z	.492	.400	.750	.400	.461	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	125	.679	.400	.679	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	125Y	.690	.400	.720	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	127	.750	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	127B	.750	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	128	.527	.400	.505	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	13P	.638	.400	.641	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	13Q	.637	.400	.632	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	164A	.588	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	195	.442	.400	.750	.400	.452	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	196	.488	.400	.750	.400	.451	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	19X	.545	.400	.750	.400	.451	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	86	.568	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	90	.750	.400	.750	.400	.468	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	13	.706	.400	.060	.400	.468	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	44	.726	.400	.531	.400	.501	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	55	.690	.400	.000	.400	.489	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	55A	.750	.400	.250	.400	.497	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	8	.584	.400	.521	.400	.597	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	93A	.601	.400	.750	.400	.455	.400	LEFM	LEFM
AUXFW	0600200-02-05	6.625	CS	B13	.658	.400	.000	.400	.489	.400	EPFM	EPFM
AUXFW	0600200-02-05	16.000	CS	2A	.750	.400	.750	.400	.450	.400	Limit	Limit
AUXFW	0600200-02-05	16.000	CS	2AC	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-05	16.000	CS	2E	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-05	16.000	CS	2EA	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-05	16.000	CS	2F	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-05	16.000	CS	ZZ	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-05	16.000	CS	ZZA	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	0600200-02-08	4.500	CS	222	.452	.400	.577	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-08	4.500	CS	222A	.488	.400	.611	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	717	.171	.400	.574	.400	.453	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	729	.000	.400	.354	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	729Z	.000	.400	.402	.400	.634	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A20	.657	.400	.750	.400	.451	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A24	.420	.400	.736	.400	.451	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A48	.000	.400	.440	.400	.560	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A50	.000	.400	.438	.400	.719	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A52	.020	.400	.468	.400	.584	.400	EPFM	EPFM
AUXFW	N3-03-05A	8.625	CS	23Y	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-05A	8.625	CS	IN22	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-05A	8.625	CS	IN23	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-05A	8.625	CS	IN24	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-05A	8.625	CS	IN25	.750	.400	.750	.400	.450	.400	EPFM	EPFM

APTECH ENGINEERING SERVICES, INC.

(Table 6-2, Continued)

System	Calc package	O.D.	Mat'l	Node	a/t (N/U)	theta/pi (N/U)	a/t (E/F)	theta/pi (E/F)	a/t (fatigue)	theta/pi (fatigue)	mode (N/U)	mode (E/F)
AUXFW	N3-03-05A	8.625	CS	IN26	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-13A	3.500	CS	153	.353	.400	.655	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-13A	3.500	CS	154	.452	.400	.722	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	100	.750	.400	.750	.400	.614	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	106	.750	.400	.750	.400	.451	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	148	.750	.400	.750	.400	.451	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	158	.750	.400	.750	.400	.451	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	356	.750	.400	.750	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	368	.724	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	PK	.660	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	PW1	.393	.400	.491	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	CS	449Y	.750	.400	.750	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	CS	475E	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	CS	IEB	.750	.400	.750	.400	.975	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	CS	LYH	.750	.400	.750	.400	.453	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	SS	737X	.750	.400	.750	.400	.458	.400	Limit	Limit
ERCW	N3-67-01A	8.625	SS	L17	.750	.400	.750	.400	.452	.400	Limit	Limit
ERCW	N3-67-01A	18.000	CS	224	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-01A	18.000	CS	224A	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-01A	18.000	CS	FL20	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-01A	18.000	CS	WP14A	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-01A	24.000	CS	48Y	.665	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-01A	24.000	CS	54X	.503	.400	.723	.400	.453	.400	EPFM	EPFM
ERCW	N3-67-01A	24.000	CS	WP4	.514	.400	.733	.400	.452	.400	EPFM	EPFM
ERCW	N3-67-01A	30.000	CS	26E	.568	.400	.750	.400	.456	.400	EPFM	EPFM
ERCW	N3-67-01A	30.000	CS	37	.000	.400	.121	.400	.533	.400	EPFM	EPFM
ERCW	N3-67-02A	8.625	CS	646	.726	.400	.750	.400	.453	.400	EPFM	EPFM
ERCW	N3-67-02A	8.625	CS	646A	.742	.400	.750	.400	.454	.400	EPFM	EPFM
ERCW	N3-67-02A	8.625	CS	I24	.750	.400	.750	.400	.460	.400	EPFM	EPFM
ERCW	N3-67-02A	8.625	CS	P21	.676	.400	.723	.400	.473	.400	EPFM	EPFM
ERCW	N3-67-02A	18.000	CS	1298	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	18.000	CS	95	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	18.000	CS	M40A	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	18.000	CS	M40B	.730	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	18.000	CS	M40C	.723	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	20.000	CS	449	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	20.000	CS	I142	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	187	.000	.400	.318	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	188	.000	.400	.330	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	196	.000	.400	.400	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	202	.138	.400	.528	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	4.500	CS	KK5	.750	.400	.750	.400	.552	.400	EPFM	EPFM
ERCW	N3-67-09A	4.500	SS	88Y	.750	.400	.750	.400	.476	.400	Limit	Limit
ERCW	N3-67-09A	6.625	CS	553Z	.750	.400	.750	.400	.452	.400	EPFM	EPFM
ERCW	N3-67-09A	6.625	CS	JJ2	.750	.400	.750	.400	.451	.400	EPFM	EPFM
ERCW	N3-67-09A	12.750	CS	V2	.683	.400	.750	.400	.482	.400	EPFM	EPFM

(Table 6-2, Continued)

System	Calc package	O.D.	Mat'l	Node	a/t (N/U)	theta/pi (N/U)	a/t (E/F)	theta/pi (E/F)	a/t (fatigue)	theta/pi (fatigue)	mode (N/U)	mode (E/F)
ERCW	N3-67-09A	12.750	CS	V3	.750	.400	.750	.400	.452	.400	EPFM	EPFM
ERCW	N3-67-09A	12.750	CS	V3A	.750	.400	.750	.400	.452	.400	EPFM	EPFM
ERCW	N3-67-09A	12.750	SS	V13	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-09A	12.750	SS	V14	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-09A	14.000	CS	Q24	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	14.000	SS	Q21	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-09A	16.000	CS	306Y	.750	.400	.750	.400	.452	.400	EPFM	EPFM
ERCW	N3-67-09A	18.000	CS	536	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	18.000	CS	Q906	.750	.400	.750	.400	.451	.400	LEFM	LEFM
ERCW	N3-67-09A	20.000	CS	275A	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	20.000	CS	277	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	24.000	CS	172	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	24.000	CS	223	.496	.400	.720	.400	.616	.400	EPFM	EPFM
ERCW	N3-67-09A	30.000	CS	493A	.750	.400	.750	.400	.450	.400	LEFM	EPFM
ERCW	N3-67-09A	36.000	CS	49	.000	.400	.000	.400	.505	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	595	.315	.400	.720	.400	.458	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	598	.075	.400	.531	.400	.562	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	598A	.278	.400	.690	.400	.465	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	652	.000	.400	.000	.400	.454	.400	EPFM	EPFM
ERCW	N3-67-23A	4.500	CS	A36	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	3.500	SS	B08	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-24A	3.500	SS	B08	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-24A	4.500	SS	759	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-24A	6.625	CS	702	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	702A	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	705	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	710	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	711	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	720	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	X710	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	CS	Z705	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-24A	6.625	SS	C1	.750	.400	.750	.400	.459	.400	Limit	Limit
ERCW	N3-67-24A	6.625	SS	C37	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-24A	6.625	SS	C38	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-24A	6.625	SS	C41	.750	.400	.750	.400	.455	.400	Limit	Limit
ERCW	N3-67-24A	8.625	SS	B05	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-24A	8.625	SS	E48	.750	.400	.750	.400	1.000	.400	Limit	Limit
ERCW	N3-67-39A	2.875	SS	14C	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	2.875	SS	B05	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	2.875	SS	C20B	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	2.875	SS	C20E	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	3.500	SS	190	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	4.500	CS	C12B	.750	.400	.750	.400	.452	.400	EPFM	EPFM
ERCW	N3-67-39A	4.500	CS	C12E	.750	.400	.750	.400	.451	.400	EPFM	EPFM
ERCW	N3-67-39A	4.500	CS	C17B	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-39A	6.625	CS	99	.750	.400	.750	.400	.450	.400	EPFM	EPFM

(Table 6-2, Continued)

System	Calc package	O.D.	Mat'l	Node	a/t (N/U)	theta/pi (N/U)	a/t (E/F)	theta/pi (E/F)	a/t (fatigue)	theta/pi (fatigue)	mode (N/U)	mode (E/F)
ERCW	N3-67-39A	6.625	SS	131	.750	.400	.750	.400	.473	.400	Limit	Limit
ERCW	N3-67-39A	6.625	SS	137	.750	.400	.750	.400	.454	.400	Limit	Limit
ERCW	N3-67-39A	6.625	SS	145	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	6.625	SS	146	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-39A	6.625	SS	P15M	.750	.400	.750	.400	.454	.400	Limit	Limit
ERCW	N3-67-43A	2.875	SS	40	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	2.875	SS	62	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	2.875	SS	C02B	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	2.875	SS	C02E	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	3.500	CS	490	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-43A	3.500	CS	500M	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-43A	3.500	SS	24	.750	.400	.750	.400	.736	.400	Limit	Limit
ERCW	N3-67-43A	3.500	SS	B03B	.750	.400	.750	.400	.457	.400	Limit	Limit
ERCW	N3-67-43A	3.500	SS	B04E	.750	.400	.750	.400	.454	.400	Limit	Limit
ERCW	N3-67-43A	3.500	SS	B05B	.750	.400	.750	.400	.551	.400	Limit	Limit
ERCW	N3-67-43A	3.500	SS	B06B	.750	.400	.750	.400	.590	.400	Limit	Limit
ERCW	N3-67-43A	3.500	SS	B06E	.750	.400	.750	.400	1.000	.400	Limit	Limit
ERCW	N3-67-43A	4.500	CS	C158	.750	.400	.750	.400	.451	.400	EPFM	EPFM
ERCW	N3-67-43A	4.500	CS	FL02	.750	.400	.750	.400	.454	.400	EPFM	EPFM
ERCW	N3-67-43A	4.500	SS	100L	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	4.500	SS	100M	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	6.625	CS	500N	.750	.400	.750	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-43A	6.625	SS	750	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	6.625	SS	770	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-67-43A	6.625	SS	P123	.750	.400	.750	.400	.450	.400	Limit	Limit
ERCW	N3-76-34A	4.500	CS	40	.750	.400	.750	.400	.450	.400	EPFM	EPFM
SFC	N3-78-01A2	8.625	SS	577	.750	.400	.750	.400	.450	.400	Limit	Limit
SFC	N3-78-01A2	10.750	SS	80	.750	.400	.750	.400	.450	.400	Limit	Limit
SFC	N3-78-01A3	3.500	SS	502	.750	.400	.750	.400	.461	.400	Limit	Limit
SFC	N3-78-01A3	3.500	SS	512	.750	.400	.750	.400	.470	.400	Limit	Limit
SFC	N3-78-01A3	3.500	SS	622	.750	.400	.750	.400	.450	.400	Limit	Limit
SFC	N3-78-01A3	3.500	SS	906	.750	.400	.750	.400	.454	.400	Limit	Limit
SFC	N3-78-01A3	3.500	SS	908	.750	.400	.750	.400	.605	.400	Limit	Limit
SFC	N3-78-01A3	3.500	SS	909	.750	.400	.750	.400	.473	.400	Limit	Limit
SFC	N3-78-01A3	4.500	SS	383	.750	.400	.750	.400	.450	.400	Limit	Limit
SFC	N3-78-01A3	10.750	SS	120A	.750	.400	.750	.400	.458	.400	Limit	Limit
SFC	N3-78-01A3	10.750	SS	120B	.750	.400	.750	.400	.457	.400	Limit	Limit
SFC	N3-78-01A3	10.750	SS	331	.750	.400	.750	.400	.453	.400	Limit	Limit
SFC	N3-78-01A4	10.750	SS	182	.750	.400	.750	.400	.450	.400	Limit	Limit
SFC	N3-78-12A	3.500	SS	255	.750	.400	.750	.400	.458	.400	Limit	Limit
SFC	N3-78-12A	3.500	SS	30	.750	.400	.750	.400	.543	.400	Limit	Limit
SFC	N3-78-12A	3.500	SS	36	.750	.400	.750	.400	.509	.400	Limit	Limit
SFC	N3-78-12A	3.500	SS	37	.750	.400	.750	.400	.482	.400	Limit	Limit
SFC	N3-78-12A	3.500	SS	55	.750	.400	.750	.400	.451	.400	Limit	Limit

Table 6-3

SUMMARY OF NODES THAT FAILED THE SECTION XI ACCEPTANCE CRITERIA

System	Calc package	O.D.	Mat'l	Node	a/t (N/U)	theta/pi (N/U)	a/t (E/F)	theta/pi (E/F)	a/t (fatigue)	theta/pi (fatigue)	mode (N/U)	mode (E/F)
AUXFW	0600200-02-05	2.375	CS	646	.437	.400	.729	.400	.481	.400	EPFM	EPFM
AUXFW	0600200-02-05	2.375	CS	646X	.447	.400	.733	.400	.509	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	125	.679	.400	.679	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	125Y	.690	.400	.720	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	127	.750	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	127B	.750	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	128	.527	.400	.505	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	13P	.638	.400	.641	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	13Q	.637	.400	.632	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	164A	.588	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-05	4.500	CS	195	.442	.400	.750	.400	.452	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	13	.706	.400	.060	.400	.468	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	55	.690	.400	.000	.400	.489	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	55A	.750	.400	.250	.400	.497	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	8	.584	.400	.521	.400	.597	.400	EPFM	EPFM
AUXFW	0600200-02-05	6.625	CS	B13	.658	.400	.000	.400	.489	.400	EPFM	EPFM
AUXFW	0600200-02-08	4.500	CS	222	.452	.400	.577	.400	1.000	.400	EPFM	EPFM
AUXFW	0600200-02-08	4.500	CS	222A	.488	.400	.611	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	717	.171	.400	.574	.400	.453	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	729	.000	.400	.354	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	729Z	.000	.400	.402	.400	.634	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A24	.420	.400	.736	.400	.451	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A48	.000	.400	.440	.400	.560	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A50	.000	.400	.438	.400	.719	.400	EPFM	EPFM
AUXFW	N3-03-05A	4.500	CS	A52	.020	.400	.468	.400	.584	.400	EPFM	EPFM
AUXFW	N3-03-13A	3.500	CS	153	.353	.400	.655	.400	.450	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	368	.724	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	PK	.660	.400	.750	.400	1.000	.400	EPFM	EPFM
AUXFW	N3-03-13A	4.500	CS	PW1	.393	.400	.491	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	CS	449Y	.750	.400	.750	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-01A	8.625	CS	IEB	.750	.400	.750	.400	.975	.400	EPFM	EPFM
ERCW	N3-67-01A	30.000	CS	37	.000	.400	.121	.400	.533	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	187	.000	.400	.318	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	188	.000	.400	.330	.400	1.000	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	196	.000	.400	.400	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-02A	24.000	CS	202	.138	.400	.528	.400	.450	.400	EPFM	EPFM
ERCW	N3-67-09A	24.000	CS	223	.496	.400	.720	.400	.616	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	49	.000	.400	.000	.400	.505	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	595	.315	.400	.720	.400	.458	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	598	.075	.400	.531	.400	.562	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	598A	.278	.400	.690	.400	.465	.400	EPFM	EPFM
ERCW	N3-67-09A	36.000	CS	652	.000	.400	.000	.400	.454	.400	EPFM	EPFM
ERCW	N3-67-24A	8.625	SS	E48	.750	.400	.750	.400	1.000	.400	Limit	Limit
ERCW	N3-67-43A	3.500	SS	B06E	.750	.400	.750	.400	1.000	.400	Limit	Limit

Section 7

SUMMARY AND CONCLUSIONS

- A random sampling procedure was used to characterize the extent of LOP/LOF in Class 3 welds at WBN. The procedure included checks that demonstrated homogeneity.

- A statistical analysis identified one welder (6EL) whose workmanship was judged substandard. All other suspects were found to be equal to the general population when additional RT samples were analyzed. On this basis, the inspection data for 6EL welder were removed from the database.

- Inspection data from the sample of Class 3 welds (i.e., all data minus 6EL data) showed that the bounding flaw size (95% reliability at 95% confidence) is 18% of the pipe section area.

- Stress data for the three systems judged to be the most highly stressed have been reviewed to identify bounding stress levels for input to the analysis.

- Using conservative combinations of flaw size, flaw location and stresses, flaw evaluations were performed.

- The stress results of the flaw evaluations were compared with the stress requirements of ASME Section III. Nine of the nodes analyzed failed to meet Section III allowables when the effect of LOP/LOF on the net section was considered.

- The flaw evaluations based on Section XI acceptance criteria showed that 44 total nodes (potential weld locations) could not tolerate the bounding flaw. All of the nodes that failed Section III also failed Section XI.

- The 44 non-conforming nodes (potential weld locations) were further evaluated with the following results. Thirty-four node locations did not correspond to Class 3 weld locations. The ten remaining welds were dispositioned on a case-by-case basis.

- On the basis of the above analyses, we conclude that there is high confidence that all welds that fall within the scope of this project meet the allowable stress requirements of ASME Sections III and XI.

- To evaluate the welds which had LOP/LOF in excess of 18%, the assessments were repeated using location specific flaw data and stress information. This evaluation, which included all inspection data including 6EL, confirmed that all inspected locations satisfied the allowable stress limits of ASME Sections III and XI. Therefore, the observed conditions would not have caused a safety issue if the existing conditions had gone undetected prior to plant operation.

Section 8
APPLICATION OF THESE ANALYSES TO WATTS BAR NUCLEAR PLANT, UNIT 2

8.1 INTRODUCTION

The analyses described in this report have been developed to cover the scope identified in Section 1. This covers Class 3 welds at WBN, Unit 1, and the common systems required for Unit 1 and start-up. This section outlines recommendations to apply the results to Unit 2.

8.2 BACKGROUND

Although Unit 2 construction was behind Unit 1 in time, there are factors that indicate the same weld quality may be expected in Unit 1 as Unit 2. From the upper tier documents (PSAR) through to the same crafts-people there are common factors between Unit 1 and Unit 2. This fact was established by the WEP, Phase II.

8.3 STRATEGY FOR UNIT 2

Based on the above expected similarities in weld quality between Units 1 and 2 the following steps will ensure that the Unit 2 welds meet the design requirements:

1. Check to see if the substandard welder worked on Unit 2
2. If yes, check all those welds with RT
3. Perform a reduced sample of RT to confirm the 95%/95% bounding flaw size from Unit 1 data. An hypothesis can be set up to check this; it can be confirmed with about 20 samples.
4. Scan the Unit 2 stress analysis packages to determine that the highest stresses in the Unit 1 analysis also would envelop Unit 2 stresses.

5. Perform limited analyses to evaluate ASME Section III and Section XI criteria

These tasks will lead to the conclusion that the Unit 2 LOP/LOF issue is adequately covered by the present analysis on Unit 1.

Appendix A

RADIOGRAPHIC TESTING EXAMINATION RESULTS

WATTS BAR CLASS THREE PIPING RADIOGRAPHY AND UT RESULT SUMMARY

RANDOM SAMPLE POPULATION - 84 WELDS

…	Mat.	Size	Thk	Weld Number	TVA RT INTERPRETATION	APTECH RT INTERPRETATION	Tot "L"	Tot LOP	% LOP/ CIRC	RT Depth	UT Depth	UT Thick	Comments
3	SS/SS	6.0"	.280"	0-067J-T145-10	NO INDICATIONS	SAME	"	"	%				VERY LIGHT DENSITY, PENNY VISIBLE, NO DEFECTS
5	SS/SS	4.0"	.237"	1-067C-T257-02	NO INDICATIONS	SAME	"	"	%				
6	SS/SS	4.0"	.237"	2-067A-T138-63	NO INDICATIONS	SAME	"	"	%				
8	SS/SS	3.0"	.216"	1-067C-T262-26	NO INDICATIONS	SAME	"	"	%				
0	SS/SS	12.0"	.375"	2-067J-T301-05B	.6,1.1,1.6,.75 LOP	1.1,.6,1.5,.7 LOP	41.20 "	4.05"	9.8%	.029			
1	CS/CS	3.0"	.216"	2-070A-T248-02	0.25 LOF TRANSVERSE - STOP/START IN TIG ROOT	.25 LOF (SAME)	12.48 "	.25"	2.0%	.046			
2	SS/SS	6.0"	.280"	0-067J-T145-09	.375,1.125,2.175,.565,1.375 IP .3 TOT MIC	.313,1.125,1.0625,.5625,1.3125	20.65 "	5.61"	27.2%	<.1	.060	.300	UT DEPTH 12-7-90 @ L=12-13"
4	SS/SS	4.0"	.237"	1-067C-T286-23	NO INDICATIONS	SAME	"	"	%				
5	SS/SS	2.5"	.203"	1-067J-T597-01	NO INDICATIONS	SAME	"	"	%				
8	SS/SS	4.0"	.237"	2-067J-T349-01B	2.425,2 IP	1.125	15.14 "	4.43"	29.2%	.071	.080	.335	UT DEPTH 12-4-90
9	CS/CS	3.0"	.216"	2-067B-D266-04	.2 SLAG, .1,.3,1.0,.4 POROSITY (cluster)	.2 SLAG	"	"	%				BACKING RING
0	CS/CS	4.0"	.237"	1-070A-D138-05	NO INDICATIONS	SAME	"	"	%				
1	SS/SS	4.0"	.237"	1-067A-T140-59	NO INDICATIONS	SAME	"	"	%				
2	SS/SS	6.0"	.280"	2-067J-T519-08A	NO INDICATIONS	SAME	"	"	%				
3	SS/SS	2.5"	.203"	2-067J-T372-07	NO INDICATIONS	SAME	"	"	%				
4	SS/SS	6.0"	.280"	0-067J-T141-03A	NO INDICATIONS	SAME	"	"	%				
5	SS/SS	3.0"	.216"	1-067C-T289-08	NO INDICATIONS	SAME	"	"	%				
0	SS/SS	2.5"	.203"	1-067B-T435-06	1,1.5 IP	.125,.1875,.25,.4375,.125	10.20 "	2.50"	24.5%	.038			
2	CS/CS	12.0"	.375"	2-070A-D064-03	NO INDICATIONS	SAME	"	"	%				
3	SS/SS	6.0"	.280"	0-067E-T131-12	NO INDICATIONS	SAME	"	"	%				
4	SS/SS	4.0"	.237"	1-067J-T605-02	NO INDICATIONS	SAME	"	"	%				
5	CS/CS	30.0"	.375"	2-067H-T120-18	14.5 MIC (TOTAL LENGTH)	NO LOP/LOF	"	"	%				CONCENTRIC REDUCER - 1 OF 6 LONG SEAMS - PREVIOUSLY RT'D
8	SS/SS	12.0"	.375"	1-067J-T526-01	9.25,3.25,.375,6.125,3.85 LOP/LOF	9.25,3.25,.25,5.6,1.5,1.9 LOP/LOF	40.68 "	22.85"	56.2%	.05	.205	.425	UT DEPTH .205 MAX 12-2-90 FILM 1-2 L=15-16
9	SS/SS	6.0"	.280"	2-067B-T173-06	.2 LOP	.2 LOP	22.10 "	.20"	.9%	<.1			
0	CS/CS	8.0"	.322"	1-067G-T041-15	.805 MIC	NO LOP/LOF	"	"	%				
1	CS/CS	8.0"	.322"	2-067G-T046-08	.25 MIC, .465 POROSITY	NO LOP/LOF	"	"	%				
3	SS/SS	3.0"	.216"	1-067C-T260-35	NO INDICATIONS	SAME	"	"	%				

PARED BY Scott Melby DATE 12/18/90 CHECKED BY [signature] DATE [illegible]

#	Mat.	Size	Thk	Weld Number	TVA RT INTERPRETATION	APTECH RT INTERPRETATION	Tot "L"	Tot LOP	% LOP/ CIRC	RT Depth	UT Depth	UT Thick	Comments
4	CS/CS	3.0"	.216"	1-070B-D172-20B	NO INDICATIONS	SAME	"	"	%				NEXT TO 1-070B-D172-20C - ALSO RADIOGRAPHED
5	SS/SS	3.0"	.216"	2-067J-T495-02	NO INDICATIONS	SAME	"	"	%				
6	SS/SS	2.0"	.154"	1-067C-T257-70	NO INDICATIONS	SAME	"	"	%				
7	SS/SS	3.0"	.216"	2-067J-T495-06	NO INDICATIONS	SAME	"	"	%				
8	SS/SS	8.0"	.322"	1-067J-T606-10	NO INDICATIONS	SAME	"	"	%				
2	SS/SS	4.0"	.237"	1-067J-T604-04	NO INDICATIONS - SURFACE GROOVE	SAME	"	"	%				
4	SS/SS	18.0"	.375"	1-067J-T635-03	NO INDICATIONS	SAME	"	"	%				
5	SS/SS	6.0"	.280"	0-067J-T177-03	.31 LOP, .125 MIC	.3 LOP	20.51 "	.31"	1.5%	<.1			
6	SS/SS	4.0"	.237"	1-067C-T281-05	NO INDICATIONS	SAME	"	"	%				
7	SS/SS	6.0"	.280"	0-067E-T154-02	NO INDICATIONS	SAME	"	"	%				
8	CS/CS	4.0"	.237"	1-070B-D170-03	NO INDICATIONS	SAME	"	"	%				
9	CS/CS	20.0"	.375"	0-067A-T105-02	.270,.625 SLAG, POROSITY	NO LOP/LOF	"	"	%				PITTING IN BASE METAL - BACKING RING
1	SS/SS	2.0"	.154"	1-067C-T270-20	NO INDICATIONS	SAME	"	"	%				
3	CS/CS	10.0"	.365"	2-067G-T047-16	NO INDICATIONS	SAME	"	"	%				
5	CS/CS	12.0"	.375"	0-026H-T012-09	.375 SLAG	NO LOP/LOF	"	"	%				BACKING RING
8	CS/CS	24.0"	.375"	1-067B-D186-06	7.235 MIC TOT 1.06 SLAG	NO LOP/LOF	"	"	%				
9	SS/SS	12.0"	.375"	1-067J-T525-04	NO INDICATIONS	SAME	"	"	%				
0	SS/SS	2.0"	.154"	1-067J-T598-02	NO INDICATIONS	SAME	"	"	%				
1	SS/SS	3.0"	.216"	1-067C-T287-33	.625 IF	.625 IF	11.90 "	.63"	5.3%	<.1			
2	CS/CS	8.0"	.365"	1-070A-T239-05	2.375, 0.25 LOP	2.3,0.25	34.89 "	2.63"	7.5%	.048			
3	CS/CS	3.0"	.216"	2-070A-D128-02	NO INDICATIONS	SAME	"	"	%				
4	CS/CS	4.0"	.237"	1-067B-T627-04	7.775" MIC	NO LOP/LOF	"	"	%				
5	SS/SS	12.0"	.375"	2-067J-T307-13	.675,.25,.28,.85,.25 LOP	.65,.25,.85	40.93 "	2.30"	5.6%	<.1			
7	CS/CS	8.0"	.322"	1-067G-T042-10	.625 MIC	NO LOP/LOF	"	"	%				
8	CS/CS	4.0"	.237"	1-067B-T627-05	6.04 MIC	NO LOP/LOF	"	"	%				
9	CS/CS	8.0"	.322"	0-026H-T010-06A	.5,.75,1.21875,.75,2.75, 1,1.25 LOF, 1.125 MIC	1,1.25,.75,.5,.5625,1.25,.8125,.25,.8125 LOF	28.75 "	8.22"	28.6%	.031	.095	.360	TVA: .406 POR..06 TUNG. UT DEPTH .095 12-5-90 @ L=7-8"
0	CS/CS	4.0"	.237"	2-070A-D099-18	NO INDICATIONS	SAME							
3	SS/SS	4.0"	.237"	2-067A-T139-50	NO INDICATIONS	SAME	"	"	%				
7	CS/CS	8.0"	.322"	0-026H-T010-07	0.25" SLAG, POROSITY	NO LOP/LOF	"	"	%				
9	CS/CS	6.0"	.280"	2-067J-T306-23	NO INDICATIONS	SAME	"	"	%				

PARED BY *Scott Muller* DATE 12/18/90 CHECKED BY *[signature]* DATE 12/19/90

.	Mat.	Size	Thk	Weld Number	TVA RT INTERPRETATION	APTECH RT INTERPRETATION	Tot "L"	Tot LOP	% LOP/ CIRC	RT Depth	UT Depth	UT Thick	Comments
1	CS/CS	2.5"	.203"	1-003C-T219-41	NO INDICATIONS	SAME	"	"	%				
3	SS/SS	3.0"	.216"	1-067C-T288-02	.85 LOP 1.0 MIC	1.4 LOP	11.30 "	.85"	7.5%	<.1			
4	SS/SS	6.0"	.280"	0-067J-T147-06	NO INDICATIONS	SAME	"	"	%				
5	SS/SS	8.0"	.322"	1-067C-T613-07	4.25,1.375,3.4,2.06,4.125,1.5,.97 LOP .625, .360 MIC	4.25,1.375,3.4,2.25,4.125, 1.5,.5 LOP	26.38 "	17.68"	67.0%	.017	.135	.360	UT DEPTH 12-6-90 @ 17-18"
7	SS/SS	3.0"	.216"	1-067C-T273-08A	.22,.22,2.43,.31 LOF	2.5,3.75 LOF	11.90 "	3.18"	26.7%	.056			
9	CS/CS	30.0"	.375"	1-067H-T127-13	1.7,1.375,1.625 SLAG .85 MIC	NO LOP/LOF	"	"	%				BACKING RING
2	CS/CS	6.0"	.280"	1-026A-T044-03	1.1 SLAG	1.0 SLAG	"	"	%				BACKING RING
1	CS/CS	3.0"	.216"	1-067B-D267-01	NO INDICATIONS	SAME	"	"	%				
2	SS/CS	3.0"	.216"	2-067B-T231-01	.7 MIC	NO LOP/LOF	"	"	%				
3	SS/SS	3.0"	.216"	1-067C-T259-74	NO INDICATIONS	SAME	"	"	%				
5	SS/CS	8.0"	.322"	2-067G-T046-07	2,.125,.5,.09,.56,.1,.375,3,1.375,.25,.675,1,.95,1.3,.8,2.75,.57 LOF	2.25,.0625,.125,.125,.1875,.375,.125,.25,3.125,1.25, .375,2.125,1.0625,1.5,.125	25.99 "	16.42"	63.2%	.038			APTECH (cont) .625,2.375,.5 , UT DEPTH <.220 LOF NO THK - REXRAY CAP GROUND
3	CS/CS	3.0"	.216"	1-070B-D162-03	0.4 POROSITY 0.625 MIC	NO LOP/LOF							
0	CS/CS	4.0"	.438"	1-003C-D007-07	NO INDICATIONS	SAME	"	"	%				
9	SS/CS	8.0"	.322"	1-067G-T045-07	8.02 MIC	NO LOP/LOF	"	"	%				
3	CS/CS	6.0"	.562"	1-003C-N242-03	NO INDICATIONS	SAME	"	"	%				REPLACED-WLD_1-003C-D008-02A
4	SS/CS	8.0"	.322"	2-067G-T046-06	10.16 MIC	NO LOP/LOF	"	"	%				DISSIMILAR WELD - MIC LOOKS STRANGE
1	SS/CS	8.0"	.322"	2-067G-T048-15	12.615 MIC	NO LOP/LOF	"	"	%				
9	CS/CS	4.0"	.216"	1-070A-D141-03	3.7 TOTAL POROSITY	NO LOP/LOF	"	"	%				
3	CS/CS	4.0"	.438"	1-070B-D163-05	NO INDICATIONS	SAME	"	"	%				
3	CS/CS	4.0"	.438"	1-003C-D006-07	.7 LOP	.7 LOP	16.25 "	.70"	4.3%	.026			
9	CS/CS	2.5"	.154"	1-070B-D179-07	NO INDICATIONS	SAME	"	"	%				
5	CS/CS	6.0"	.562"	1-003C-D008-05	NO INDICATIONS	SAME	"	"	%				
6	CS/CS	4.0"	.438"	1-003C-D005-11	.31 LOP	.31 LOP	15.00 "	.31"	2.1%	.005			
2	CS/CS	6.0"	.562"	1-003C-D004-11	NO INDICATIONS	SAME	"	"	%				
6	CS/CS	4.0"	.438"	1-070A-D183-03	.2,.3 LOP	.2,.3 LOP	12.40 "	.50"	4.0%	<.1			
4	CS/CS	3.0"	.216"	1-070B-D172-20C	.675 LOP	.68 LOP	11.95 "	.68"	5.6%	<.1			NEXT TO 1-070B-D172-20B (ITEM #44)
3	CS/CS	10.0"	.365"	2-067G-T047-15	2,2.56,.375,.425,22.0 IP .325+ MIC	1.625,2.5,.25,.3125,.375,.75,.1875,.875,.375,1.25,17.75	33.76 "	27.36"	81.0%	.072	.150	.390	EXTRA WLD NXT TO #63 - UT 12-4-90 @ L=27-28"=.150

PARED BY [signature] DATE 12/18/90 CHECKED BY [signature] DATE 12/11/90

D NUMBER	SIZE	THK	MAT	NRC RES	TVA EVALUATION	APTECH EVALUATION	TOT IND LG	% DEF	RT DPTH	UT DEPTH	UT THICK	UT INDICATIONS	COMMENTS
78A-D196-05A	10.0	.365	SS	OK			0.00	0.0					
78A-D196-05B	10.0	.365	SS	REJ	22.435 LOP	22.5 LOP	22.43	68.0	.036	.130	.385	TVA UT DEPTH .10 MAX 9-09-90	UT DPTH .13 MAX 12-2-90
67C-T614-02	8.0	.322	SS		0.2 IF	.25 LOF	.25	1.0	<.1				
67C-T612-01	8.0	.322	SS		NO INDICATIONS	NO LOP/LOF	0.00	0.0					
67C-T612-02	8.0	.322	SS		OK	OK	0.00	0.0					
67C-T612-03	8.0	.322	SS		5.25 TOT LOP	1.35,.2,.45,.45,.3,.8,.75 LOP	5.25	20.9	.127				
67C-T612-04	8.0	.322	SS		1.88 LOP	.45, .55 LOP	1.88	6.9	<.1				NOT IN WELD PRINTOUT
67C-T612-05	8.0	.322	SS		5.225 LOP TOT	4.7,2.35,1.6,.75,1.2 LOP	5.23	19.0	<.1				
67C-T614-01	8.0	.322	SS		2.0 LOP	2.0 LOP	2.00	7.4	.021				
67C-T614-02A	8.0	.322	SS		OK	OK							
67C-T614-03	8.0	.322	SS		3.3 LOP	3.05 LOP	3.38	12.5	.058				NOT IN WELD PRINTOUT
67C-T614-05	8.0	.322	SS		0.185 MIC	.3 MIC, .2 MIC	0.00	0.0					
67C-T614-09	8.0	.322	SS		2.55 LOP	2.55 LOP	2.55	10.1					
67J-T606-01	8.0	.322	SS		6.618 LOP,.562 MIC	2.65,2.4 LOP, 2.3 LF, .3 MIC	6.50	24.0	<.1				EC - WI-85-050-001
67J-T606-02	8.0	.322	SS	OK	OK	DENSITY VERY LIGHT -NO EVAL	0.00	0.0					NOT IN WELD PRINTOUTEC - WI-85-050-001
67J-T606-03	8.0	.322	SS	REJ	.25 IF, .125 RND	.2 TRAN IF, .1 RNDED - DVL	.52	2.0	<.1				EC - WI-85-050-001
67J-T606-04	8.0	.322	SS	REJ	.875 IP 2.5 IF	.75, 2.4 LOP	3.38	12.5	<.1				EC - WI-85-050-001CAQR WPB 900336
67J-T606-07	8.0	.322	SS		OK	DENSITY VERY LIGHT - NO EVAL	0.00	0.0					EC - WI-85-050-001
67J-T606-08	8.0	.322	SS		OK	.7 LOP	.70	2.7					
67J-T606-11	8.0	.322	SS		OK	DENSITY VERY LIGHT - NO EVAL	0.00	0.0					
67J-T608-01	8.0	.322	SS		.93 LOF, .18 MIC	1.0 LOF .2 MIC	.93	3.7					
67J-T608-02	8.0	.322	SS	REJ	.1875,3.125,6.5,4.625	.35,1.3,1.9,.65,3.35,3.7,4.2 LOP .2,.5,1.5 LF .1 RNDED	14.44	53.0	.05	.100	.360	IP-REMAIN LIG = .170" 8-90	UT DEPTH 12-6-90CAQR WBP 900336
67J-T608-03	8.0	.322	SS	REJ	6.5,3.625,1.375,6,3.75	1.4,.6,1.4,.65,.85,.25,.5,3.5,.55,1.9,.45,5.65,2.2,.1,.1,2.5	21.06	82.2	.038	.120	.350	IP- REMAIN LIG = .174" 8-90	EC - WI-85-050-001,.3 TRAN LINUT DEPTH 12-6-90

PARED BY Scott Miller DATE 12/18/90 CHECKED BY [signature] DATE 12/19/90

.D NUMBER	SIZE	THK	MAT	NRC RES	TVA EVALUATION	APTECH EVALUATION	TOT IND LG	% DEF	RT DPTH	UT DEPTH	UT THICK	UT INDICATIONS	COMMENTS
367J-T608-04	8.0	.322	SS	OK	OK	.35,1.35 LOP .35 MIC	1.70	6.7					EC - WI-85-050-001
367J-T608-05	8.0	.322	SS	OK	OK	OK	0.00	0.0					EC - WI-85-050-001
367J-T608-06	8.0	.322	SS	OK		OK	0.00	0.0					
367J-T608-07	8.0	.322	SS	REJ	1,.3125,.3125,.25, 1.5,.125	.85,.35,.35,1.0 LOP .15 LF .2 RNDED .2, .15 MIC	3.50	13.0	.045				EC - WI-85-050-001CAQR WPB 900336
367J-T608-10	8.0	.322	SS		OK	OK	0.00	0.0					
367J-T608-16	8.0	.322	SS		.625, MIC	.65 LOP .2, .25 MIC	.63	2.3	.07				EC - WI-85-050-001
367J-T635-05	18.0	.375	SS	REJ	6.7 SLAG	NO LOP/LOF	0.00	0.0					
367J-T635-06	18.0	.375	SS	REJ	14,2.75,2.5,1.5,1.4,1.375 ETC	25" TOTAL - 14" LONGEST	25.33	46.0	.031	.140	.540	UT DEPTH .15 MAX 9-9-90	UT DEPTH 12-2-90 L=22.2
370A-D168-01	14.0	.375	CS	REJ	3.58 LOP/LOF	.875,1.25,1.4,.375,2.1, 1.8 LOF.375,.31 LOP.5,.3,.2,.1 SLAG	3.58	8.3	<.1				TVA WELD

PARED BY Scott Walker DATE 12/18/90 CHECKED BY [illegible] DATE 12/19/90

JOB AES 90091312-1Q

19-Dec-90 04:20 PM

LOP DEFECT THROUGH WALL THICKNESS DETERMINATION USING H&D DENSITIES FROM RADIOGRAPHS

ITEM NO.	WELD ID	FILM #	WALL THK	PENNY+ SHIM	PROC LOC	DATA SHEET LOCATION	PIXEL VALUE	H&D DENSITY	CALCULATED R*	a/T
9063	2-067G-1047-15	2-3	0.355	0.10375	D4	1	111	2.69	0.072	0.197
					D3	2	123	3.48		
					D2	3	196	2.72		
					D1	4	184	2.96		
136	2-067G-1046-07	1-2	0.322	0.135	D4	1	146	2.88	0.039	0.122
					D3	2	156	2.78		
					D2	3	159	2.84		
					D1	4	140	2.98		
38	1-067J-1528-01	0-1	0.375	0.10375	D4	1	148	3.15	0.051	0.136
					D3	2	161	3.00		
					D2	3	164	2.96		
					D1	4	138	3.27		
79	0-026H-1010-06A	0-1	0.322	0.07	D4	1	140	2.54	0.031	0.098
					D3	2	151	2.43		
					D2	3	162	2.32		
					D1	4	128	2.56		
ORIG 32	1-007J-1635-06	0-1	0.322	0.0745	D4	1	140	1.94	0.031	0.098
					D3	2	151	1.88		
					D2	3	162	1.85		
					D1	4	138	1.78		
266	1-003C-D005-11	1-2	0.438	0.0745	D4	1	172	2.23	0.005	0.012
					D3	2	175	2.2		
					D2	3	215	1.75		
					D1	4	183	2.11		
198	1-003C-D006-07	2-3	0.438	0.10375	D4	1	108	2.98	0.026	0.059
					D3	2	115	2.88		
					D2	3	153	2.46		
					D1	4	153	2.82		

Prepared By [illegible] Date 12/19/90 Checked By [illegible] Date 12/19/90

JOB AES 90091312-1Q

19-Dec-90 04:20 PM

LOP DEFECT THROUGH WALL THICKNESS DETERMINATION USING H&D DENSITIES FROM RADIOGRAPHS

ITEM NO.	WELD ID	FILM #	WALL THK	PENNY+ SHIM	PROC LOC	DATA SHEET LOCATION	PIXEL VALUE	H&D DENSITY	CALCULATED R"	a/T
97	1-087C-1273-08A	1-2	0.216	0.10375	D4	1	108	2.98	0.056	0.257
					D3	2	118	2.84		
					D2	3	134	2.66		
					D1	4	112	2.91		
95	1-087C-1613-07	2-3	0.322	0.135	D4	1	172	2	0.017	0.053
					D3	2	178	1.97		
					D2	3	219	1.58		
					D1	4	195	1.78		
72	1-070A-1239-05	3-4	0.365	0.135	D4	1	103	2.79	0.048	0.131
					D3	2	110	2.63		
					D2	3	116	2.32		
					D1	4	105	2.74		
30	1-087J-1435-06	B	0.203	0.135	D4	1	99	2.31	0.035	0.166
					D3	2	119	2.55		
					D2	3	132	2.33		
					D1	4	114	2.53		
18	2-087J-1349-01B	1-2	0.203	0.10375	D4	1	94	2.28	0.071	0.351
					D3	2	102	2.06		
					D2	3	114	1.86		
					D1	4	103	1.9		
10	2-087J-1301-5B	0-1	0.375	0.135	D4	1	192	3.28	0.029	0.078
					D3	2	195	3.23		
					D2	3	201	3.12		
					D1	4	186	3.35		
11	2-070A-1248-02	2-3	0.216	0.10375	D4	1	181	3.18	0.046	0.215
					D3	2	186	2.99		
					D2	3	215	2.57		
					D1	4	187	2.95		

Prepared By [signature] Date 12/18/90 Checked By [signature] Date 12/19/90

LOP DEFECT THROUGH WALL THICKNESS DETERMINATION USING H&D DENSITIES FROM RADIOGRAPHS

ITEM NO.	WELD ID	FILM #	WALL THK	PENNY+ SHIM	PROC LOC	DATA SHEET LOCATION	PIXEL VALUE	H&D DENSITY	CALCULATED R"	a/T
ORIG 32	0078A-D196-05B	0-1	0.365	0.072	D4	1	98	2.52	0.034	0.092
					D3	2	101	2.45		
					D2	3	110	2.41		
					D1	4	103	2.56		
ORIG 32	0078A-D196-05B	1-2	0.365	0.072	D4	1	98	2.58	0.035	0.095
					D3	2	100	2.47		
					D2	3	106	2.34		
					D1	4	98	2.52		
ORIG 32	0078A-D196-05B	2-3	0.365	0.072	D4	1	94	2.6	0.034	0.094
					D3	2	98	2.62		
					D2	3	106	2.36		
					D1	4	98	2.62		
ORIG 32	0078A-D196-05B	3-0	0.365	0.072	D4	1	97	2.54	0.035	0.095
					D3	2	102	2.43		
					D2	3	110	2.36		
					D1	4	100	2.47		
ORIG 32	0078A-D196-05B MAGNIFIED VIEW @ 17"	2-3	0.365	0.072	D4	1	132	2.63	0.040	0.110
					D3	2	142	2.51		
					D2	3	163	2.29		
					D1	4	144	2.49		
ORIG 32	0078A-D196-05B MAGNIFIED VIEW @ 25"	2-3	0.365	0.01	D4	1	168	2.58	0.037	0.100
					D3	2	175	2.61		
					D2	3	182	2.65		
					D1	4	160	2.67		

Prepared By [signature] Date 12/18/90 Checked By [signature] Date 12/19/90

JOB AES 90091312-1Q

19-Dec 17:03

LOP DEFECT THROUGH WALL THICKNESS DETERMINATION USING H&D DENSITIES FROM RADIOGRAPHS

(all dimensions in inches)

WELD ID	FILM #	WALL THK	PENNY +SHIM	PROC LOC	SHEET LOCATION	PIX. VAL	H&D DENSITY	CALCULATED DEPTH	a/t
1-067J-T608-02	2-3	0.322	0.07	D4	1	109	3.66	0.050	0.155
				D3	2	119	3.35	—	
				D2	3	212	2.27		
				D1	4	177	2.57		
1-067J-T608-02	1-2	0.322	0.07	D4	1	146	2.88	0.020	0.063
				D3	2	156	2.78		
				D2	3	169	2.64		
				D1	4	140	2.96		
1-067J-T608-03	1-2	0.322	0.07	D4	1	148	2.89	0.032	0.099
				D3	2	155	2.79		
				D2	3	148	2.86		
				D1	4	131	3.09		
1-067J-T608-03	1-2	0.322	0.07	D4	1	182	2.67	0.013	0.041
				D3	2	194	2.84		
				D2	3	165	2.55		
				D1	4	161	3.12		
1-067J-T608-03	2-3	0.322	0.07	D4	1	174	3.27	0.038	0.117
				D3	2	179	2.90		
				D2	3	189	2.36		
				D1	4	160	2.95		
1-067J-T608-07	0-1	0.322	0.07	D4	1	175	2.64	0.045	0.138
				D3	2	186	2.47		
				D2	3	194	2.38		
				D1	4	176	2.82		
1-067J-T608-16	2-3	0.322	0.07	D4	1	138	2.84	0.070	0.218
				D3	2	154	2.09		
				D2	3	138	2.24		
				D1	4	123	2.40		

Prepared By [signature] Date 12/18/90 Checked By [signature] Date 12/19/90

LOP DEFECT THROUGH WALL THICKNESS DETERMINATION USING H&D DENSITIES FROM RADIOGRAPHS

(all dimensions in inches)

WELD ID	FILM #	WALL THK	PENNY +SHIM	PROC LOC	SHEET LOCATION	PIX. VAL	H&D DENSITY	CALCULATED DEPTH	a/t
1-067C-T612-03	0-1	0.322	0.07	D4	1	129	2.51	0.127	0.396
				D3	2	145	2.34		
				D2	3	105	2.80		
				D1	4	111	2.91		
1-067C-T612-03	1-2	0.322	0.07	D4	1	141	2.36	0.032	0.099
				D3	2	147	2.30		
				D2	3	153	2.24		
				D1	4	140	2.37		
1-067C-T612-03	3-0	0.322	0.07	D4	1	140	2.31	0.048	0.149
				D3	2	151	2.22		
				D2	3	174	2.01		
				D1	4	161	2.13		
1-067J-T614-03	1-2	0.322	0.07	D4	1	148	0.96	0.058	0.180
				D3	2	168	0.88		
				D2	3	142	0.99		
				D1	4	133	1.10		
1-067C-T614-01	2-3	0.322	0.07	D4	1	106	1.81	0.021	0.065
				D3	2	107	1.57		
				D2	3	101	1.71		
				D1	4	96	1.86		

Prepared By Scott Miller Date 12/18/90 Checked By [signature] Date 12/19/10

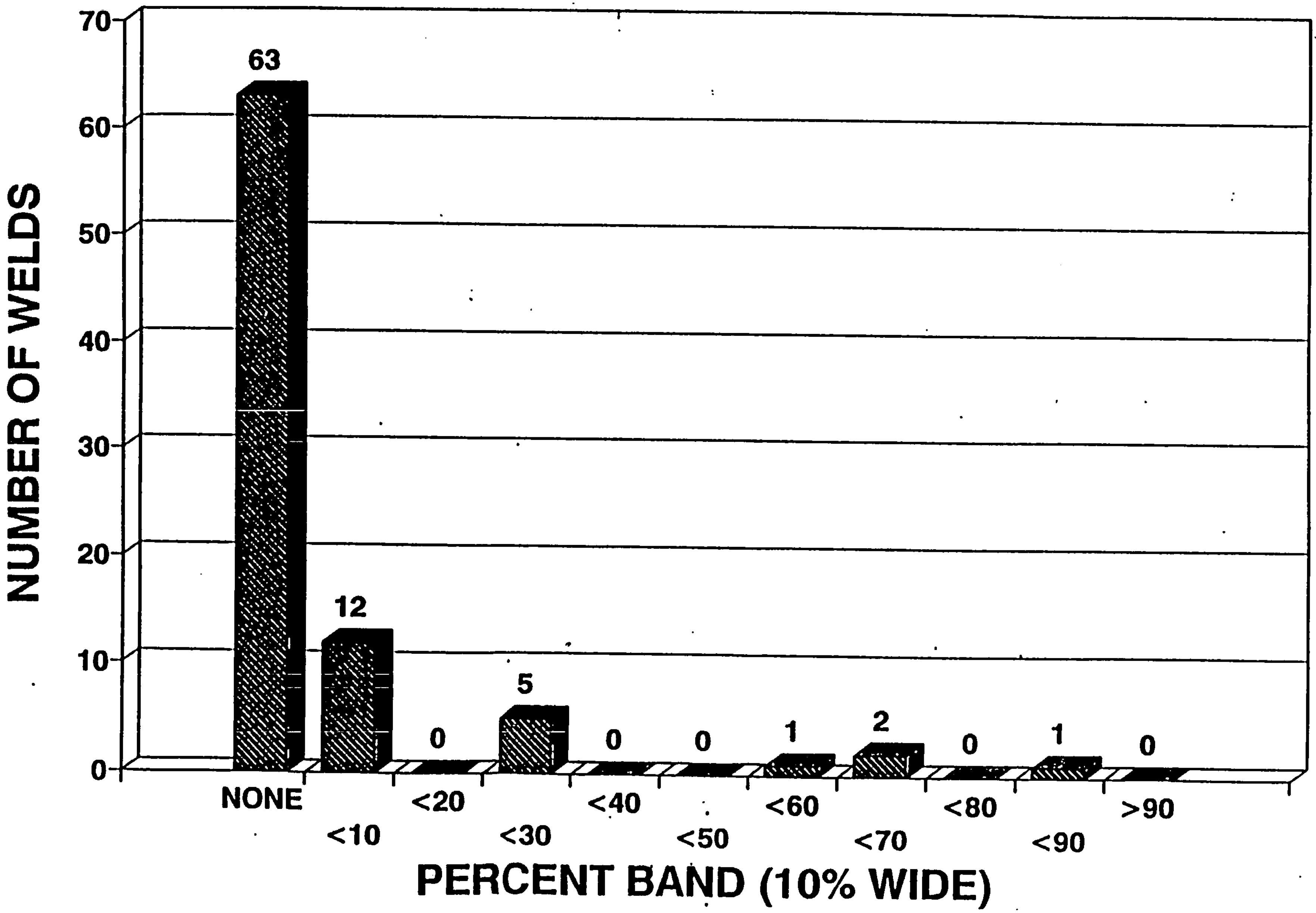
WATTS BAR CLASS THREE WELD RANDOM SAMPLING
LOP/LOF DISTRIBUTION BY PERCENT OF CIRCUMFERENCE

LOP/LOF % AMT	TOTAL RANDOM POP.	ALL SS-CS	CS LESS O EQ TO 0.25	CS >0.25 OR <.375	CS >.375	SS<.25	SS>.25	ORIGINAL 32 WELDS TOTAL
NONE	63	4	13	12	5	19	10	12
O<amt<10	12	0	2	1	3	2	4	9
10<amt<20	0	0	0	0	0	0	0	6
20<amt<30	5	0	0	1	0	3	1	1
30<amt<40	0	0	0	0	0	0	0	0
40<amt<50	0	0	0	0	0	0	0	1
50<amt<60	1	0	0	0	0	0	1	1
60<amt<70	2	1	0	0	0	0	1	1
70<amt<80	0	0	0	0	0	0	0	0
80<amt<90	1	0	0	1	0	0	0	1
amt>90	0	0	0	0	0	0	0	0
TOTALS	84	5	15	15	8	24	17	32
TOTAL w/IP	21	1	2	3	3	5	7	20
PERCENT	25%	20%	13%	20%	38%	21%	41%	63%

SUMMARY: OUT OF 84 WELDS ON RANDOM SAMPLE
21 HAVE LOP/LOF DEFECTS

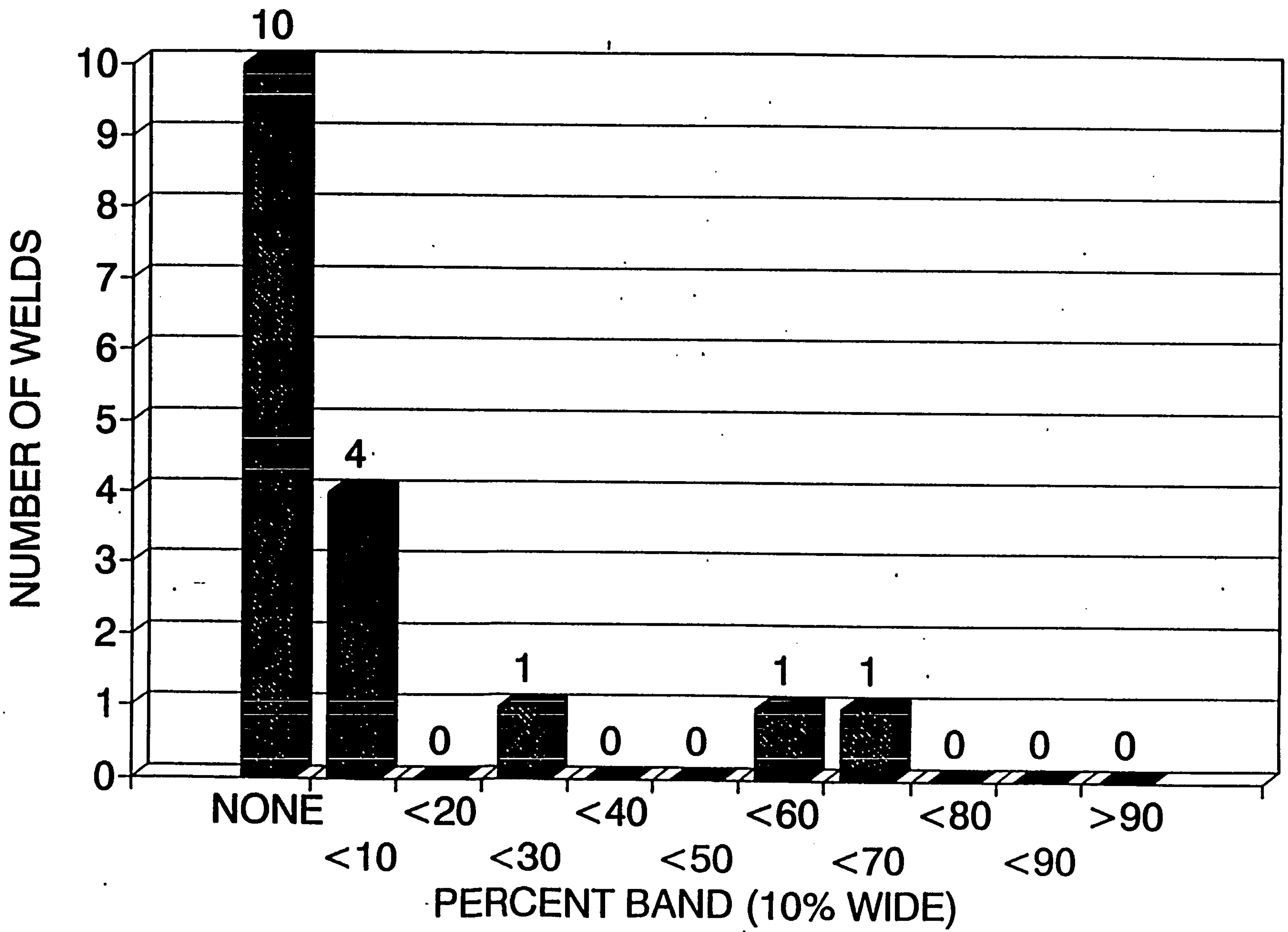
OUT OF 32 WELDS RT'D BY TVA 20
HAVE LOP/LOF DEFECTS

WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRC. TOTAL RNDM POP

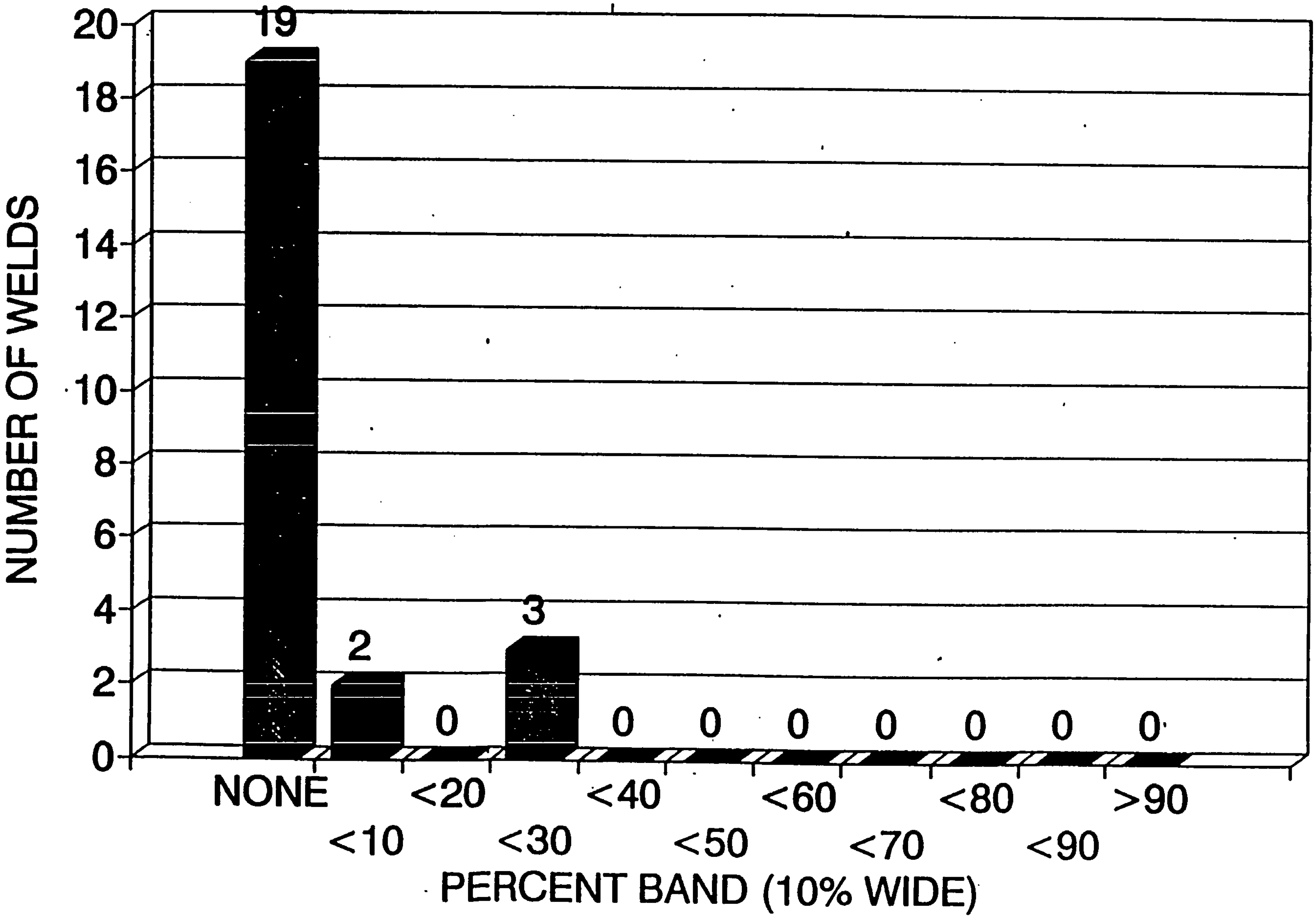


WATTS BAR CLASS 3 WELD LOP DISTRIBUTION

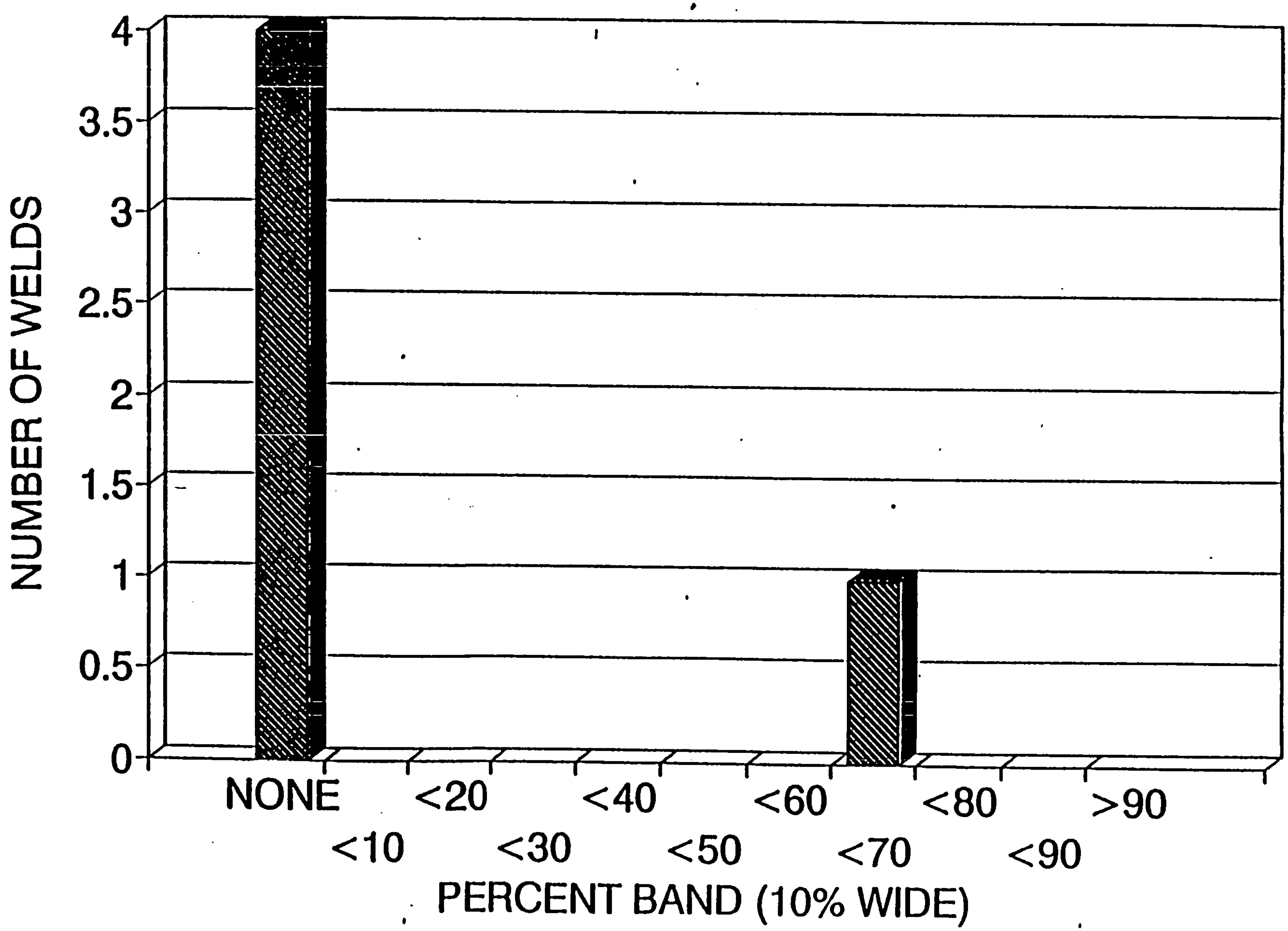
PERCENT LOP/LOF OF CIRC.: SS>.25



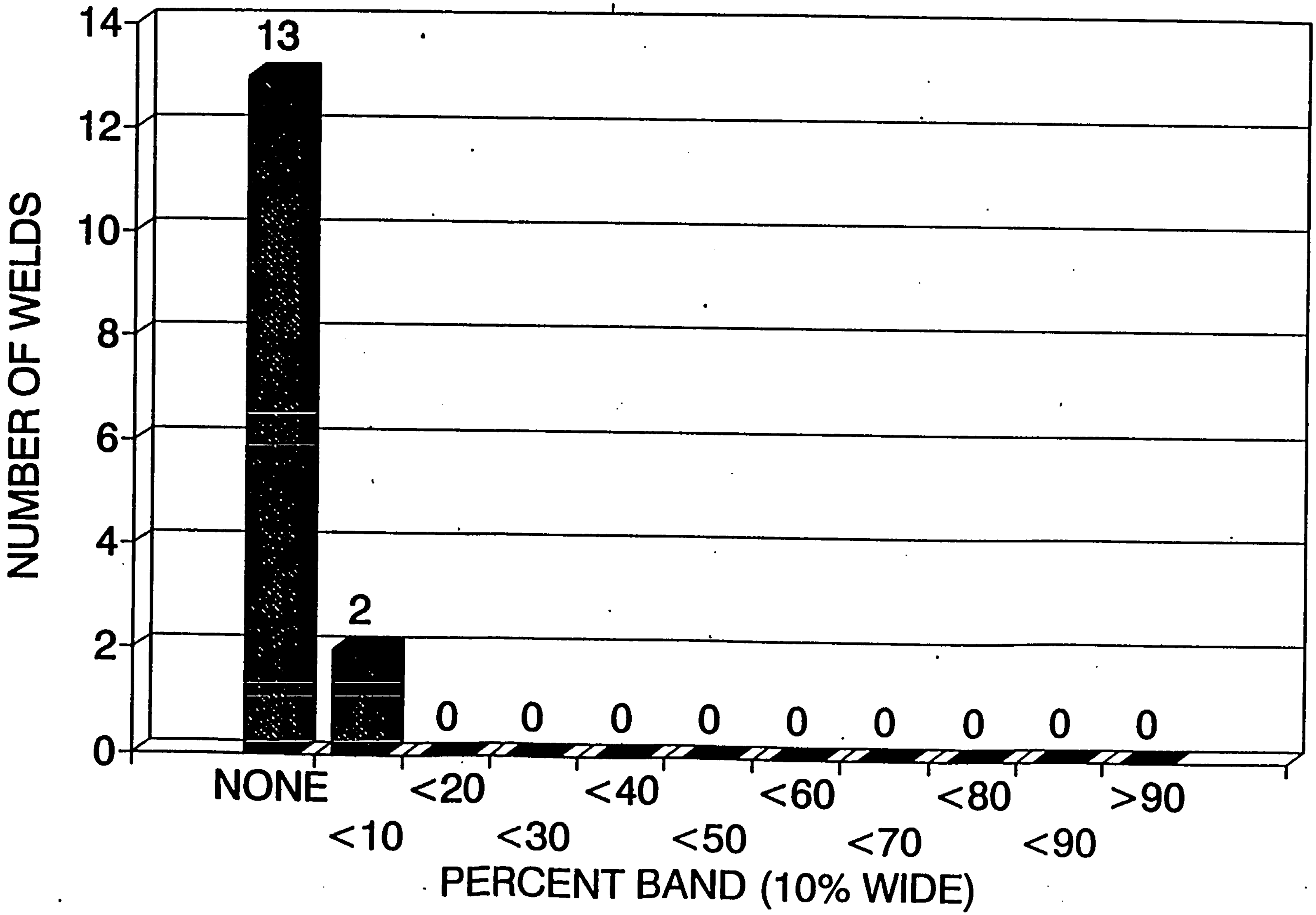
WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRC. :SS≤.25



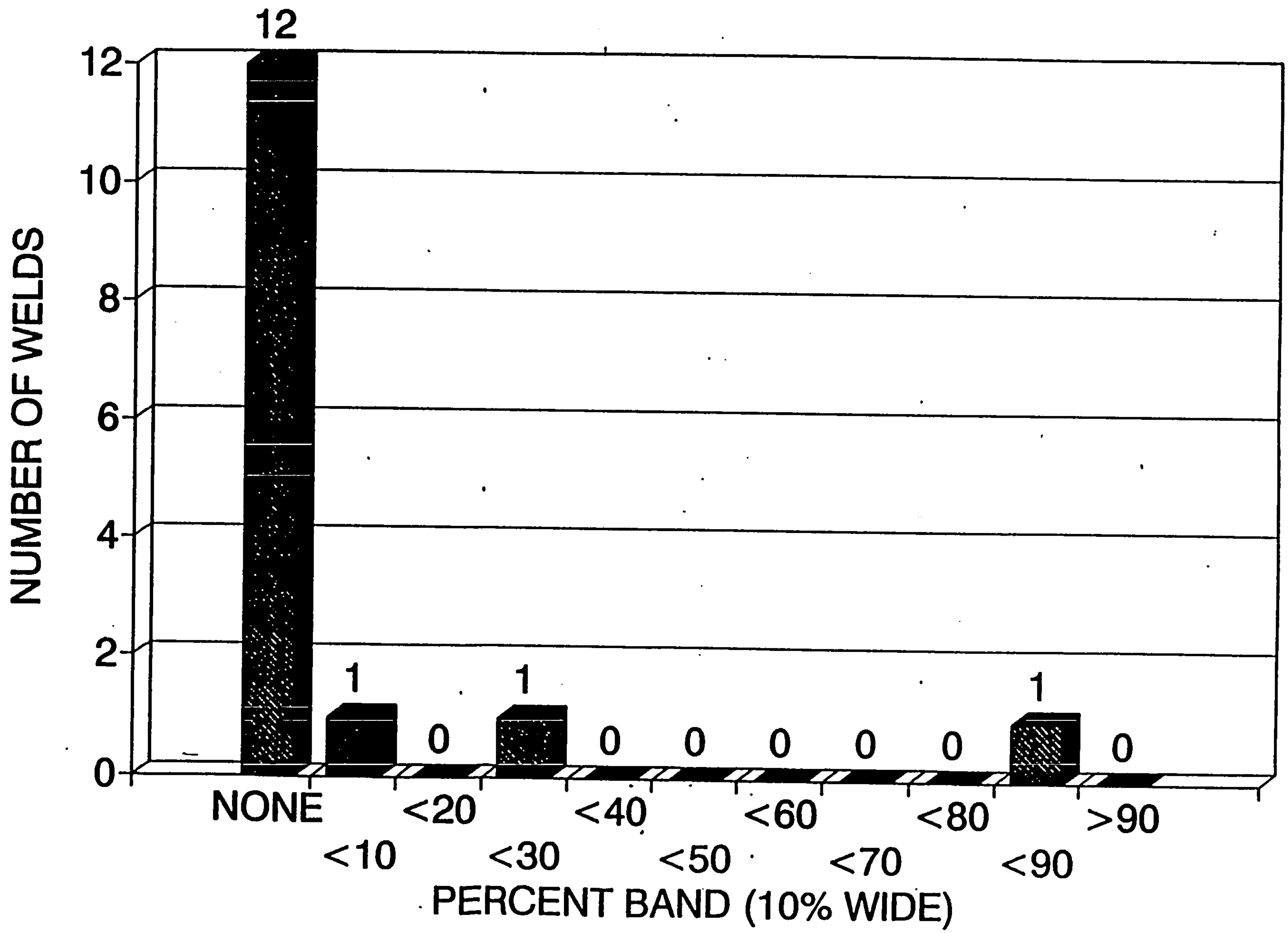
WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRCUMFERENCE: SS-CS



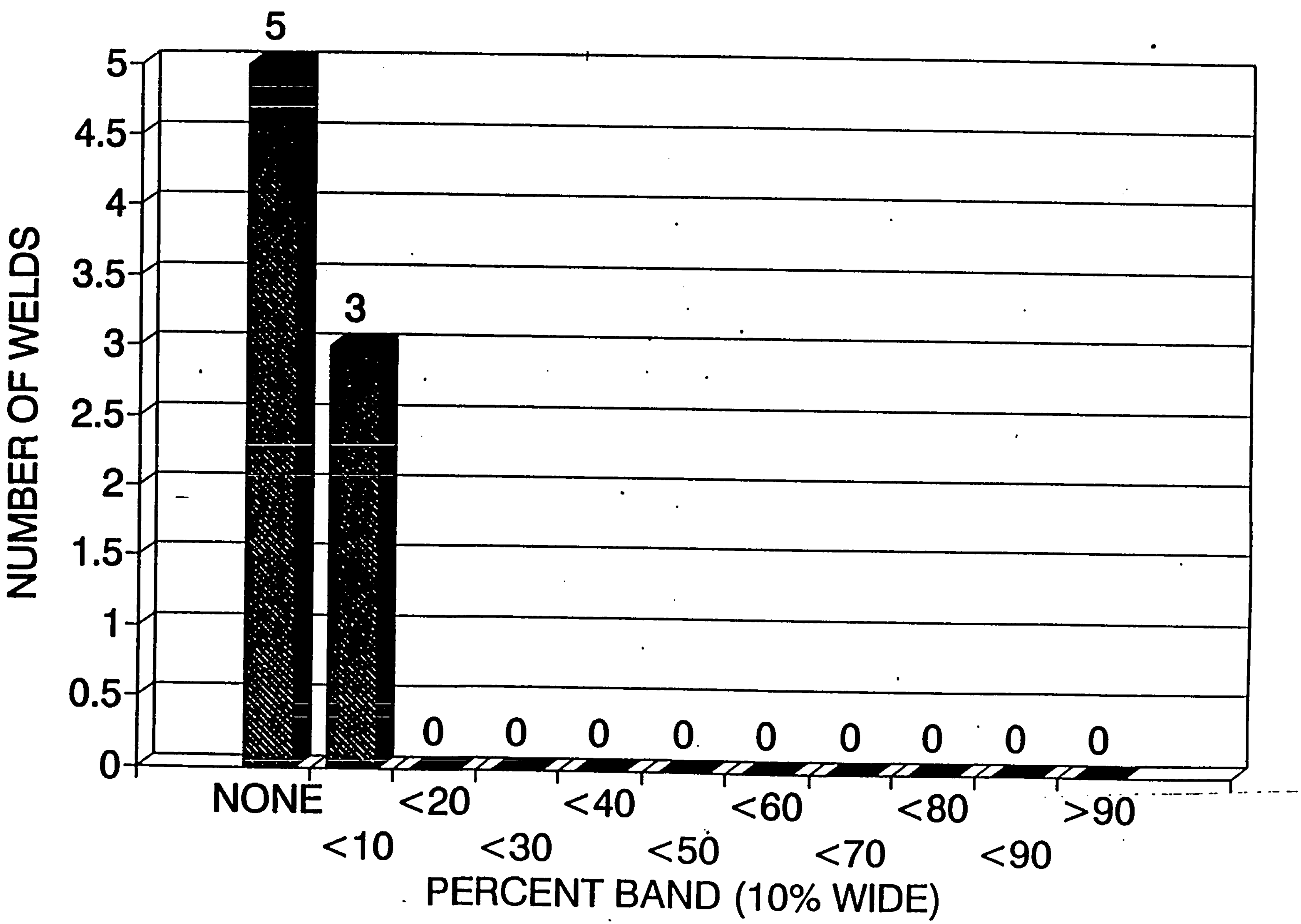
WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRCUMFERENCE:CS<.25



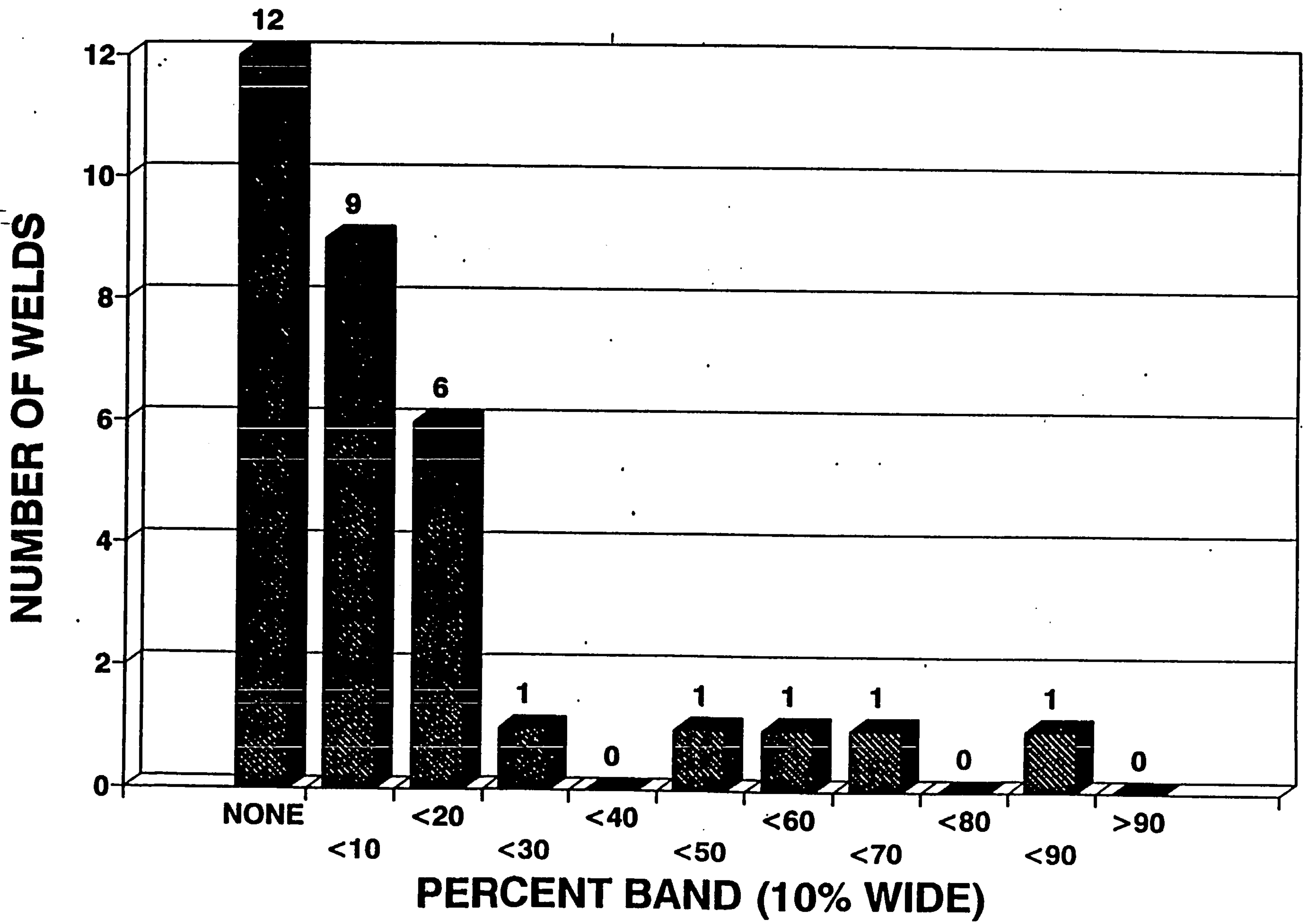
WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRC. :CS >.25,<.375



WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRC. :CS >.375



WATTS BAR CLASS 3 WELD LOP DISTRIBUTION
PERCENT LOP/LOF OF CIRC.:ORIG 33 WELDS



Appendix B
STATISTICAL ANALYSIS METHOD

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STATISTICAL ANALYSIS METHOD

A standard nonparametric technique of order statistics is employed to compute upper and lower confidence limits of the cumulative distribution, F(R) of the random variable R. The technique requires no assumed probability distribution model to compute limits and plot data as discrete points. This relieves the analyst from making an arbitrary selection of a model like the normal, log normal, or Weibull distribution.

After executing the nonparametric analysis and plotting all data, the program plots some curves. These curves are three-parameter Weibull distributions used to fit the nonparametric data points. Each curve was used to estimate flaw areas and was checked for its fit of the distribution – free data.

BEST (POINT) ESTIMATES OF F(R)

Following the recommended graphical procedures of Gumbel (B-1), and Whittaker and Besuner (B-2), the mean rank is used to estimate the plotting position (R, F(R)) in a cumulative failure probability plot. Figures 4-1 and 4-2 are such plots. This mean rank is given by:

$$F(R) = I(R)/(N + 1) \qquad \text{(B-1)}$$

where N is the sample size and i is the order number of the value of R. That is, i = 1 is used for the lowest value of R, i = 2 is for the next largest, etc. In other words, the data are ordered by the procedure, so that $R_1 \leq R_2 \leq \ldots \leq R_n$.

The procedure most easily handles "complete" samples for which all the R_i values are known. Also, the procedure handles so-called incomplete samples. These samples contain suspended data expressed as $R<r$ or $R>r$, not $R=r$. The procedure and software handle any mixture of suspended and complete data.

For suspended data samples, the best-estimate equations for F(R) are:

$$F(R_{i+1}) = F(R_i) + 1/(N_{eff} + 1);\ i = 0, n_f \quad \text{(B-2)}$$

where,

$F(R_i)$ denotes the plotting position of the ith of n_f ordered data values for which R is known precisely (i.e., nonsuspended values of R).

$$F(R_o) = 0 \quad \text{(B-3)}$$

and

$$N_{eff} = \text{Effective number of units with } R > R_i$$

$$N_{eff} = N_t + \sum_{j=1}^{N^-} (R_j - R_i)/(R_{i+1} - R_i)$$

where,

N_t = Number of units for which R is known to be $> R_{i+1}$

N^- = Number of units for which R is known to be $> R_j$, where $R_i \leq R_j \leq R_{i+1}$

Use of the above algorithm is equivalent to assuming a piecewise linear cumulative probability function for observed values of R.

CONFIDENCE BOUNDS $F_r(R)$ OF F(R)

The procedure uses a rigorous nonparametric confidence bound estimation method to handle small sample sizes. This avoids the errors of asymptotically normal distribution confidence levels, which should only be used for large samples. For complete samples in which the value of R of one unit is independent of all other values of R, the exact confidence bounds for the ith order statistic in N are given by the cumulative binomial distribution. The specific equation used is given below:

$$\gamma = 1 - \sum_{k=0}^{I-1} \frac{N!}{k!(N-k)!} F_\gamma^k (1 - F_\gamma)^{N-k} \qquad \text{(B-4)}$$

where γ is the specified confidence level and F_γ, defined as

$$F_\gamma = F_\gamma(R_i, i, N)$$

is the desired confidence bound estimate of cumulative R probability. This means that γ is the probability that the true cumulative value F(R) lies in the interval between 0 and F_γ. For all but the simplest situations, the above equation must be solved implicitly through an iterative numerical scheme.

For the case of suspended data, the previous set of equations is used with N_e. Ne is the effective size of the sample rather than the complete sample value N. The parameter N_e is completed from the relationship

$$N_e = (I/F(R_i)) - 1 \qquad \text{(B-5)}$$

for each $[R_i, F(R_i)]$ point plotted.

This procedure accounts for the fact that the fewer the values of R, the less the accuracy in making estimates of R. In general, N_e is not an integer. A linear interpolation is used to estimate the confidence bounds, F_γ for noninteger values.

The specific equation used is given by:

$$F_\gamma(R_i, N_e) = F_\gamma(R_i, NB) + (N_e - NB)(F_\gamma(R_i, NA) - F_\gamma(R_i, NB)) \quad \text{(B-6)}$$

where N_e lies in the closed interval between the two integers NB and NA = NB + 1.

The above procedure, while complex in nature, has been benchmarked twice against an independent analysis method with fewer capabilities ((B-3) through (A-5)). Reasonable-to-excellent agreement between the two methods was observed.

REFERENCES

B-1 Gumbel, E. J., *Statistics of Extremes*, Columbia University Press, New York (1958).

B-2 Whittaker, I. C., and P. M. Besuner, "A Reliability Analysis Approach to Fatigue Life Variability of Aircraft Structures", Wright-Patterson Air Force Base, AFML-TR-69-65 (April 1969).

B-3 Calculations 3 and 4, APTECH Project AES 90041243-1Q

B-4 Cipolla, R. C., "Statistical Analysis of Hole Depth Data",. APTECH Project AES 89121166-1Q, Calculation 1166-1Q-6 (Document I-7) (March 6, 1990).

B-5 Cipolla, R. C., J. L. Grover, and P. M. Besuner, "Significance of Over-Drilled Oil Holes on Fatigue Life of the KSV-4-2A Connecting Rod in the Standby Diesel Engines at South Texas Project", APTECH Report AES 89121166-1Q-1 (March 1990) (See Section 3, especially).

Appendix C
ASSUMPTIONS FOR FLAW DISTRIBUTION ANALYSIS

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ASSUMPTIONS FOR FLAW DISTRIBUTION ANALYSIS

1. We assume the cumulative probability distributions (CPDs),

   $$F(x) = \text{PROBABILITY}(X \leq x),$$

   for various statistical samples of weld inspection data are continuous functions. For more details see Refs. (C-1) through (C-5).

2. The inspection data analyzed here are for two types of crack-like flaws:

   - Lack of penetration (LOP)
   - Lack of fusion (LOF)

   In all that follows, these two similar flaw types are assumed to be interchangeable and combined.

3. We deal only with the transformed variable

   $$X = 1/(10\% + Y).$$

4. We assume that these data include a combination of visual, radiographic (RT), and ultrasonic (UT) inspection results to estimate two flaw dimensions:

   - %L/C = the length L of the defect along the circumference and measured as a percent of the circumference C

   - a/t = the maximum measured depth of the defect (despite where that maximum occurred along the circumference "a") divided by our best estimate of thickness "t." UT measurements of t are used if existing. If not, nominal thickness is used. For the estimate of "a" see the equation below.

5. Nonparametric method in Appendix B assumes no specific probability distribution function for F(x).

6. The Weibull (three-parameter) probability distribution is used to fit nonparametric data calculations of F(x) in Assumption 5. <u>It is also used as an interpolator to compute the desired 95-95 flaw area bound.</u> The specific equation used is

   $$F(x) = 1 - \exp\{-[(x-x_o)/(B-x_o)]^e\} \text{ for } x \geq x_o \text{ and} \qquad \text{(C-1)}$$

$$F(x) = 0 \text{ for } x < x_o$$

α, B, and x_o are Weibull-distribution constants used here as mere fitting parameters. They are used differently for small and large samples. See the last few assumptions for more information on this.

In the literature, the Weibull distribution is classified as an "asymptotic distribution of the lowest extreme values." Because the Weibull models the lower tail of the distribution better than the higher, we use the X(Y) transformation above.

7. For the transformed variable X, the lower tail region (e.g., Y = PAR = Area > 10% so that X < 0.05) and its lower 95% confidence bound are the regions of primary interest. For significance testing in the "Weld Comparisons" of Section 4, we are also interested in the best and the upper 5% confidence bound F(x) estimates.

8. Accordingly, for purpose of this calculation we have no interest in the upper part of the distribution, X > 0.0833 (Area < 2%).

9. The inspection data from Section 4 are accurate.

10. Flaw Length (%L/C) is taken directly from Section 4.

11. Using destructive inspection data on five weld flaw locations in Section 4 as a guideline, the maximum defect depth "a" is the lesser of:

    - The largest value measured with UT where available (a_{UT})
    - The largest value measured with RT (a_{RT}) plus 60 mils (0.060 in.)

    In equation notation,

$$a = \text{minimum}[a_{UT}, (a_{RT} + 0.060)]$$

12. Defect area Y is calculated from

$$Y = \%L/C \text{ times } a/t$$

    and, as defined above, is expressed as a percent of the cross section removed. This product is very conservative because it assumes that the defect will be at maximum depth "a" over its entire length.

13. No leaks from LOF/LOP defects have ever resulted in any of the existing 7120 TVA Watts Bar Class 3 welds. Therefore, Y < 100% (and so is a/t) for all 7120 welds. For large groups we rely on this assumption in a conservative way. We input one leak and 7119 no-leaks into the computer program.

14. For large groups in which the leak assumption is used, we assume the database is sufficient to estimate all three Weibull parameters.

15. For small samples, that typically contain only one or two precisely measured flaw areas, we

- Rely on the baseline sample of 108 welds (BASEL) to estimate the Weibull minimum x_o and shape parameter α
- Use the small sample data only to estimate the Weibull characteristic value B
- Omit the no-leak Assumption 13. The effect of assuming 0 or 1 leak in the large sample is conservatively simulated by using the large baseline sample to set x_o

REFERENCES

C-1 Besuner, P. M., "Statistical Analysis of LOP and LOF Weld Flaw Areas", Calculation 1312-1Q-8 (January 2, 1991).

C-2 Besuner, P. M., "Statistical Analysis of Flaw Area in Weld Samples", Calculation 1312-1Q-9 (January 2, 1991).

C-3 Besuner, P. M., "Statistical Tests of Flaw Lengths by Welders", Calculation 1312-1Q-10 (January 4, 1991).

C-4 Cipolla, R. C., "Statistical Analysis of Hole Depth Data", APTECH Project AES 89121166-1Q, Calculation 1166-1Q-6 (Document I-7) (March 6, 1990).

C-5 Cipolla, R. C., J. L. Grover and P. M. Besuner, "Significance of Over-Drilled Oil Holes on Fatigue Life of the KSV-4-2A Connecting Rod in the Standby Diesel Engines at South Texas Project," APTECH Report AES 89121166-1Q-1, March 1990 (See Section 3, especially).

Appendix D
REVISED MEMO OF WELDER COMPARISON ANALYSES

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MEMORANDUM

TO: G. Egan

FROM: P. Besuner

SUBJECT: Welder Comparisons (AES 1366-Q, Revision 1)

DATE: January 21, 1991

The attached material can be used to present my statistical analysis of the subject welders. I trust the work and conclusions are clear from our discussions. Please let me know if you also want a write-up in plain english to back up our discussions.

cc: A. Curtis
J. Grover
E. Merrick

STATISTICAL PLAN TO COMPARE WORKMANSHIP OF WELDERS

Figure 1 is a flowchart of our procedure to evaluate welders and help find a root cause for substandard workmanship, if any. The following comments amplify the flowchart.

- Define Substandard Workmanship as an LOP/LOF Flaw of Length ℓ Greater Than 10% of the Girth Weld Circumference
- Informal Inspection of Original Database to Pick Welder(s) With Possibly Substandard Performance
- After Picking Welder(s), Test the Following Hypotheses in at Least Two Different Statistically Valid Ways:

  "For Stainless Steel Welds, is the Distribution of LOP Lengths $F(\ell)$ the Same For the Welder(s) and the 41 Randomly Selected SS Welds?"

  "For Carbon or Dissimilar Steel Welds, is the Distribution of LOP Lengths $F(\ell)$ the Same For the Welder(s) and the 43 Randomly Selected CS and SS/CS Welds?"

STATISTICAL PLAN (CONTINUED)

- One Statistical Test Will Focus on the Poor Workmanship Cutoff $\ell > 10\%$ Circumference and the Second Will Focus on the Largest Flaws, $\ell > 50\%$ Circumference.
- Conclusions Will Be Based Upon the Outcome of the Hypothesis Tests
- Regression Fits on Flaw Area Have Already Been Used to Test Other Variables (Weld Material and Thickness)

SPECIFIC APPROACH CHOSEN

1. Define an Avoiding-Long-Flaw Indication (or ALFI) Index. Index ($\ell/c > 10\%$) Measures How Well Flaws Over 10% Circumference Are Avoided. Index ($\ell/c > 50\%$) Does the Same for Half+ Circumference Flaws. Big Values of the Indices Are Good. Index Values Below a "Critical" (Specified) Value ALFI $< \alpha_{SPECIFIED} = 10\%$ Are Bad.

   (TVA's informal review of our preliminary results led them to use the more conservative value $\alpha_{SPECIFIED} = 15\%$ to pick more welders for additional inspection. Here, for consistency with our judgement and "weld comparison" analysis in section 5, we use $\alpha_{SPECIFIED} = 10\%$ to make recommendations. The tabulated results will allow the reader to use his or her own critical value.)

2. ALFI Index = Chance That a Random Sample Will Do No Better Than the Subject Welder(s).

3. Baseline is APTECH-Chosen Random Sample of 41 SS/SS Welds or 43 CS/CS or SS/CS Welds.

4. Index Computed From Hypergeometric Distribution Using QA'd Program HYPERGEO.C By Jeff Grover Of APTECH.

5. Index Can Be Used Directly For Hypothesis Testing. It is the Most Rigorous Treatment We Know of the Small-Sample Problem.

6. On This Basis and Assuming Welds are O.K. Until Proven Otherwise, Index > 10% Can Be Ignored. Index Values Much Less Than 5% to 10% Show Substandard Workmanship. For Conservatism, We Use Index Values < 10% to Identify Suspect Welder(s).

7. See Next Page For Results.

INDEX OF SELECTED WELDERS' ABILITY TO AVOID LONG FLAWS IN STAINLESS STEEL (SS)

Welder(s) or Weld(s)	Welds Inspected (NI)	Avoiding Medium Flaws: Number at L/C>10%	Avoiding Medium Flaws: Index (10%)	Avoiding Large Flaws: Number at L/C>50%	Avoiding Large Flaws: Index (50%)	Welds Existing
Random sample	41	6 flawed	N/A	2 big flaws	N/A	3105 (all SS Class C)
31 original SS	31	11 flawed	3.3%	3 big flaws	35.7%	31
31 originals minus 8 from 6EL	23	7 flawed	11.0%	1 big flaw	73.7%	23
6EL (originals)	8	4 flawed	4.1%	2 big flaws	11.5%	8
6EL (all)	18	8 flawed	1.6%	3 big flaws	15.4%	35 (23 roots) (all Class C)
6SV	2	1 flaw	29.6%	1 big flaw	13.3%	54 Class C
6TTC	7	3 flaws	10.5%	No big flaws	100.0%	52 Class C (33 roots)
6RSS	4	2 flaws	13.4%	No big flaws	100.0%	10 Class C (8 roots)
6NU	1	1 flaw	16.3%	0 or 1 big (L/C = 46%)	7% or 100%	87 Class C 2 Class B

Note: See previous page for definitions.

CONCLUSIONS ABOUT ORIGINAL 31 STAINLESS STEEL WELDS

On the Basis of Current Data and Statistical Hypothesis Tests:

- **The Workmanship of the Total Group of 31 SS Welds is Probably Inferior to the Stainless Steel Weld Population in General.**

- **There is Little Reason to Suspect Inferior Workmanship in the Group of 23 Original SS Welds Not Produced By Welder 6EL. In these 23 Original SS Welds, While the Ability to Avoid 10%-Circumference Flaws is Marginal (with ALFI = 11%), the Ability to Avoid Large Flaws (ALFI = 73.7%) Equals the Random Sample. This is Consistent with Our Finding in Section 5 (Under Weld Comparisons) That the 95th Percentile Estimate of Flaw Area is Similar for the Original and Random Weld Samples.**

POSSIBLE APPROACH BASED ON STATISTICAL COMPARISON OF SS WELDERS (ALFI INDEX)

1. Assume Welder(s) are O.K. Unless Present Data or Other Knowledge Says Otherwise (Else All Welders Must Be Checked With Multiple Inspections).

2. If Welders' Presently Inspected Work Product Give Both ALFI Indices (For L/C > 10% and L/C > 50%) Greater Than 10% (or for extra Conservatism 15%), Do Nothing. See a Previous Page For Definition and Values of Current ALFI Indices.

3. If Either ALFI Index is Less Than 10%, the Welders' Workmanship is Suspect. In This Case, Inspect More Suspect Welds Until Either the Indices Rise Above 10% or All Are Inspected.

4. On This Basis, from the Original Welds Only One Welder (6EL) is a Prime Suspect and One (6NU) is a Minor Suspect. Two additional Minor Suspects Come from Our Random Sample.

5. However, if a Specified Cutoff of $\alpha_{SPECIFIED} = 15\%$ is used, 3 More Minor Suspects are Added. The Next Page Gives Specific Suggestions to Deal With These Seven Welders' Work Products.

SUGGESTED INSPECTIONS OF SEVEN WELDERS

Figure 2 is a flowchart of the approach we recommend to investigate welders suspected of poor workmanship. The comments below amplify this flowchart.

1. Welder 6EL is an Outlier and Using Figure 2, All of His Welds Will Need to Be Looked at.

2. Welder 6NU Had Only One Inspected Weld at 46% Circumference. Rounding This Up to 50%, One or Two New Clean Random Samples Will Eliminate This Suspect. We Suggest Starting With 4 Welds For Caution. It Can Be Argued That Pulling More Welds on the Basis of One Data Point is Overkill. Yet 50% Circumference Flaws Are Rare and Are The Most Important Flaws to Consider For Structural Integrity. It May Be Prudent to Treat One Bad Data Point as an Alarm and Check For More.

3. APTECH's Random Sample Picked up two Welders Similar to 6NU (One Big Flaw in Only One SS Weld Inspection). These Are 6GK and 6PFF. We Suggest Planning 4 New Inspections Each With More as Required.

4. Note That of the Six Minor Suspects, 6GK, 6SV, 6TTC and 6NU Each Made Many Uninspected SS Class 3 Welds so They are More Important to Check Than 6PFF and 6RSS.

5. Welder 6RSS Shows Up at the 13.4% Level. If TVA continues to specify $\alpha_{SPECIFIED} = 15\%$, we Suggest a Further Sample of Four Welds.

6. Welder 6SV Shows Up at Less Than 15% For One Big Flaw in Two Welds. We Suggest a Further Sample of Four Welds.

7. Finally, Welder 6TTC shows up marginally at ALFI=10.5% for 3 Flaws in 7 Welds. Note that 6TTC had No Big Flaws and on of His Three Barely Qualified at 10.1% of the Circumference.

8. Any More Inspecting Beyond That Suggested Above Falls Under the Category of "Looking For New SS Welder Suspects."

INDEX OF SELECTED WELDERS' ABILITY TO AVOID LONG FLAWS IN CARBON AND DISSIMILAR WELDS

		Avoiding Medium Flaws		Avoiding Large Flaws		
Welder(s) or Weld(s)	Welds Inspected (NI)	Number at L/C>10%	Index (10%)	Number at L/C>50%	Index (50%)	Welds Existing
Random Sample	43	3 flawed	N/A	2 big flaws	N/A	4015 Class C
6AAI	2	1 flaw	17.2% (13.3%)	1 big flaw	12.8% (9.0%)	54A, 123B, 40C, and 20 Class D
6RS	1	1 flaw	8.9% (6.8%)	1 big flaw	6.7% (4.5%)	12 Class C
6NM	1	1 flaw	8.9% (6.8%)	0	100.0% (100%)	124 Class C

NOTES ON CARBON STEEL WELD ANALYSIS

1. Values in Brackets () are Based on a More Rigorous Approach Which Temporarily Removes the Evaluated Welder From the 43-Weld Random Sample Before Applying the Hypothesis Tests. This Was Not Necessary For the Evaluation of Welders Outside the Random Sample (e.g., the Welders in the Original SS-Weld Sample). All Other Assumptions Are as for the ALFI Index Analysis of the Stainless Steel Welds.

2. Based on the Above, We Rely on the More Conservative Bracketed Values for Our Conclusions.

3. Yet, Note That at the $\alpha_{SPECIFIED} = 15\%$ Level of Significance, Using the Lower of the Two Medium and Large-Flaw Indices, the Bracketed and Unbracketed Values Give the Same Conclusion. To Wit, All Three Welders are "Minor Suspects". Using $\alpha_{SPECIFIED} = 10\%$ with the bracketed values gives the same results.

4. As for the SS Welders, The Flowchart in Figure 2 Should be Used to Investigate these Minor Suspects, Starting with Four Inspected Welds Each.

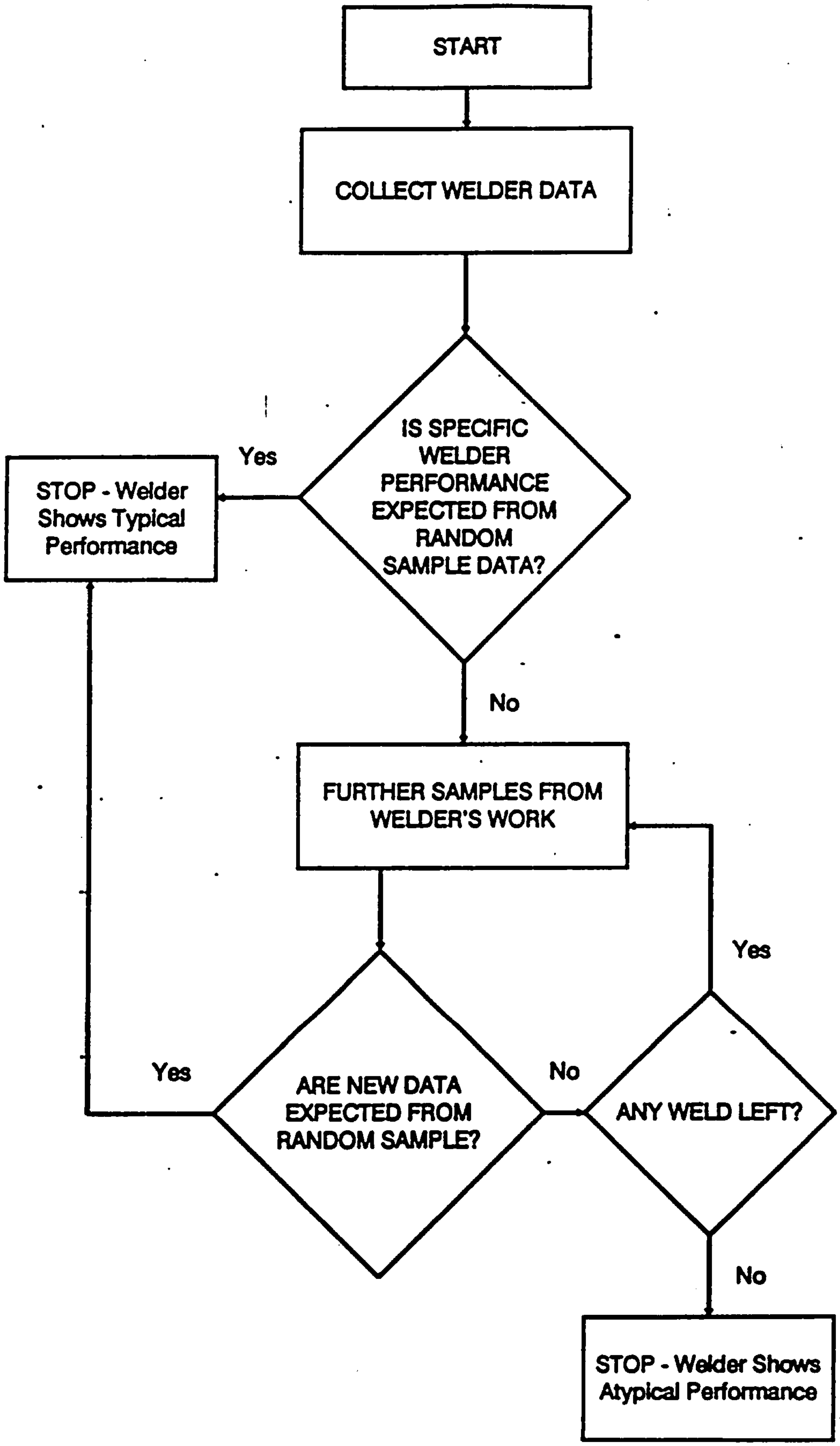

Figure 1 - Generic Screening Technique Applied to Any Welder.

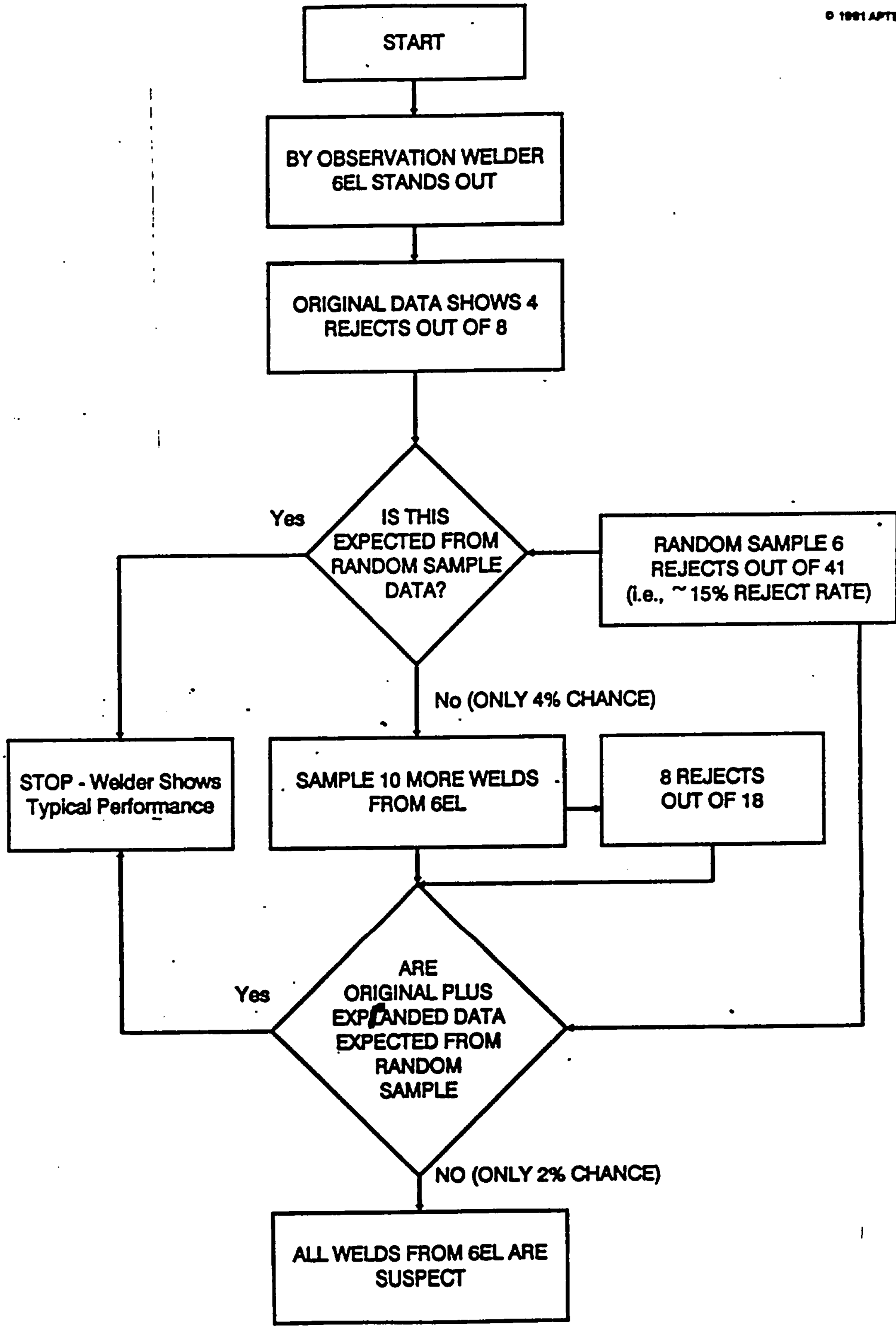

Figure 2 - Statistical Screening Technique Applied to Welder 6EL.

Appendix E
SUMMARY OF CALCULATION PACKAGES

CALCULATION COVER SHEET

Document No.: I-7 1312-C-5	Client: Tennessee Valley Authority
Title: Highest Stress Ratios in Class 3 Piping Analyses	Project No.: AES 90091312-1Q
	APTECH Office: Houston
	Sheet No. 1 of 17

Purpose:

This calculation documents the identification of stress analyses for selected ASME Boiler and Pressure Vessel Code Section III Class 3 piping systems and the highest stresses within the analyses.

Assumptions:

The identification of drawings and stress analysis calculations used are found in Table 1 and Table 2 respectively.

Results:

Stress analyses were identified and reviewed for the Auxiliary Feedwater, Essential Raw Cooling Water (ERCW), Component Cooling, and Spent Fuel Pit Cooling systems. The applicable stress analysis calculations and their most highly stressed nodes and stress ratios are listed in Table 3.

Revision No.:	Prepared By: / Date:	Checked By: / Date:	Verified By: / Date:	Approved By: / Date:	Revision Description
0	WP [signature] 10/27/90	WLB 10/30/90	[signature] 31JAN91	[signature] 1-31-91	Initial Issue

APTECH® ENGINEERING SERVICES, INC.

QAN45
REV. 7/90

Method of data extraction and results -
Piping systems for stress analysis review were selected from a preliminary list of the number of butt welds made by TVA within a piping system. The list had been separated into carbon steel welds, stainless steel welds, and welds between carbon steel and stainless steel. The systems were selected to ensure two stainless steel piping systems and one carbon steel system. TVA engineers suggested that the carbon steel Auxiliary Feedwater system stress analyses contained relatively high stresses. The Component Cooling Water system was selected to ensure an adequate sample of carbon steel piping stress analyses. The ERCW and Spent Fuel Pit Cooling systems were selected for stainless steel content.

All class 3 piping was identified on Flow Diagrams (see Table 1) of the four systems. The identification number of corresponding stress analysis calculations were obtained from flow diagrams which had been marked with analysis numbers by TVA. The latest revisions of the analysis calculations were located in the TVA RIMS records system. Successor calculations were obtained for three calculations which had been superseded.

Because of difficulties in locating the calculations in the records system, Table 2 is an index into the records system to locate calculations and microfiches of computer output. The applicable drawings and Design Change Authorizations are noted in the calculations.

The results of the review are in Table 3. Materials, pipe sizes, and pipe thicknesses are a complete list of those used in a analysis. Stress ratios and node identifications are the most highly stressed nodes as identified in computer output stress summaries ~~of an~~ entire analysis. The information may or may not represent Class 3 piping or piping welds. Many analyses contain Class 2 piping or piping less than 2 inch nominal pipe size.

Several of the stress ratios in Table 3 violate ASME Section III requirements. A cursory review of the calculations indicated that the calculated stresses at these locations had been reduced using alternate analyses. However, the stress ratios from the computer output have been used in Table 3 to provide a uniform standard for comparison of stresses.

Table 1

Piping Systems and Flow Diagrams Reviewed

Auxiliary Feedwater
1-47W803-1 Rev. 0
1-47W803-2 Rev. 1
1-47W803-3 Rev. 0

Essential Raw Cooling Water
1-47W845-1 Rev. 4
1-47W845-2 Rev. 2
1-47W845-3 Rev. 3
1-47W845-4 Rev. 1
1-47W845-5 Rev. 3
1-47W845-7 Rev. 1

Component Cooling
1-47W859-1 Rev. 5
1-47W859-2 Rev. 3
1-47W859-3 Rev. 1
1-47W859-4 Rev. 0

Spent Fuel Cooling

47W855-1 Rev. CC

Table 2
Location of Class 3 Calculations

Calculation	Reel& Frame	Microfiche	Accession No.
** System: Auxiliary Feedwater			
0600200-02-05	8888.0001	TVA-F-G096262	B18900716057
0600200-02-08	8519.1531	TVA-F-G092390	B18900405044
N3-03-01A,2A	8875.0602	TVA-F-G090888	B18900806001
N3-03-03A	8771.0581	TVA-F-G092748	B18900703059
N3-03-05A	8809.0497	TVA-F-G091526	B18900717034
N3-03-10A	8814.1135	TVA-F-G090316	B18900717039
N3-03-12A	8810.2229	TVA-F-G090398	B18900717053
N3-03-13A	8771.0989	TVA-F-G095112	B18900705004
N3-03-14A	8827.0253	TVA-F-G092494	B18900705047
** System: Component Cooling			
0600200-04-08	8773.0666	TVA-F-G095138	B18900717032
0600200-04-09	8175.0430	TVA-F-G088628	B18891220256
0600200-04-11	8698.0001	TVA-F-G087922	B18900614043
N3-70-01A	8800.0217	TVA-F-G095144	B18900712066
N3-70-02A	8772.0743	TVA-F-G088816	B18900703050
N3-70-03A	8798.0001	TVA-F-G088514	B18900621013
N3-70-04A	8765.1163	TVA-F-G088932	B18900712003
N3-70-05A	8815.1526	TVA-F-G095170	B18900725023
N3-70-05R	8897.0001	TVA-F-G089194	B18900828001
N3-70-06A	8800.0001	TVA-F-G095150	B18900712065
N3-70-06R	8880.0001	TVA-F-G096002	B18900712011
N3-70-07A	8801.0146	TVA-F-G092530	B18900712029
N3-70-08A	8827.2060	TVA-F-G091536	B18900731004
N3-70-09A	8711.0852	TVA-F-G089272	B18900622029
N3-70-10A	8848.0928	TVA-F-G089188&95978	B18900731002
N3-70-26A	8810.1923	TVA-F-G091774	B18900717050
N3-70-29A	8772.1809	TVA-F-G088080	B18900705005
N3-70-30A	8720.0163	TVA-F-G088100	B18900621011
N3-70-31A	8711.1159	TVA-F-G089896	B18900622033
N3-70-32A	8715.1514	TVA-F-G087606	B18900618012
N3-70-33A	8815.1087	TVA-F-G088414	B18900725017
N3-70-38A	8766.1226	TVA-F-G091776	B18900705044
N3-70-39A	8784.1737	TVA-F-G089800	B18900705006
N3-70-42A	8767.1937	TVA-F-G095140	B18900627086
N3-70-43A	8788.0854	TVA-F-G092696	B18900705037
N3-70-45A	8879.0001	TVA-F-G088102	B18900705043
N3-70-47A	8719.0469	TVA-F-G088178	B18900618004
N3-70-48A	8715.1270	TVA-F-G088042	B18900618006
N3-70-49A	8713.0219	TVA-F-G000146	B18900618005
N3-70-50A	8716.0798	TVA-F-G087760	B18900618017
N3-70-51A	8710.1245	TVA-F-G088148	B18900618003
N3-70-52A	8749.0517	TVA-F-G088600	B18900703021
N3-70-53A	8815.0829	TVA-F-G000035	B18900717048
N3-70-54A	8818.0368	TVA-F-G088718	B18900716095
N3-70-55A	8815.0717	TVA-F-G088550	B18900717047

Table 2 (cont)
Location of Class 3 Calculations

Calculation	Reel& Frame	Microfiche	Accession No.
** System: Essential Raw Cooling Water			
N3-67-01A	8830.0001	TVA-F-G095256	B18900716052
N3-67-01P	8768.0916	TVA-F-G088538	B18900712009
N3-67-02A	8709.1084	TVA-F-G089926&93686	B18900622031
N3-67-02P	8801.0001	TVA-F-G088540	B18900529005
N3-67-03A	8766.0832	TVA-F-G088808	B18900705031
N3-67-03P	8771.1116	TVA-F-G088536	B18900705048
N3-67-03R	8827.1710	TVA-F-G095146	B18900730054
N3-67-04A	8827.0472	TVA-F-G089246	B18900716053
N3-67-04P	8771.0001	TVA-F-G088542	B18900529002
N3-67-04R	8847.0720	TVA-F-G095166	B18900717035
N3-67-05A	8815.0394	TVA-F-G089336	B18900717004
N3-67-06A	8770.0521	TVA-F-G085610	B18900703045
N3-67-06R	8842.0699	TVA-F-G089362	B18900712027
N3-67-07A	8791.1673	TVA-F-G087258	B18900529003
N3-67-08A	8815.0940	TVA-F-G087434	B18900725016
N3-67-09A	8879.0197	TVA-F-G095722	B18900730053
N3-67-10A	8808.0001	TVA-F-G088000	B18900529006
N3-67-11A	8849.0078	TVA-F-G087470	B18900712012
N3-67-12R	8711.0508	TVA-F-G087762	B18900618009
N3-67-13A	8781.0781	TVA-F-G087440	B18900712023
N3-67-13R	8839.0048	TVA-F-G087792	B18900705026
N3-67-14R	8788.0961	TVA-F-G087532	B18900705038
N3-67-15A	8791.2063	TVA-F-G087998	B18900705011
N3-67-15R	8766.0730	TVA-F-G087992	B18900705030
N3-67-16A	8788.1075	TVA-F-G087422	B18900705039
N3-67-16R	8780.0733	TVA-F-G092470	B18900705008
N3-67-17A	8806.0078	TVA-F-G091770	B18900618015
N3-67-17R	8720.0329	TVA-F-G087974	B18900621012
N3-67-18A	8719.0627	TVA-F-G095810	B18890106007
N3-67-18R	8810.2105	TVA-F-G088668	B18900717052
N3-67-19A	8827.1984	TVA-F-G095604	B18900731003
N3-67-19R	8766.0212	TVA-F-G087896	B18900705027
N3-67-20A	8720.0440	TVA-F-G093796	B18900621014
N3-67-20R	8815.0641	TVA-F-G088632	B18900717046
N3-67-21A	8750.0067	TVA-F-G089178&092168	B18900629035
N3-67-21R	8842.0109	TVA-F-G088326	B18900716093
N3-67-22A	8703.0204	TVA-F-G092516	B18900614002
N3-67-22R	8814.1910	TVA-F-G088410	B18900725015
N3-67-23A	8781.1565	TVA-F-G095666	B18900713054
N3-67-23R	8808.1223	TVA-F-G088710	B18900717057
N3-67-24A	8848.0001	TVA-F-G088290	B18900703024
N3-67-24R	8808.1305	TVA-F-G088680	B18900717058
N3-67-25A	8771.0716	TVA-F-G095134	B18900703061
N3-67-25R	8814.1826	TVA-F-G088626	B18900725013
N3-67-26A	8771.0460	TVA-F-G089184	B18900703049
N3-67-26R	8750.0245	TVA-F-G088980	B18900701002
N3-67-27A	8770.0866	TVA-F-G095132	B18900701060

Table 2 (cont)
Location of Class 3 Calculations

Calculation	Reel& Frame	Microfiche	Accession No.
** System: Essential Raw Cooling Water (cont)			
N3-67-27R	8772.1006	TVA-F-G088630	B18900703951
N3-67-28A	8827.1498	TVA-F-G095706	B18900730052
N3-67-29A	8725.0202	TVA-F-G095584	B18900621007
N3-67-30A	8703.0001	TVA-F-G087938	B18900614001
N3-67-31A	8815.0086	TVA-F-G088296	B18900717041
N3-67-32A	8818.0725	TVA-F-G088008	B18900717054
N3-67-33A	8749.0334	TVA-F-G095156	B18900703019
N3-67-34A	8815.0542	TVA-F-G088010	B18900717045
N3-67-35A	8814.0890	TVA-F-G088580	B18900717037
N3-67-36A	8791.2292	TVA-F-G088314	B18900705046
N3-67-37A	8810.2020	TVA-F-G089062	B18900717051
N3-67-38A	8716.0667	TVA-F-G087536	B18900618016
N3-67-39A	8781.0068	TVA-F-G087480	B18900712022
N3-67-40A	8710.1329	TVA-F-G087816	B18900618007
N3-67-41A	8741.0001	TVA-F-G088128	B18900618013
N3-67-42A	8713.0309	TVA-F-G087552	B18900618011
N3-67-43A	8724.0259	TVA-F-G088022	B18900621009
N3-67-44A	8788.0001	TVA-F-G087702	B18900529001
N3-67-45A	8829.1268	TVA-F-G088076	B18900712028
N3-67-46A	8784.1161	TVA-F-G088184	B18900705032
N3-67-49A	8784.2106	TVA-F-G087672	B18900705035
N3-67-51A	8784.1052	TVA-F-G088756	B18900705033
N3-67-52A	8766.1318	TVA-F-G092548	B18890923155
N3-67-53A	8715.1037	TVA-F-G090052	B18900618001
N3-67-54A	8780.0614	TVA-F-G088098	B18900705007
N3-67-56A	8766.1109	TVA-F-G087966	B18900705042
N3-67-57A	8800.0454	TVA-F-G090056	B18900716090
N3-67-58A	8748.1310	TVA-F-G089614	B18900614004
N3-67-59A	8791.2201	TVA-F-G089456	B18900705024
N3-67-62A	8719.0548	TVA-F-G090320	B18900618010
N3-82-01D	8520.1141	TVA-F-G090872	B41900426006
N3-82-02D	8520.1242	TVA-F-G090784	B41900426007
N3-82-03D	8520.1341	TVA-F-G091106	B41900426008
N3-82-04D	8520.1057	TVA-F-G091788	B41900426005
N3-82-05D	8520.0954	TVA-F-G091876	B41900426004
N3-82-06D	8540.1147	TVA-F-G090794	B41090426010
N3-82-07D	8520.1407	TVA-F-G090792	B41900426009
N3-82-08D	8520.1531	TVA-F-G090850	B41090426011
** System: Spent Fuel Pit Cooling			
N3-78-01A1	8278.0001	TVA-F-G094302	B04900228403
N3-78-01A2	8278.0001	TVA-F-G094302	B04900228403
N3-78-01A3	8278.0001	TVA-F-G094302	B04900228403
N3-78-01A4	8278.0001	TVA-F-G094302	B04900228403
N3-78-01A5	8278.0001	TVA-F-G094302	B04900228403
N3-78-12A	8015.0001	TVA-F-G092164	891113D0001
[illegible]	[illegible]	[illegible]	[illegible]

Table 3
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Auxiliary Feedwater							
0600200-02-05	CS	2 x .344, 4 x .337, 4 x .438, 6 x .437, 6 x .562, 8 x .500	650A 1.187	650A .798	A13 1.013	13S 1.173	13S .850
0600200-02-08	CS	2 x .218, 2 x .344, 4 x .337, 4 x .438, 6 x .432, 6 x .562, 8 x .500	612 .924	612 .616	6 .966	CENTR 1.208	CENTR .785
N3-03-01A,2A	CS&SS	4 x .237, 6 x .280, 8 x .322, 10 x .365, 12 x .375	531 .635	71 .224	531 .327	429 .820	429 .557
N3-03-03A	CS	3 x .438, 4 x .337, 4 x .438, 6 x .562	44A 1.095	44A .731	44A .772	14C .885	14C .645
N3-03-05A	CS&SS	2 x .218, 2.5x .276, 3 x .300, 4 x .237, 6 x .280, 8 x .322, 10 x .365	A32 .949	A32 .636	A32 .652	G11 1.291	G11 .802
N3-03-10A	CS	2 x .343, 4 x .438; 6 x .562	549 .786	97 .272	549 .400	423 .651	423 .471
N3-03-12A	CS	2 x .343, 4 x .438, 6 x .562, 6 x .718	D1 .567	D1 .409	D1 .526	282 .714	282 .562
N3-03-13A	CS	3 x .438, 4 x .337, 4 x .438, 6 x .280	154A .897	154A .601	154A .656	PW1 .792	PW1 .576
N3-03-14A	CS	4 x .437, 4 x .438, 6 x .280	303 .838	303 .581	303 .649	PW1 1.053	PW1 .737

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Component Cooling							
0600200-04-08	CS	2 x .154, 3 x .216, 3 x .438	32 .617	32 .412	32 .444	CENTR .622	1 .394
0600200-04-09	CS	2 x .154, 3 x .216	366E .344	366E .229	279 .231	232 1.137	232 .833
0600200-04-11	CS	4 x .237, 6 x .280	29 .357	29 .238	29 .243	113 .510	113 .339
N3-70-01A	CS	4 x .237, 6 x .280, 8 x .322	63 .761	63 .507	63 .734	32 .646	32 .435
N3-70-02A	CS	2 x .154, 14 x .375, 16 x .375, 20 x .375, 24 x .375	166 .784	166 .523	329 .676	198 1.079	198 .715
N3-70-03A	CS	2 x .154, 3 x .216, 4 x .237, 8 x .322, 10 x .365, 12 x .375, 14 x .375, 16 x .375, 18 x .375, 20 x .375, 24 x .375	CA9 1.005	CA9 .670	CA9 .860	CE1 1.243	CE1 .814
N3-70-04A	CS	2 x .154, 3 x .216, 4 x .237, 8 x .322, 10 x .365, 12 x .375, 16 x .375, 18 x .375, 24 x .375	T2A .940	T2A .627	235 .733	D2B 1.240	D2B .864
N3-70-05A	CS	2 x .154, 3 x .216, 3 x .438, 6 x .280, 8 x .322	FC3 .845	FC3 .564	FC3 .703	124 .743	124 .470
N3-70-05R	CS	4 x .237, 6 x .280	PX52 .550	PX52 .367	PX52 .469	CENTR .750	CENTR .479
N3-70-06A	CS	2 x .154, 3 x .216, 3 x .438, 6 x .280, 8 x .322	91X .815	91X .591	225 .646	50 .970	50 .615
N3-70-06R	CS	2 x .344, 3 x .438	585 1.130	585 .758	585 .574	167 1.417	167 .921

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Component Cooling (cont)							
N3-70-07A	CS	2 x .154, 3 x .216, 4 x .237, 6 x .280, 8 x .322, 10 x .365, 16 x .375	F17 .476	F17 .318	F17 .342	P158 1.110	P158 .697
N3-70-08A	CS	3 x .216, 4 x .237, 6 x .280, 8 x .322, 10 x .365, 16 x .375	G51A .746	G51A .498	G51A .533	M83 .935	M83 .593
N3-70-09A	CS	2 x .154, 3 x .216, 4 x .237, 6 x .280, 8 x .322, 10 x .365, 16 x .375, 18 x .375	E8B .983	E8B .656	E8B .668	F94 1.205	F94 .746
N3-70-10A	CS	2 x .154, 3 x .216, 4 x .237, 6 x .280, 8 x .322, 10 x .365, 16 x .375, 18 x .375	P1PB .954	P1PB .636	P1PB .612	N57 1.289	N57 .811
N3-70-26A	CS	2 x .154, 3 x .216	155 .166	155 .111	155 .112	FC1 .340	FC1 .236
N3-70-29A	CS&SS	2 x .154, 3 x .216	217C .416	217C .277	217C .320	631 .455	P135 .284
N3-70-30A	CS&SS	2 x .154, 3 x .216	40A .302	40A .201	47K .210	E46L .464	40A .356
N3-70-31A	CS/AL	3 x .216, 4 x .237	110 .641	110 .427	110 .590	CENTR .557	CENTR .360
N3-70-32A	CS	4 x .237	L16 .122	L16 .081	L16 .092	CENTR .440	CENTR .281
N3-70-33A	CS	2 x .154, 3 x .216	190 .219	190 .146	190 .156	13 .593	13 .383
N3-70-38A	CS	4 x .237	40E .187	40E .125	40E .163	50B .256	50B .176
N3-70-39A	CS/AL	3 x .216, 4 x .237	M38 .889	M38 .593	190 .799	M16 .797	M16 .513

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Component Cooling (cont)							
N3-70-42A	CS	3 x .216, 3 x .438	013 .735	013 .490	013 .563	5C3 .265	013 .260
N3-70-43A	CS	3 x .216, 3 x .438	13 .678	13 .452	CENTR .499	2A .291	32 .250
N3-70-45A	CS	2 x .154, 3 x .216	190 .344	190 .299	155 .246	310 1.209	310 .739
N3-70-47A	CS	2 x .154, 3 x .216	5A .578	5A .386	5A .375	16A .279	5A .193
N3-70-48A	CS	2 x .154, 3 x .216	94A .965	94A .643	57A .767	49 .957	49 .596
N3-70-49A	CS	2 x .154, 3 x .216	E45 .408	E45 .272	E45 .318	D10 .717	C13 .451
N3-70-50A	CS	2 x .154, 3 x .216	12 .391	12 .261	46N .326	54 .788	54 .550
N3-70-51A	CS	2 x .154, 3 x .216	E25 .345	- -	F50 .241	C10 .831	C10 .572
N3-70-52A	CS	2 x .154, 3 x .216, 4 x .237	434A .367	434A .245	434A .275	450 1.235	450 .766
N3-70-53A	CS	2 x .154, 3 x .216, 4 x .237	400 .209	400 .139	400 .151	400 .947	400 .621
N3-70-54A	CS	3 x .216	214 .218	214 .145	581 .145	230 .180	230 .149
N3-70-55A	CS	2 x .154, 3 x .216	535 .163	535 .109	535 .115	100 .813	100 .505

Made LRJ Date 10/26/90 Checked WIB Date 10/30/90

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water							
N3-67-01A	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280, 8 x .322, 10 x .365, 18 x .375, 24 x .375, 30 x .375	275X 1.086	275X .724	275X .900	449X 2.042	449X 1.261
N3-67-01P	SS	4 x .237	92 .659	92 .439	92 .561	5 1.080	5 .666
N3-67-02A	CS&SS	2 x .154, 3 x .216, 6 x .280, 8 x .322, 18 x .375, 20 x .375, 24 x .375	230A 1.049	230A .699	A16 .930	134 1.013	88X .693
N3-67-02P	SS	4 x .237	92 .659	92 .439	92 .561	5 1.121	5 .690
N3-67-03A	CS&SS	6 x .280, 8 x .322	A36 .582	A36 .388	A36 .442	A90 1.511	A90 .999
N3-67-03P	SS	4 x .237	92 .658	92 .439	92 .560	105 .665	105 .429
N3-67-03R	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280	AN9 .311	AN9 .207	203A .425	434 1.632	434 .995
N3-67-04A	CS	2 x .218, 20 x .375, 24 x .375	22 .373	22 .249	22 .242	65 .856	65 .608
N3-67-04P	SS	4 x .237	92 .659	92 .439	92 .561	5 .598	5 .377
N3-67-04R	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280	A11 .304	A11 .204	A11 .207	24A .923	24A .589
N3-67-05A	CS&SS	2 x .154, 3 x .216, 8 x .322, 18 x .375, 20 x .375	20A .655	20A .437	20A .622	44 .850	44 .570
N3-67-06A	CS&SS	2 x .154, 3 x .216, 8 x .322, 18 x .375, 20 x .375	141B .555	141B .564	141A .568	141A 1.374	141A .834

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water (cont)							
N3-67-06R	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280	232 .212	232 .142	197 .584	159 .989	159 .611
N3-67-07A	SS	6 x .280	NN8 .206	NN8 .138	MD07 .141	C16B 1.014	C16B .630
N3-67-08A	SS	6 x .280	13 .319	13 .213	13 .211	P16B 1.040	P16B .650
N3-67-09A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280, 8 x .322, 12 x .375, 14 x .375, 16 x .375, 18 x .375, 20 x .375, 24 x .375, 30 x .375, 36 x .375, 36 x .438	36 .770	36 .513	CENTR .664	551 1.434	551 .990
N3-67-10A	CS	3 x .216, 6 x .280	5150 .154	5150 .103	5150 .101	C03B .424	C03B .287
N3-67-11A	SS	6 x .280	NK2 .212	NK2 .141	NK2 .142	CENTR .914	CENTR .569
N3-67-12R	SS	3 x .216	16 .082	16 .055	16 .047	10 .456	10 .289
N3-67-13A	SS	6 x .280	C14B .314	C14B .210	C14B .291	CENTR .931	CENTR .581
N3-67-13R	SS	3 x .322	34 .087	34 .058	34 .048	28 .307	28 .199
N3-67-14R	SS	3 x .216	AN9 .074	AN9 .049	70A .043	55 .296	55 .193
N3-67-15A	SS	6 x .280	30A .253	30A .168	30A .205	CENTR .194	CENTR .141
N3-67-15R	SS	2.5x .203, 3 x .216	60 .117	60 .078	60 .070	CENTR .355	CENTR .232
N3-67-16A	SS	4 x .237, 6 x .280	145 .248	145 .165	145 .162	C04B .236	C04B .166

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water (cont)							
N3-67-16R	SS	3 x .216	1 .152	1 .102	1 .092	CENTR .296	CENTR .190
N3-67-17A	CS&SS	6 x .280	52 .239	52 .159	52 .173	105 .342	105 .269
N3-67-17R	SS	3 x .216	78 .086	78 .057	78 .051	1 .639	1 .396
N3-67-18A	SS	6 x .280	49 .332	49 .221	49 .249	CENTR .126	49 .137
N3-67-18R	SS	3 x .216	1 .094	1 .063	1 .052	CENTR .486	CENTR .308
N3-67-19A	CS&SS	6 x .280, 6 x .432	10 .176	10 .122	10 .216	789 .602	789 .391
N3-67-19R	SS	3 x .216	65 .049	65 .033	145 .029	1 .437	1 .277
N3-67-20A	CS&SS	6 x .280, 8 x .322	E49 .705	E49 .482	E49 .447	E49 1.316	E49 1.018
N3-67-20R	SS	2 x .154, 3 x .216	30 .164	30 .109	38 .119	18 .619	18 .434
N3-67-21A	CS&SS	6 x .280, 6 x .432, 8 x .322	A106 .643	A106 .493	A106 .758	A96 1.189	A106 .934
N3-67-21R	SS	2 x .154, 3 x .216	10A .059	10A .039	10A .042	900B 1.013	900B .619
N3-67-22A	CS&SS	6 x .280, 8 x .322	68B .131	68B .091	68B .097	885 .237	885 .170
N3-67-22R	SS	2 x .154, 3 x .216	21 .152	21 .102	21 .120	17G .717	17G .490
N3-67-23A	CS&SS	2 x .154, 4 x .237, 8 x .322, 10 x .365, 24 x .375, 30 x .375	22 .974	22 .649	22 .916	R27 1.573	R27 .972

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water (cont)							
N3-67-23R	SS	2 x .154, 3 x .216	FL3 .244	FL3 .162	FL3 .139	FL3 .867	FL3 .624
N3-67-24A	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280, 8 x .322	BB06 .778	BB06 .519	BB06 .662	F17 1.495	F18 .964
N3-67-24R	SS	2 x .154, 3 x .216	FL03 .141	FL03 .094	FL03 .077	FL01 .598	FL01 .388
N3-67-25A	CS&SS	6 x .280, 6 x .432, 8 x .322	R3Y .364	R3Y .243	R3Y .366	R12 .521	R12 .337
N3-67-25R	SS	2 x .154, 3 x .216	FL01 .229	FL01 .153	FL01 .126	FL01 .833	FL01 .598
N3-67-26A	CS&SS	6 x .280, 6 x .432, 8 x .322	B92B .925	B92B .606	B92B .840	B92B 1.296	B92B 1.001
N3-67-26R	SS	2 x .154, 3 x .216	FL03 .168	FL03 .112	FL01 .110	FL01 .593	FL03 .413
N3-67-27A	CS&SS	6 x .280, 6 x .432, 8 x .322	10 .216	10 .144	C06E .299	10 .371	10 .284
N3-67-27R	SS	2 x .154, 3 x .216	FL01 .213	FL01 .142	FL01 .120	FL01 .765	FL01 .548
N3-67-28A	CS&SS	2 x .154, 4 x .237, 8 x .322, 10 x .365, 24 x .375, 30 x .375	800 .768	800 .512	800 .596	820 1.292	820 .815
N3-67-29A	CS&SS	2 x .154, 3 x .216, 8 x .322, 18 x .375, 20 x .375	141 .453	141 .302	141 .388	11E 1.059	11E .678
N3-67-30A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	505 .316	505 .211	505 .267	495 .844	495 .537
N3-67-31A	SS	2 x .154, 3 x .216, 4 x .237	10 .094	10 .063	10 .084	10 .468	10 .292

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water (cont)							
N3-67-32A	SS	3 x .216, 2 x .154	A722 .662	A722 .441	A722 .495	A71 1.021	A71 .625
N3-67-33A	CS	3 x .216	3 .126	3 .084	23 .080	CENTR .449	CENTR .283
N3-67-34A	CS&SS	2 x .154, 4 x .237	16 .956	17B .054	17B .053	44 1.529	44 .938
N3-67-35A	CS&SS	2 x .154, 4 x .237	27A .146	27A .098	27A .096	A59 1.205	A59 .745
N3-67-36A	CS&SS	2 x .154, 4 x .237	36 .430	36 .286	36 .334	10 .629	10 .411
N3-67-37A	CS&SS	2 x .154, 4 x .237	228 .304	228 .202	405 .211	82 .561	228 .409
N3-67-38A	SS	2 x .154, 3 x .216	58 .452	- -	58 .413	CENTR .763	CENTR .473
N3-67-39A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	E18 .796	E18 .548	B23 .448	D23 1.024	D23 .632
N3-67-40A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	D64 .408	D64 .272	D64 .312	D02 1.615	D02 .990
N3-67-41A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	AV51 .585	AV51 .394	AV51 .491	G06 1.401	G06 .858
N3-67-42A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	174 .293	174 .195	174 .238	282 1.398	282 .856
N3-67-43A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	S38 .960	S38 .681	S38 .585	B06E 1.168	E01 .752
N3-67-44A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	720 .438	720 .292	720 .385	699 1.144	699 .731

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water (cont)							
N3-67-45A	CS&SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237, 6 x .280	CENTR .727	CENTR .501	CENTR .666	21 1.029	21 .642
N3-67-46A	SS	2 x .154, 2.5x .203, 3 x .216, 4 x .237	1 .251	1 .167	1 .153	22 .277	22 .194
N3-67-49A	CS&SS	2 x .154, 2.5x .203, 3 x .216	101 .263	101 .175	101 .242	CENTR .566	CENTR .352
N3-67-51A	CS	3 x .216	B170 .705	B230 .126	B230 .164	B170 1.569	B170 .963
N3-67-52A	CS	3 x .216	16 .229	16 .153	16 .140	A130 1.332	A130 .820
N3-67-53A	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280, 8 x .322	F1 .240	F1 .160	514 .184	514 1.533	514 .957
N3-67-54A	SS	2 x .154, 2.5x .203, 3 x .216	P240 .318	P240 .224	P240 .241	480A 1.089	480A .674
N3-67-56A	SS	2.5x .203, 6 x .280	80A .348	80A .232	80A .316	C06B .417	C06B .275
N3-67-57A	CS&SS	2 x .154, 3 x .216, 4 x .237, 6 x .280	956 .290	956 .193	956 .224	956 1.551	956 .976
N3-67-58A	CS&SS	2 x .154, 3 x .216	5 .505	5 .337	5 .426	30 .238	30 .204
N3-67-59A	CS&SS	2 x .154, 3 x .216, 6 x .280, 20 x .375	999 .163	999 .109	999 .132	999 1.417	999 .882
N3-67-62A	SS	2 x .154, 3 x .216	47 .726	47 .484	47 .723	61 1.111	61 .702
N3-82-01D	CS	8 x .322, 10 x .365	11 .244	11 .163	11 .139	CENTR .471	CENTR .315
N3-82-02D	CS&SS	8 x .322	2 .175	2 .116	2 .134	2 .131	2 .109

Table 3 (cont)
Maximum Stress Ratios

Calculation	Mater.	Pipe sizes	Stress ratios and nodes for Eq. 9U	9E	9F	10	11
** Piping System Essential Raw Cooling Water (cont)							
N3-82-03D	CS&SS	8 x .322	2 .183	2 .122	2 .139	24 .114	24 .196
N3-82-04D	CS	8 x .322, 10 x .365	33 .298	33 .199	42 .139	CENTR .550	CENTR .363
N3-82-05D	CS	8 x .322	290 .365	290 .243	290 .197	320 .567	320 .369
N3-82-06D	CS	8 x .322, 10 x .365	11 .243	11 .162	11 .138	CENTR .499	CENTR .331
N3-82-07D	CS	8 x .322, 10 x .365	11 .245	11 .163	11 .139	CENTR .472	CENTR .316
N3-82-08D	CS	8 x .322, 10 x .365	11 .242	11 .161	11 .137	CENTR .511	CENTR .338
** Piping System Spent Fuel Pit Cooling							
N3-78-01A1	SS	10 x .365	CENTR .178	CENTR .185	CENTR .246	200 .582	200 .383
N3-78-01A2	SS	3 x .216, 8 x .322, 10 x .365	B260 .373	B260 .249	B260 .323	452 .217	452 .154
N3-78-01A3	SS	3 x .216, 4 x .237, 8 x .322, 10 x .365	352 .385	352 .257	622 .357	908 .892	908 .570
N3-78-01A4	SS	10 x .250, 10 x .365	176 .520	176 .346	176 .413	192 .225	192 .183
N3-78-01A5	SS	4 x .237	404 .144	404 .096	404 .090	406 .004	404 .051
N3-78-12A	SS	2 x .154, 3 x .216	360 .060	360 .040	315 .038	30 .825	30 .516
N3-78-13A	SS	10 x .365	90 .270	90 .180	90 .184	135 .548	135 .378

Appendix F
DATABASE OF MOST HIGHLY STRESSED NODES

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
AUXFW	0600200-02-05	4.500	CS	59	.438	1.216	15000	3645	.254	.301	.209	.272	.773	.566
AUXFW	0600200-02-05	4.500	CS	60E	.438	1.216	15000	3645	.251	.286	.198	.243	.732	.540
AUXFW	0600200-02-05	4.500	CS	82	.438	2.073	15000	3645	.272	.608	.407	.386	.650	.499
AUXFW	0600200-02-05	4.500	CS	86	.438	1.000	15000	3645	.401	.622	.416	.377	.012	.168
AUXFW	0600200-02-05	4.500	CS	86X	.438	1.298	15000	3645	.386	.600	.402	.363	.041	.179
AUXFW	0600200-02-05	4.500	CS	192A	.438	2.073	15000	3645	.266	.700	.468	.457	.280	.275
AUXFW	0600200-02-05	4.500	CS	195	.438	1.000	15000	3645	.410	.682	.459	.420	.072	.207
AUXFW	0600200-02-05	4.500	CS	196	.438	1.000	15000	3645	.393	.655	.440	.403	.063	.195
AUXFW	0600200-02-05	4.500	CS	19X	.438	1.000	15000	3645	.368	.620	.416	.382	.053	.179
AUXFW	0600200-02-05	4.500	CS	197	.438	1.900	15000	3645	.413	.672	.452	.413	.191	.280
AUXFW	0600200-02-05	6.625	CS	91R	.562	2.000	15000	4385	.299	.270	.181	.141	.089	.173
AUXFW	0600200-02-05	6.625	CS	92	.562	2.000	15000	4385	.301	.278	.187	.146	.053	.152
AUXFW	0600200-02-05	6.625	CS	93	.562	1.031	15000	4385	.307	.288	.194	.152	.048	.152
AUXFW	0600200-02-05	6.625	CS	93A	.562	1.000	15000	4385	.312	.296	.200	.157	.057	.159
AUXFW	0600200-02-05	6.625	CS	94	.562	1.770	15000	4385	.334	.430	.290	.250	.445	.401
AUXFW	0600200-02-05	4.500	CS	90	.438	1.000	15000	3645	.254	.253	.169	.136	.178	.208
AUXFW	0600200-02-05	2.375	CS	623A	.344	2.100	15000	2011	.198	.279	.191	.169	1.056	.713
AUXFW	0600200-02-05	2.375	CS	625	.344	2.100	15000	2011	.191	.387	.262	.249	1.059	.712
AUXFW	0600200-02-05	2.375	CS	634	.344	2.100	15000	2011	.329	1.000	.752	.744	.324	.326
AUXFW	0600200-02-05	2.375	CS	650A	.344	2.100	15000	2011	.318	.957	.798	.804	1.086	.779
AUXFW	0600200-02-05	2.375	CS	647	.344	2.100	15000	2011	.305	.863	.580	.576	.535	.443
AUXFW	0600200-02-05	2.375	CS	618	.344	2.100	15000	2011	.242	.436	.324	.294	.619	.469
AUXFW	0600200-02-05	2.375	CS	619A	.344	2.100	15000	2011	.170	.241	.186	.172	.511	.375
AUXFW	0600200-02-05	2.375	CS	629	.344	2.100	15000	2011	.253	.734	.494	.487	.304	.284
AUXFW	0600200-02-05	2.375	CS	630	.344	2.100	15000	2011	.267	.709	.480	.467	.347	.315
AUXFW	0600200-02-05	2.375	CS	632	.344	2.100	15000	2011	.240	.731	.491	.483	.353	.308
AUXFW	0600200-02-05	2.375	CS	635	.344	2.100	15000	2011	.202	.425	.308	.284	.504	.383
AUXFW	0600200-02-05	2.375	CS	646	.344	1.000	15000	2011	.248	.571	.383	.369	.310	.286
AUXFW	0600200-02-05	2.375	CS	646X	.344	1.000	15000	2011	.260	.549	.368	.351	.344	.310
AUXFW	0600200-02-05	2.375	CS	647Z	.344	1.000	15000	2011	.239	.560	.376	.366	.255	.249
AUXFW	0600200-02-05	2.375	CS	650	.344	2.100	15000	2011	.262	.719	.484	.477	.553	.437
AUXFW	0600200-02-05	4.500	CS	13R	.337	2.000	15000	3091	.365	.424	.286	.563	1.128	.823
AUXFW	0600200-02-05	4.500	CS	127A	.337	1.496	15000	3091	.236	.258	.173	.256	.875	.620
AUXFW	0600200-02-05	4.500	CS	128	.337	1.000	15000	3091	.235	.267	.179	.281	.861	.611
AUXFW	0600200-02-05	4.500	CS	54	.337	1.496	15000	3091	.214	.271	.187	.349	.779	.553
AUXFW	0600200-02-05	4.500	CS	56A	.337	1.496	15000	3091	.210	.251	.177	.360	.758	.539
AUXFW	0600200-02-05	4.500	CS	125	.337	1.000	15000	3091	.272	.297	.202	.296	.553	.440
AUXFW	0600200-02-05	4.500	CS	125Y	.337	1.000	15000	3091	.286	.307	.210	.283	.514	.423
AUXFW	0600200-02-05	4.500	CS	127	.337	1.000	15000	3091	.231	.236	.162	.203	.538	.415
AUXFW	0600200-02-05	4.500	CS	127B	.337	1.000	15000	3091	.231	.237	.161	.208	.549	.422
AUXFW	0600200-02-05	4.500	CS	13P	.337	1.000	15000	3091	.311	.345	.231	.342	.513	.432
AUXFW	0600200-02-05	4.500	CS	13Q	.337	1.000	15000	3091	.311	.344	.231	.346	.518	.435
AUXFW	0600200-02-05	4.500	CS	164A	.337	1.000	15000	3091	.219	.342	.252	.199	.600	.448
AUXFW	0600200-02-05	16.000	CS	2AC	.500	1.000	15000	115	.036	.069	.047	.081	.047	.042
AUXFW	0600200-02-05	16.000	CS	2EA	.500	1.000	15000	115	.018	.027	.018	.027	.065	.046

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
AUXFW	0600200-02-05	16.000	CS	2E	.500	1.000	15000	115	.016	.048	.032	.037	.080	.054
AUXFW	0600200-02-05	16.000	CS	2F	.500	1.000	15000	115	.029	.076	.050	.062	.091	.066
AUXFW	0600200-02-05	16.000	CS	ZZ	.500	1.000	15000	115	.014	.047	.031	.042	.055	.039
AUXFW	0600200-02-05	16.000	CS	ZZA	.500	1.000	15000	115	.017	.028	.019	.022	.020	.019
AUXFW	0600200-02-05	16.000	CS	2A	.500	1.000	15000	115	.008	.006	.004	.003	0.000	.003
AUXFW	0600200-02-05	6.625	CS	31A	.432	2.000	15000	3675	.330	.459	.307	.470	.643	.578
AUXFW	0600200-02-05	6.625	CS	32	.432	2.000	15000	3675	.326	.454	.303	.438	.651	.521
AUXFW	0600200-02-05	6.625	CS	32A	.432	1.643	15000	3675	.313	.411	.274	.369	.540	.449
AUXFW	0600200-02-05	6.625	CS	32A-C	.432	1.643	15000	3675	.319	.424	.283	.342	.523	.441
AUXFW	0600200-02-05	6.625	CS	44B	.432	1.900	15000	3675	.335	.398	.266	.647	.429	.391
AUXFW	0600200-02-05	6.625	CS	44	.432	1.000	15000	3675	.351	.388	.259	.524	.231	.279
AUXFW	0600200-02-05	6.625	CS	50X	.432	1.643	15000	3675	.261	.263	.176	.259	.501	.405
AUXFW	0600200-02-05	6.625	CS	29	.432	2.000	15000	3675	.396	.546	.365	.573	.619	.530
AUXFW	0600200-02-05	6.625	CS	5	.432	1.643	15000	3675	.248	.333	.222	.360	.589	.452
AUXFW	0600200-02-05	6.625	CS	8	.432	1.000	15000	3675	.287	.471	.315	.512	.272	.278
AUXFW	0600200-02-05	6.625	CS	11A	.432	1.643	15000	3675	.253	.305	.212	.655	.351	.312
AUXFW	0600200-02-05	6.625	CS	13	.432	1.000	15000	3675	.309	.427	.296	.829	.177	.230
AUXFW	0600200-02-05	6.625	CS	B13	.432	1.000	15000	3675	.274	.444	.305	.903	.217	.240
AUXFW	0600200-02-05	6.625	CS	55	.432	1.000	15000	3675	.268	.421	.289	.870	.217	.237
AUXFW	0600200-02-05	6.625	CS	55A	.432	1.000	15000	3675	.253	.318	.222	.702	.227	.237
AUXFW	0600200-02-05	6.625	CS	24	.432	1.643	15000	3675	.258	.827	.554	.700	.799	.583
AUXFW	0600200-02-05	6.625	CS	24-C	.432	1.643	15000	3675	.258	.944	.632	.821	.861	.620
AUXFW	0600200-02-05	6.625	CS	25	.432	1.642	15000	3675	.296	.976	.688	.900	.883	.648
AUXFW	0600200-02-05	8.625	CS	140	.500	1.355	15000	4240	.326	.339	.226	.298	.201	.251
AUXFW	0600200-02-05	8.625	CS	31	.500	2.000	15000	4240	.330	.369	.246	.324	.318	.323
AUXFW	0600200-02-08	2.375	CS	612	.344	2.100	15000	1207	.190	.933	.622	.697	.428	.333
AUXFW	0600200-02-08	2.375	CS	613	.344	2.100	15000	1207	.169	.884	.589	.665	.580	.415
AUXFW	0600200-02-08	2.375	CS	594	.344	2.100	15000	1207	.194	.861	.574	.579	.109	.143
AUXFW	0600200-02-08	2.375	CS	614	.344	2.100	15000	1207	.157	.827	.551	.620	.592	.418
AUXFW	0600200-02-08	2.375	CS	596	.344	2.100	15000	1207	.226	.816	.544	.542	.139	.173
AUXFW	0600200-02-08	4.500	CS	29C	.337	1.225	15000	3091	.399	.378	.252	.796	1.116	.829
AUXFW	0600200-02-08	4.500	CS	29B	.337	1.225	15000	3091	.385	.356	.237	.682	1.008	.759
AUXFW	0600200-02-08	4.500	CS	CENTR	.337	1.496	15000	3091	.220	.344	.230	.235	.927	.644
AUXFW	0600200-02-08	4.500	CS	219	.337	1.496	15000	3091	.232	.356	.237	.237	.910	.639
AUXFW	0600200-02-08	4.500	CS	286	.337	1.496	15000	3091	.307	.279	.186	.462	.730	.561
AUXFW	0600200-02-08	4.500	CS	CENTR	.438	1.216	15000	2187	.155	.264	.176	.182	1.207	.786
AUXFW	0600200-02-08	4.500	CS	222	.438	1.216	15000	2187	.158	.269	.180	.185	1.167	.764
AUXFW	0600200-02-08	4.500	CS	221	.438	1.216	15000	2187	.159	.262	.175	.178	1.044	.690
AUXFW	0600200-02-08	4.500	CS	222	.438	1.000	15000	2187	.158	.269	.180	.185	.960	.639
AUXFW	0600200-02-08	4.500	CS	222A	.438	1.000	15000	2187	.158	.270	.180	.186	.905	.606
AUXFW	0600200-02-08	4.500	CS	249	.438	1.900	15000	2187	.373	.857	.572	.556	.197	.267
AUXFW	0600200-02-08	4.500	CS	269	.438	1.900	15000	2187	.321	.763	.509	.497	.176	.234
AUXFW	0600200-02-08	6.625	CS	53	.432	1.643	15000	3675	.384	.361	.241	.556	1.149	.843
AUXFW	0600200-02-08	6.625	CS	CENTR	.432	1.643	15000	3675	.345	.318	.212	.511	1.101	.798
AUXFW	0600200-02-08	6.625	CS	6	.432	1.643	15000	3675	.314	.452	.301	.972	1.005	.728
AUXFW	0600200-02-08	6.625	CS	52B	.432	1.418	15000	3675	.354	.328	.219	.485	1.001	.742

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
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AUXFW	0600200-02-08	6.625	CS	56	.432	1.643	15000	3675	.326	.298	.199	.462	.901	.671
AUXFW	0600200-02-08	6.625	CS	77	.432	1.643	15000	3675	.261	.259	.173	.143	.869	.626
AUXFW	0600200-02-08	6.625	CS	259	.562	1.770	15000	2631	.384	.572	.381	.346	.423	.407
AUXFW	0600200-02-08	6.625	CS	258	.562	1.900	15000	2631	.315	.417	.278	.245	.423	.380
AUXFW	0600200-02-08	6.625	CS	257	.562	1.031	15000	2631	.248	.286	.190	.161	.208	.224
AUXFW	0600200-02-08	8.625	CS	52B	.500	1.418	15000	4240	.337	.297	.198	.308	.499	.434
AUXFW	0600200-02-08	8.625	CS	294	.500	1.418	15000	4240	.355	.318	.212	.328	.496	.439
AUXFW	0600200-02-08	8.625	CS	52A	.500	1.418	15000	4240	.366	.329	.219	.276	.419	.398
AUXFW	N3-03-3A	3.500	CS	43	.438	2.000	15000	2535	.301	.686	.460	.562	.092	.176
AUXFW	N3-03-3A	3.500	CS	46	.438	2.000	15000	2535	.317	.541	.362	.410	.222	.260
AUXFW	N3-03-3A	3.500	CS	205	.438	2.000	15000	2535	.297	.641	.434	.520	.120	.191
AUXFW	N3-03-3A	3.500	CS	208	.438	2.000	15000	2535	.318	.510	.345	.379	.378	.354
AUXFW	N3-03-3A	4.500	CS	212	.337	1.317	15000	3091	.213	.219	.155	.131	.160	.181
AUXFW	N3-03-3A	4.500	CS	50	.337	1.317	15000	3091	.215	.216	.150	.129	.112	.153
AUXFW	N3-03-3A	4.500	CS	295	.438	2.020	15000	3645	.297	.489	.346	.297	.722	.552
AUXFW	N3-03-3A	4.500	CS	14C	.438	2.020	15000	3645	.284	.397	.275	.225	.385	.645
AUXFW	N3-03-3A	4.500	CS	145	.438	1.800	15000	3645	.329	.403	.283	.237	.594	.488
AUXFW	N3-03-3A	4.500	CS	38	.438	1.800	15000	3645	.253	.383	.275	.240	.359	.317
AUXFW	N3-03-3A	6.625	CS	9	.562	1.900	15000	4385	.417	.529	.371	.362	.159	.263
AUXFW	N3-03-3A	6.625	CS	10	.562	1.900	15000	4385	.401	.505	.354	.345	.163	.258
AUXFW	N3-03-3A	6.625	CS	32A	.562	1.800	15000	4385	.341	.481	.345	.301	.219	.268
AUXFW	N3-03-3A	6.625	CS	12	.562	1.800	15000	4385	.374	.455	.335	.300	.208	.274
AUXFW	N3-03-05A	2.375	CS	G80	.218	1.800	15000	0	.026	.037	.025	.023	.393	.246
AUXFW	N3-03-05A	2.375	CS	G64	.218	2.100	15000	0	.017	.018	.012	.011	.657	.401
AUXFW	N3-03-05A	2.375	CS	G66	.218	2.100	15000	0	.017	.019	.012	.011	.651	.398
AUXFW	N3-03-05A	2.375	CS	G67	.218	2.100	15000	0	.041	.041	.028	.023	.529	.334
AUXFW	N3-03-05A	2.375	CS	G69	.218	2.100	15000	0	.048	.049	.032	.027	.534	.340
AUXFW	N3-03-05A	2.375	CS	B13	.218	2.100	15000	0	.049	.053	.035	.031	.392	.255
AUXFW	N3-03-05A	2.875	CS	C48	.276	1.800	15000	188	.019	.041	.027	.027	.111	.074
AUXFW	N3-03-05A	2.875	CS	C54	.276	1.800	15000	188	.018	.026	.017	.016	.223	.141
AUXFW	N3-03-05A	2.875	CS	C72	.276	1.800	15000	188	.059	.067	.044	.038	.144	.110
AUXFW	N3-03-05A	3.500	CS	D65	.300	1.000	15000	219	.025	.047	.031	.029	.129	.088
AUXFW	N3-03-05A	4.500	CS	A20	.337	1.000	15000	3091	.219	.515	.345	.335	.107	.152
AUXFW	N3-03-05A	4.500	CS	A24	.337	1.000	15000	3091	.219	.680	.456	.456	.104	.150
AUXFW	N3-03-05A	4.500	CS	717	.337	1.000	15000	3091	.220	.818	.549	.560	.134	.169
AUXFW	N3-03-05A	4.500	CS	A31	.337	1.800	15000	3091	.218	.889	.596	.606	.843	.593
AUXFW	N3-03-05A	4.500	CS	A31-C	.337	1.496	15000	3091	.212	.810	.543	.551	.727	.521
AUXFW	N3-03-05A	4.500	CS	A32	.337	1.800	15000	3091	.211	.949	.636	.652	.834	.585
AUXFW	N3-03-05A	4.500	CS	A38	.337	1.800	15000	3091	.212	.681	.456	.452	.916	.634
AUXFW	N3-03-05A	4.500	CS	A38-C	.337	1.496	15000	3091	.218	.584	.391	.380	.795	.564
AUXFW	N3-03-05A	4.500	CS	A40	.337	1.800	15000	3091	.224	.649	.434	.425	.925	.645
AUXFW	N3-03-05A	4.500	CS	A48	.337	1.000	15000	3091	.215	.840	.563	.565	.326	.281
AUXFW	N3-03-05A	4.500	CS	729Z	.337	1.000	15000	3091	.215	.863	.578	.582	.342	.291
AUXFW	N3-03-05A	4.500	CS	729	.337	1.000	15000	3091	.215	.866	.581	.585	.404	.328
AUXFW	N3-03-05A	4.500	CS	A50	.337	1.000	15000	3091	.215	.825	.553	.554	.352	.297
AUXFW	N3-03-05A	4.500	CS	A52	.337	1.000	15000	3091	.215	.810	.543	.543	.333	.286

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
AUXFW	N3-03-05A	6.625	CS	D3-C	.280	2.266	15000	518	.059	.161	.108	.106	.233	.163
AUXFW	N3-03-05A	8.625	CS	C98	.322	4.949	15000	596	.091	.469	.313	.322	.425	.292
AUXFW	N3-03-05A	8.625	CS	C100	.322	2.439	15000	596	.066	.278	.186	.189	.190	.140
AUXFW	N3-03-05A	8.625	CS	C104-C	.322	2.439	15000	596	.062	.248	.165	.168	.301	.205
AUXFW	N3-03-05A	8.625	CS	C106	.322	2.439	15000	596	.066	.146	.097	.095	.312	.214
AUXFW	N3-03-05A	8.625	CS	C112	.322	2.439	15000	596	.070	.236	.157	.160	.360	.244
AUXFW	N3-03-05A	8.625	CS	C112-C	.322	2.439	15000	596	.051	.244	.163	.169	.395	.258
AUXFW	N3-03-05A	8.625	CS	C114	.322	2.439	15000	596	.110	.301	.201	.199	.353	.256
AUXFW	N3-03-05A	8.625	CS	23Y	.322	1.000	15000	596	.101	.197	.131	.125	.127	.116
AUXFW	N3-03-05A	8.625	CS	IN26	.322	1.000	15000	596	.046	.252	.168	.178	.022	.031
AUXFW	N3-03-05A	8.625	CS	IN25	.322	1.000	15000	596	.046	.283	.189	.201	.019	.030
AUXFW	N3-03-05A	8.625	CS	IN23	.322	1.000	15000	596	.043	.316	.211	.226	.011	.024
AUXFW	N3-03-05A	8.625	CS	IN22	.322	1.000	15000	596	.043	.304	.203	.218	.009	.023
AUXFW	N3-03-05A	8.625	CS	IN24	.322	1.000	15000	596	.042	.298	.199	.213	.009	.022
AUXFW	N3-03-05A	10.750	CS	D50	.365	1.328	15000	662	.045	.041	.027	.021	.020	.030
AUXFW	N3-03-13A	3.500	CS	153	.438	1.000	15000	2535	.482	.743	.496	.539	.052	.224
AUXFW	N3-03-13A	3.500	CS	154	.438	1.000	15000	2535	.447	.677	.453	.487	.059	.214
AUXFW	N3-03-13A	3.500	CS	154A	.438	2.000	15000	2535	.561	.897	.601	.656	.125	.299
AUXFW	N3-03-13A	4.500	CS	155	.674	1.590	15000	1902	.249	.343	.230	.236	.045	.126
AUXFW	N3-03-13A	4.500	CS	157A	.674	1.680	15000	3091	.445	.353	.341	.342	.144	.265
AUXFW	N3-03-13A	4.500	CS	157	.337	1.317	15000	3091	.396	.452	.303	.289	.113	.226
AUXFW	N3-03-13A	4.500	CS	157-C	.337	1.317	15000	3091	.361	.411	.277	.262	.119	.216
AUXFW	N3-03-13A	4.500	CS	158	.337	1.000	15000	3091	.317	.351	.239	.220	.081	.175
AUXFW	N3-03-13A	4.500	CS	106	.337	1.000	15000	3091	.214	.359	.272	.267	.091	.141
AUXFW	N3-03-13A	4.500	CS	356	.337	1.000	15000	3091	.283	.376	.271	.286	.067	.154
AUXFW	N3-03-13A	4.500	CS	100	.337	1.000	15000	3091	.233	.296	.201	.223	.339	.297
AUXFW	N3-03-13A	4.500	CS	368	.337	1.000	15000	3091	.237	.323	.220	.252	.421	.347
AUXFW	N3-03-13A	4.500	CS	PW1	.337	1.000	15000	3091	.253	.387	.266	.321	.792	.576
AUXFW	N3-03-13A	4.500	CS	PK	.337	1.000	15000	3091	.244	.345	.237	.276	.478	.385
AUXFW	N3-03-13A	4.500	CS	14C	.438	2.020	15000	3645	.400	.532	.390	.376	.171	.262
AUXFW	N3-03-13A	4.500	CS	148	.438	1.000	15000	3645	.415	.452	.303	.281	.034	.186
AUXFW	N3-03-13A	4.500	CS	154A	.438	2.000	15000	3645	.460	.621	.416	.426	.069	.226
AUXFW	N3-03-13A	4.500	CS	155	.438	1.590	15000	3645	.403	.513	.334	.342	.058	.196
AUXFW	N3-03-13A	6.625	CS	PSCV	.280	1.000	15000	6134	.436	.445	.301	.283	.276	.340
ERCW	N3-67-01A	2.375	SS	7XXX	.154	2.100	15700	500	.051	.084	.056	.060	1.061	.657
ERCW	N3-67-01A	2.375	SS	XLX	.154	2.100	15700	500	.055	.079	.053	.054	.569	.364
ERCW	N3-67-01A	2.375	SS	X5X	.154	2.100	15700	500	.105	.153	.102	.103	1.334	.843
ERCW	N3-67-01A	2.375	SS	XVX	.154	2.100	15700	500	.104	.149	.099	.099	1.184	.752
ERCW	N3-67-01A	2.375	CS	308X	.154	2.100	15000	50	.036	.104	.070	.089	0.000	.014
ERCW	N3-67-01A	2.375	CS	1A13	.154	1.000	15000	50	.033	.028	.019	.014	0.000	.013
ERCW	N3-67-01A	3.500	SS	47XX	.216	1.672	15700	531	.155	.520	.424	.476	.149	.152
ERCW	N3-67-01A	3.500	SS	47XY	.216	1.800	15700	531	.161	.536	.437	.491	.154	.157
ERCW	N3-67-01A	3.500	SS	XXT	.216	1.800	15700	531	.200	.319	.230	.235	.078	.127
ERCW	N3-67-01A	3.500	SS	XDX	.216	2.100	15700	531	.446	.706	.526	.541	.264	.336
ERCW	N3-67-01A	3.500	CS	ZWAX	.216	1.544	15000	531	.047	.333	.222	.297	.121	.091
ERCW	N3-67-01A	3.500	CS	ZWAY	.216	1.800	15000	531	.049	.208	.139	.178	.101	.080

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-01A	3.500	CS	ZHH	.216	2.100	15000	531	.119	.186	.124	.130	.131	.126
ERCW	N3-67-01A	4.500	CS	66X	.237	1.928	15000	642	.378	.755	.504	.570	.618	.522
ERCW	N3-67-01A	4.500	CS	66Y	.237	1.800	15000	642	.334	.668	.445	.504	.541	.458
ERCW	N3-67-01A	4.500	CS	IA8	.237	1.800	15000	642	.132	.420	.280	.332	.070	.095
ERCW	N3-67-01A	4.500	CS	275X	.237	2.854	15000	642	.364	.800	.724	.900	.796	.623
ERCW	N3-67-01A	4.500	CS	275Y	.237	1.800	15000	642	.230	.661	.441	.545	.476	.377
ERCW	N3-67-01A	6.625	SS	FL34	.280	1.800	15700	828	.139	.308	.206	.236	.327	.252
ERCW	N3-67-01A	6.625	SS	906B	.280	1.800	15700	828	.081	.199	.133	.154	.273	.196
ERCW	N3-67-01A	6.625	SS	907A	.280	1.800	15700	828	.084	.180	.120	.137	.306	.217
ERCW	N3-67-01A	6.625	SS	FL35	.280	1.800	15700	828	.099	.193	.129	.144	.327	.236
ERCW	N3-67-01A	6.625	SS	NBX	.280	1.844	15700	828	.072	.124	.087	.091	.445	.296
ERCW	N3-67-01A	6.625	CS	AHZX	.280	2.784	15000	828	.136	.218	.145	.152	1.599	.965
ERCW	N3-67-01A	6.625	CS	AHZY	.280	1.800	15000	828	.101	.141	.094	.094	.879	.568
ERCW	N3-67-01A	6.625	CS	900X	.280	2.780	15000	828	.208	.588	.392	.473	.596	.441
ERCW	N3-67-01A	6.625	CS	900Y	.280	1.800	15000	828	.153	.378	.252	.296	.373	.285
ERCW	N3-67-01A	6.625	CS	FL33	.280	1.800	15000	828	.151	.353	.235	.273	.356	.274
ERCW	N3-67-01A	6.625	CS	516	.280	1.800	15000	828	.175	.248	.165	.169	.213	.198
ERCW	N3-67-01A	6.625	CS	510	.280	1.800	15000	828	.161	.275	.183	.198	.039	.088
ERCW	N3-67-01A	6.625	CS	527X	.280	1.800	15000	828	.190	.250	.167	.164	.335	.277
ERCW	N3-67-01A	8.625	CS	449X	.322	3.869	15000	953	.090	.245	.163	.192	2.042	.897
ERCW	N3-67-01A	8.625	CS	449Y	.322	1.000	15000	953	.074	.115	.077	.079	.507	.334
ERCW	N3-67-01A	8.625	CS	IEB	.322	1.000	15000	953	.075	.109	.072	.073	.477	.316
ERCW	N3-67-01A	8.625	CS	LYH	.322	1.000	15000	953	.079	.114	.076	.076	.236	.173
ERCW	N3-67-01A	8.625	CS	475E	.322	2.439	15000	953	.133	.233	.158	.166	.244	.199
ERCW	N3-67-01A	8.625	CS	475E	.322	1.000	15000	953	.102	.152	.103	.103	.100	.101
ERCW	N3-67-01A	8.625	SS	736	.322	2.000	15700	953	.103	.263	.175	.220	.806	.525
ERCW	N3-67-01A	8.625	SS	737X	.322	1.000	15700	953	.071	.142	.095	.112	.249	.178
ERCW	N3-67-01A	8.625	SS	765	.322	2.000	15700	953	.109	.242	.161	.196	1.017	.654
ERCW	N3-67-01A	8.625	SS	789	.322	2.100	15700	953	.139	.228	.153	.168	1.020	.668
ERCW	N3-67-01A	8.625	SS	811	.322	2.000	15700	953	.115	.335	.224	.285	.899	.585
ERCW	N3-67-01A	8.625	SS	L17	.322	1.000	15700	953	.091	.151	.101	.113	.153	.128
ERCW	N3-67-01A	8.625	SS	830E	.322	2.439	15700	953	.083	.246	.165	.210	.739	.477
ERCW	N3-67-01A	8.625	SS	834	.322	2.100	15700	953	.173	.421	.282	.347	1.029	.687
ERCW	N3-67-01A	10.750	CS	XX1	.365	5.143	15000	1059	.139	.489	.326	.431	1.096	.713
ERCW	N3-67-01A	10.750	CS	735	.365	1.968	15000	1059	.108	.213	.142	.168	.587	.395
ERCW	N3-67-01A	10.750	CS	735	.365	1.968	15000	1059	.105	.305	.204	.262	.256	.196
ERCW	N3-67-01A	10.750	CS	736	.365	2.000	15000	1059	.095	.184	.122	.144	.474	.323
ERCW	N3-67-01A	10.750	CS	800X	.365	5.143	15000	1059	.129	.555	.371	.499	.949	.621
ERCW	N3-67-01A	10.750	CS	810	.365	1.968	15000	1059	.104	.334	.223	.288	.486	.333
ERCW	N3-67-01A	10.750	CS	810	.365	1.968	15000	1059	.099	.166	.111	.124	.447	.308
ERCW	N3-67-01A	18.000	CS	85X	.375	8.014	15000	1801	.215	.472	.312	.391	1.550	.878
ERCW	N3-67-01A	18.000	CS	206X	.375	8.014	15000	1801	.342	.874	.582	.687	1.090	.791
ERCW	N3-67-01A	18.000	CS	211B-C	.375	2.493	15000	1801	.123	.140	.093	.087	.257	.203
ERCW	N3-67-01A	18.000	CS	211E	.375	2.493	15000	1801	.138	.209	.139	.146	.237	.197
ERCW	N3-67-01A	18.000	CS	FL20	.375	1.000	15000	1801	.132	.168	.112	.109	.086	.105
ERCW	N3-67-01A	18.000	CS	224	.375	1.000	15000	1801	.222	.274	.183	.179	.030	.107

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-01A	18.000	CS	WP14A	.375	1.000	15000	1801	.162	.194	.129	.125	.018	.090
ERCW	N3-67-01A	18.000	CS	224A	.375	1.000	15000	1801	.229	.275	.183	.177	.030	.110
ERCW	N3-67-01A	18.000	CS	ID14	.375	3.500	15000	1801	.171	.265	.177	.190	.093	.124
ERCW	N3-67-01A	18.000	CS	231E	.375	3.500	15000	1801	.225	.356	.238	.258	.071	.133
ERCW	N3-67-01A	18.000	CS	245B	.375	3.500	15000	1801	.183	.308	.205	.222	.167	.174
ERCW	N3-67-01A	18.000	CS	253B	.375	3.500	15000	1801	.153	.218	.145	.148	.258	.216
ERCW	N3-67-01A	24.000	CS	48Y	.375	1.000	15000	2441	.231	.292	.194	.191	.063	.130
ERCW	N3-67-01A	24.000	CS	WP4	.375	1.000	15000	2441	.213	.313	.209	.223	.150	.175
ERCW	N3-67-01A	24.000	CS	54X	.375	1.000	15000	2441	.214	.316	.211	.226	.153	.177
ERCW	N3-67-01A	24.000	CS	85	.375	6.420	15000	2441	.446	.799	.532	.577	.793	.654
ERCW	N3-67-01A	24.000	CS	85X	.375	8.014	15000	2441	.215	.340	.226	.236	.861	.603
ERCW	N3-67-01A	24.000	CS	85	.375	6.420	15000	2441	.445	.755	.503	.536	.390	.412
ERCW	N3-67-01A	24.000	CS	160	.375	3.345	15000	2441	.188	.636	.424	.554	.365	.294
ERCW	N3-67-01A	24.000	CS	206	.375	6.420	15000	2441	.317	.487	.572	.381	.601	.487
ERCW	N3-67-01A	24.000	CS	206X	.375	8.014	15000	2441	.286	.564	.376	.421	.603	.476
ERCW	N3-67-01A	24.000	CS	206	.375	6.420	15000	2441	.323	.572	.381	.410	1.131	.808
ERCW	N3-67-01A	30.000	CS	23E-C	.375	4.976	15000	3081	.254	.312	.208	.206	.904	.644
ERCW	N3-67-01A	30.000	CS	26E	.375	4.976	15000	3081	.225	.405	.270	.311	.821	.583
ERCW	N3-67-01A	30.000	CS	26E	.375	1.000	15000	3081	.211	.234	.156	.146	.165	.183
ERCW	N3-67-01A	30.000	CS	35B	.375	4.976	15000	3081	.246	.507	.338	.403	1.123	.772
ERCW	N3-67-01A	30.000	CS	37	.375	1.000	15000	3081	.354	.459	.306	.310	.299	.321
ERCW	N3-67-01A	30.000	CS	331E	.375	4.976	15000	3081	.255	.547	.364	.439	1.103	.764
ERCW	N3-67-01A	30.000	CS	335B	.375	4.976	15000	3081	.233	.484	.323	.384	.795	.570
ERCW	N3-67-01A	30.000	CS	335B-C	.375	4.976	15000	3081	.257	.340	.227	.232	.886	.634
ERCW	N3-67-02A	2.375	SS	T41	.154	2.100	18800	500	.060	.357	.238	.330	.529	.342
ERCW	N3-67-02A	2.375	SS	T42A	.154	2.100	18800	500	.041	.389	.259	.378	.646	.404
ERCW	N3-67-02A	2.375	SS	T44A	.154	2.100	18800	500	.048	.330	.220	.317	.577	.365
ERCW	N3-67-02A	2.375	CS	N7B	.154	2.100	15000	500	.053	.108	.072	.083	.651	.411
ERCW	N3-67-02A	2.375	SS	T42B	.154	2.100	18800	500	.042	.377	.251	.365	.557	.351
ERCW	N3-67-02A	2.375	SS	T44B	.154	2.100	18800	500	.045	.361	.241	.350	.626	.393
ERCW	N3-67-02A	2.375	CS	N232	.154	2.000	15000	500	.083	.172	.115	.134	.670	.435
ERCW	N3-67-02A	2.375	CS	N6B	.151	2.100	15000	500	.057	.116	.077	.089	.454	.295
ERCW	N3-67-02A	3.500	CS	13X	.216	1.000	15000	531	.083	.522	.348	.478	.631	.412
ERCW	N3-67-02A	3.500	CS	134	.216	1.800	15000	531	.100	.656	.437	.604	1.013	.648
ERCW	N3-67-02A	3.500	CS	150	.216	1.800	15000	531	.114	.619	.413	.569	.069	.087
ERCW	N3-67-02A	3.500	CS	147	.216	1.800	15000	531	.112	.625	.416	.575	.066	.084
ERCW	N3-67-02A	3.500	CS	148	.216	1.800	15000	531	.109	.626	.417	.579	.059	.079
ERCW	N3-67-02A	3.500	CS	151	.216	1.800	15000	531	.107	.623	.416	.577	.056	.076
ERCW	N3-67-02A	3.500	CS	N1X	.216	2.374	15000	531	.068	.455	.303	.405	.724	.461
ERCW	N3-67-02A	3.500	CS	C15B	.216	1.800	15000	531	.043	.138	.092	.118	.906	.560
ERCW	N3-67-02A	3.500	CS	C15B	.216	1.777	15000	531	.043	.137	.091	.116	.894	.553
ERCW	N3-67-02A	3.500	CS	C15E	.216	1.800	15000	531	.038	.113	.075	.095	.662	.413
ERCW	N3-67-02A	3.500	CS	C16E	.216	1.800	15000	531	.040	.135	.090	.117	.656	.410
ERCW	N3-67-02A	6.625	SS	T3	.280	2.800	18800	828	.127	.364	.243	.298	.661	.448
ERCW	N3-67-02A	6.625	SS	T3A	.280	1.800	18800	828	.093	.239	.159	.192	.404	.280
ERCW	N3-67-02A	6.625	SS	T11	.280	2.266	18800	828	.075	.186	.124	.146	.439	.294

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-02A	6.625	SS	T12E	.280	2.266	18800	828	.061	.134	.089	.106	.414	.273
ERCW	N3-67-02A	6.625	SS	P87	.280	1.800	18800	828	.093	.120	.080	.078	.490	.331
ERCW	N3-67-02A	6.625	SS	T19	.280	1.800	18800	828	.079	.222	.148	.178	.363	.249
ERCW	N3-67-02A	6.625	SS	FL21	.280	1.800	18800	357	.042	.119	.079	.095	.183	.127
ERCW	N3-67-02A	6.625	CS	90X	.280	2.800	15000	828	.090	.276	.184	.226	.551	.367
ERCW	N3-67-02A	6.625	CS	90Y	.280	1.800	15000	828	.078	.174	.116	.136	.336	.233
ERCW	N3-67-02A	6.625	CS	903B	.280	2.266	15000	828	.089	.151	.101	.113	.335	.237
ERCW	N3-67-02A	6.625	CS	911A	.280	1.800	15000	828	.130	.274	.183	.222	.375	.277
ERCW	N3-67-02A	6.625	CS	111	.280	1.800	15000	828	.105	.224	.149	.181	.314	.230
ERCW	N3-67-02A	6.625	CS	911A	.280	1.800	15000	828	.130	.274	.183	.222	.375	.277
ERCW	N3-67-02A	8.625	CS	P2X	.322	2.416	15000	953	.087	.593	.395	.558	.888	.568
ERCW	N3-67-02A	8.625	CS	P21	.322	1.000	15000	953	.077	.339	.226	.308	.349	.240
ERCW	N3-67-02A	8.625	CS	I24	.322	1.000	15000	953	.079	.310	.206	.277	.302	.213
ERCW	N3-67-02A	8.625	CS	P24E	.322	2.439	15000	953	.096	.183	.122	.143	.355	.257
ERCW	N3-67-02A	8.625	CS	I15	.322	2.439	15000	953	.091	.235	.157	.196	.399	.275
ERCW	N3-67-02A	8.625	CS	646	.322	1.000	15000	953	.133	.355	.236	.285	.243	.199
ERCW	N3-67-02A	8.625	CS	646A	.322	1.000	15000	953	.127	.338	.225	.271	.258	.206
ERCW	N3-67-02A	8.625	CS	655	.322	1.440	15000	953	.078	.478	.318	.427	.162	.128
ERCW	N3-67-02A	8.625	SS	P44	.322	1.843	18800	953	.070	.166	.111	.137	.106	.091
ERCW	N3-67-02A	12.750	SS	FL38	.250	1.000	18800	1801	.096	.080	.053	.040	0.000	.038
ERCW	N3-67-02A	12.750	SS	CH3	.250	1.000	18800	1801	.098	.627	.418	.595	0.000	.039
ERCW	N3-67-02A	12.750	SS	CHA3	.250	1.000	18800	1801	.098	.673	.449	.642	.001	.040
ERCW	N3-67-02A	18.000	CS	M40A	.375	1.000	15000	1801	.214	.304	.203	.215	.018	.096
ERCW	N3-67-02A	18.000	CS	M40B	.375	1.000	15000	1801	.224	.341	.227	.247	.014	.098
ERCW	N3-67-02A	18.000	CS	M40C	.375	1.000	15000	1801	.220	.345	.230	.253	.013	.095
ERCW	N3-67-02A	18.000	CS	95	.375	1.000	15000	1801	.199	.314	.210	.231	.014	.088
ERCW	N3-67-02A	18.000	CS	111A	.375	3.500	15000	1801	.251	.378	.252	.273	.078	.147
ERCW	N3-67-02A	18.000	CS	129E	.375	2.493	15000	1801	.146	.202	.135	.140	.323	.252
ERCW	N3-67-02A	18.000	CS	129B-C	.375	2.493	15000	1801	.145	.186	.124	.125	.303	.240
ERCW	N3-67-02A	18.000	CS	23X	.375	5.000	15000	1801	.267	.778	.519	.664	.188	.220
ERCW	N3-67-02A	18.000	CS	235B	.375	2.493	15000	1801	.166	.333	.222	.242	.036	.088
ERCW	N3-67-02A	18.000	CS	129B	.375	1.000	15000	1801	.132	.146	.097	.090	.096	.110
ERCW	N3-67-02A	18.000	CS	129B	.375	2.493	15000	1801	.142	.185	.123	.126	.239	.200
ERCW	N3-67-02A	18.000	CS	88X	.375	5.000	15000	1801	.243	.657	.438	.551	.993	.693
ERCW	N3-67-02A	20.000	CS	165	.375	3.345	15000	2014	.138	.266	.178	.205	.051	.086
ERCW	N3-67-02A	20.000	CS	I142	.375	1.000	15000	2014	.185	.201	.134	.122	.017	.084
ERCW	N3-67-02A	20.000	CS	449	.375	1.000	15000	2014	.196	.215	.144	.131	.019	.090
ERCW	N3-67-02A	20.000	CS	466B-C	.375	3.766	15000	2014	.199	.257	.171	.170	.025	.094
ERCW	N3-67-02A	24.000	CS	80B	.375	5.596	15000	2441	.205	.351	.234	.263	.843	.588
ERCW	N3-67-02A	24.000	CS	88	.375	6.416	15000	2441	.562	.825	.550	.582	.703	.647
ERCW	N3-67-02A	24.000	CS	88	.375	6.416	15000	2441	.255	.570	.380	.460	.858	.617
ERCW	N3-67-02A	24.000	CS	I120	.375	4.270	15000	2441	.253	.374	.249	.260	.722	.535
ERCW	N3-67-02A	24.000	CS	230A	.375	6.416	15000	2441	.568	.999	.699	.781	.149	.317
ERCW	N3-67-02A	24.000	CS	230A	.375	6.416	15000	2441	.294	.806	.538	.679	.178	.224
ERCW	N3-67-02A	24.000	CS	154	.375	3.345	15000	2441	.202	.370	.247	.285	.989	.674
ERCW	N3-67-02A	24.000	CS	196	.375	1.000	15000	2441	.267	.541	.361	.405	.038	.129

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-02A	24.000	CS	202	.375	1.000	15000	2441	.288	.501	.334	.363	.024	.129
ERCW	N3-67-02A	24.000	CS	187	.375	1.000	15000	2441	.247	.356	.238	.246	.456	.373
ERCW	N3-67-02A	24.000	CS	188	.375	1.000	15000	2441	.246	.354	.236	.244	.451	.369
ERCW	N3-67-02A	24.000	CS	23X	.375	5.000	15000	2441	.244	.511	.341	.408	.104	.160
ERCW	N3-67-43A	6.625	CS	500N	.280	1.800	15000	828	.079	.090	.060	.056	.212	.159
ERCW	N3-67-43A	6.625	CS	410	.280	2.000	15000	828	.073	.094	.063	.062	.275	.194
ERCW	N3-67-43A	6.625	SS	770	.280	1.800	15700	828	.079	.088	.059	.054	.152	.123
ERCW	N3-67-43A	6.625	SS	750	.280	1.800	15700	828	.112	.119	.079	.069	.173	.149
ERCW	N3-67-43A	6.625	SS	C29E	.280	2.266	15700	828	.062	.062	.041	.035	.205	.147
ERCW	N3-67-43A	6.625	SS	CENTR	.280	2.266	15700	828	.055	.076	.050	.051	.276	.188
ERCW	N3-67-43A	6.625	SS	C27E	.280	2.266	15700	828	.055	.076	.051	.052	.269	.184
ERCW	N3-67-43A	6.625	SS	P123	.280	1.800	15700	828	.133	.183	.122	.120	.022	.067
ERCW	N3-67-43A	4.500	CS	410	.237	2.000	15000	642	.090	.162	.108	.121	.727	.472
ERCW	N3-67-43A	4.500	CS	FL02	.237	1.800	15000	642	.064	.126	.084	.097	.535	.346
ERCW	N3-67-43A	4.500	CS	FL01	.237	1.000	15000	642	.060	.121	.081	.094	.497	.322
ERCW	N3-67-43A	4.500	CS	C158	.237	1.800	15000	642	.056	.110	.080	.089	.407	.266
ERCW	N3-67-43A	4.500	CS	CENTR	.237	1.952	15000	642	.058	.120	.088	.099	.460	.299
ERCW	N3-67-43A	4.500	CS	C158	.237	1.952	15000	642	.057	.117	.084	.095	.441	.288
ERCW	N3-67-43A	4.500	CS	P42J	.237	1.952	15000	642	.096	.163	.121	.111	.238	.181
ERCW	N3-67-43A	3.500	SS	B06E	.216	1.800	15700	531	.053	.079	.053	.056	1.168	.772
ERCW	N3-67-43A	3.500	SS	24	.216	1.800	15700	531	.045	.072	.048	.052	1.076	.663
ERCW	N3-67-43A	3.500	SS	B06B	.216	1.800	15700	531	.061	.080	.056	.055	.995	.621
ERCW	N3-67-43A	3.500	SS	B05B	.216	1.800	15700	531	.040	.121	.082	.065	.947	.584
ERCW	N3-67-43A	3.500	SS	B03B	.216	1.800	15700	531	.073	.286	.196	.157	.512	.336
ERCW	N3-67-43A	3.500	SS	B04E	.216	1.800	15700	531	.061	.224	.155	.128	.456	.298
ERCW	N3-67-43A	3.500	CS	500M	.216	1.800	15000	531	.190	.307	.205	.222	.354	.288
ERCW	N3-67-43A	3.500	CS	490	.216	1.800	15000	531	.160	.270	.180	.198	.330	.262
ERCW	N3-67-43A	4.500	SS	100M	.237	1.800	15700	642	.073	.166	.085	.075	.074	.074
ERCW	N3-67-43A	4.500	SS	100L	.237	1.800	15700	642	.050	.083	.063	.059	.031	.039
ERCW	N3-67-43A	4.500	SS	100L	.237	1.800	15700	642	.050	.083	.063	.059	.031	.039
ERCW	N3-67-43A	2.875	SS	C02E	.203	1.800	15700	450	.035	.112	.082	.097	.190	.128
ERCW	N3-67-43A	2.875	SS	C02B	.203	1.800	15700	450	.045	.123	.085	.102	.180	.126
ERCW	N3-67-43A	2.875	SS	62	.203	1.800	15700	450	.045	.123	.085	.103	.178	.125
ERCW	N3-67-43A	2.875	SS	40	.203	1.800	15700	450	.032	.131	.106	.123	.174	.117
ERCW	N3-67-43A	2.875	SS	CENTR	.203	1.500	15700	450	.037	.106	.076	.090	.170	.117
ERCW	N3-67-43A	2.875	SS	62	.203	1.800	15700	450	.045	.123	.085	.103	.178	.125
ERCW	N3-67-43A	2.375	SS	E01	.154	2.100	15700	500	.146	.340	.261	.251	1.156	.752
ERCW	N3-67-43A	2.375	SS	E38	.154	2.100	15700	500	.088	.214	.148	.178	.790	.509
ERCW	N3-67-43A	2.375	SS	E55	.154	2.100	15700	500	.123	.235	.168	.185	.758	.504
ERCW	N3-67-43A	2.375	SS	E34	.154	2.100	15700	500	.040	.288	.201	.272	.693	.432
ERCW	N3-67-43A	2.375	SS	E52	.154	2.100	15700	500	.111	.209	.148	.163	.688	.457
ERCW	N3-67-43A	2.375	SS	E34	.154	2.100	15700	500	.040	.288	.201	.272	.693	.432
ERCW	N3-67-09A	2.375	SS	HXAC	.154	2.100	18800	500	.054	.131	.087	.109	1.109	.687
ERCW	N3-67-09A	2.375	SS	HXAD	.154	2.100	18800	500	.038	.108	.072	.092	1.153	.707
ERCW	N3-67-09A	2.375	SS	HXAF	.154	2.100	18800	500	.031	.085	.057	.073	1.181	.721
ERCW	N3-67-09A	2.375	SS	HXAG	.154	2.100	18800	500	.031	.064	.042	.052	1.144	.698

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-09A	2.375	SS	HXCC	.154	2.100	18800	162	.055	.303	.202	.253	1.098	.681
ERCW	N3-67-09A	2.375	SS	HXCD	.154	2.100	18800	500	.039	.286	.191	.242	1.129	.693
ERCW	N3-67-09A	2.375	SS	HXCG	.154	2.100	18800	500	.030	.252	.168	.213	1.108	.677
ERCW	N3-67-09A	2.375	SS	058	.154	1.000	18800	500	.037	.053	.035	.037	.132	.094
ERCW	N3-67-09A	2.375	SS	HXCQ	.154	1.000	18800	500	.027	.022	.015	.011	0.000	.011
ERCW	N3-67-09A	4.500	SS	88Y	.237	1.800	18800	642	.072	.292	.195	.260	.578	.375
ERCW	N3-67-09A	4.500	CS	KK5	.237	1.800	15000	642	.076	.268	.178	.231	.883	.561
ERCW	N3-67-09A	4.500	CS	87A	.237	1.952	15000	642	.261	.426	.284	.302	.860	.620
ERCW	N3-67-09A	4.500	CS	87C	.237	1.952	15000	642	.241	.398	.266	.283	.787	.569
ERCW	N3-67-09A	4.500	CS	87I	.237	2.100	15000	642	.133	.323	.216	.252	.605	.416
ERCW	N3-67-09A	4.500	CS	KKK5	.237	1.000	15000	642	.084	.156	.104	.115	.371	.256
ERCW	N3-67-09A	6.625	SS	J4	.280	1.000	18800	673	.078	.149	.099	.112	.076	.077
ERCW	N3-67-09A	6.625	SS	J6	.280	1.000	18800	673	.102	.177	.118	.128	.037	.063
ERCW	N3-67-09A	6.625	CS	563	.280	2.100	15000	828	.076	.074	.050	.042	.975	.616
ERCW	N3-67-09A	6.625	CS	59	.280	2.100	15000	828	.078	.088	.059	.057	1.005	.635
ERCW	N3-67-09A	6.625	CS	NN2	.280	2.266	15000	828	.075	.142	.095	.107	1.142	.715
ERCW	N3-67-09A	6.625	CS	NN2-C	.280	2.266	15000	828	.069	.121	.080	.089	1.142	.713
ERCW	N3-67-09A	6.625	CS	NN4	.280	2.266	15000	828	.064	.098	.066	.070	1.076	.671
ERCW	N3-67-09A	6.625	CS	NN8	.280	2.100	15000	828	.096	.193	.129	.145	1.115	.707
ERCW	N3-67-09A	6.625	CS	JJ2	.280	1.800	15000	673	.104	.188	.125	.140	.414	.290
ERCW	N3-67-09A	6.625	CS	553Z	.280	1.800	15000	828	.151	.180	.120	.115	.412	.308
ERCW	N3-67-09A	6.625	CS	551	.280	8.610	15000	397	.324	.460	.307	.317	1.434	.990
ERCW	N3-67-09A	8.625	SS	B8	.322	2.439	18800	953	.057	.083	.055	.056	.462	.300
ERCW	N3-67-09A	8.625	SS	B8-C	.322	2.439	18800	953	.057	.082	.055	.056	.529	.340
ERCW	N3-67-09A	8.625	SS	B10	.322	2.439	18800	953	.057	.082	.055	.055	.494	.319
ERCW	N3-67-09A	8.625	SS	T6A	.322	3.230	18800	953	.112	.136	.091	.088	.193	.161
ERCW	N3-67-09A	8.625	SS	T7	.322	2.100	18800	953	.110	.126	.084	.078	.148	.132
ERCW	N3-67-09A	8.625	SS/CS	KK1	.322	1.800	18800	953	.063	.147	.098	.116	.708	.450
ERCW	N3-67-09A	8.625	CS	874	.322	1.843	15000	953	.084	.265	.176	.221	1.038	.656
ERCW	N3-67-09A	8.625	CS	87M	.322	1.843	15000	953	.085	.201	.134	.159	1.051	.665
ERCW	N3-67-09A	8.625	SS/CS	KK1	.322	1.800	18800	953	.079	.184	.123	.146	.887	.564
ERCW	N3-67-09A	8.625	CS	873A	.322	1.800	15000	953	.093	.234	.156	.188	.834	.538
ERCW	N3-67-09A	8.625	CS	874	.322	1.843	15000	953	.101	.275	.183	.223	.957	.615
ERCW	N3-67-09A	12.750	SS	V7	.375	2.862	18800	1241	.117	.421	.281	.353	.157	.141
ERCW	N3-67-09A	12.750	SS	V7-C	.375	2.862	18800	1241	.114	.444	.296	.375	.177	.152
ERCW	N3-67-09A	12.750	SS	V8	.375	2.862	18800	1241	.120	.417	.278	.348	.171	.150
ERCW	N3-67-09A	12.750	SS	V13	.375	1.000	18800	1241	.190	.408	.272	.314	.046	.103
ERCW	N3-67-09A	12.750	SS	V14	.375	1.000	18800	1241	.220	.501	.334	.390	.032	.107
ERCW	N3-67-09A	12.750	SS	V16A	.375	2.862	18800	1241	.306	.462	.308	.322	.044	.149
ERCW	N3-67-09A	12.750	SS	V17A	.375	2.862	18800	1241	.236	.489	.326	.373	.076	.140
ERCW	N3-67-09A	12.750	SS	V16-C	.375	2.862	18800	1241	.217	.451	.300	.344	.039	.110
ERCW	N3-67-09A	12.750	SS	V52	.375	1.800	18800	1241	.120	.165	.110	.114	.571	.391
ERCW	N3-67-09A	12.750	SS	X21	.375	2.862	18800	1241	.070	.093	.062	.062	.973	.612
ERCW	N3-67-09A	12.750	SS	X21-C	.375	2.862	18800	1241	.070	.093	.062	.062	.733	.468
ERCW	N3-67-09A	12.750	SS	Y20-C	.375	2.862	18800	1241	.087	.164	.109	.126	.754	.487
ERCW	N3-67-09A	12.750	CS	V2	.375	1.000	15000	1241	.181	.290	.193	.207	.335	.273

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
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ERCW	N3-67-09A	12.750	CS	V3	.375	1.000	15000	1241	.123	.219	.146	.161	.197	.168
ERCW	N3-67-09A	12.750	CS	V3A	.375	1.000	15000	1241	.124	.215	.143	.157	.191	.164
ERCW	N3-67-09A	12.750	CS	X1	.375	4.700	15000	3081	.223	.283	.189	.186	.159	.185
ERCW	N3-67-09A	12.750	CS	X2	.375	2.100	15000	548	.055	.154	.103	.127	.192	.137
ERCW	N3-67-09A	14.000	SS	Q7	.375	3.848	18800	1374	.091	.211	.140	.164	.236	.178
ERCW	N3-67-09A	14.000	SS	Q8	.375	3.848	18800	1374	.108	.219	.146	.167	.213	.171
ERCW	N3-67-09A	14.000	SS	Q10	.375	2.936	18800	1374	.167	.236	.157	.161	.149	.156
ERCW	N3-67-09A	14.000	SS	Q21	.375	1.000	18800	1374	.200	.323	.215	.233	.052	.111
ERCW	N3-67-09A	14.000	SS	Q102	.375	2.936	18800	1374	.080	.107	.071	.071	.251	.183
ERCW	N3-67-09A	14.000	CS	Q24	.375	1.000	15000	669	.132	.215	.143	.155	.036	.075
ERCW	N3-67-09A	14.000	CS	Q83	.375	2.936	15000	1374	.169	.276	.184	.197	.359	.283
ERCW	N3-67-09A	14.000	CS	Q85	.375	2.936	15000	1374	.159	.236	.157	.163	.312	.251
ERCW	N3-67-09A	14.000	CS	QY07	.375	1.800	15000	1374	.115	.402	.268	.336	.315	.235
ERCW	N3-67-09A	14.000	CS	Q108	.375	4.050	15000	434	.048	.300	.200	.265	.242	.164
ERCW	N3-67-09A	16.000	CS	306Y	.375	1.000	15000	1588	.169	.200	.133	.126	.172	.171
ERCW	N3-67-09A	16.000	CS	308	.375	1.800	15000	1588	.152	.217	.145	.148	.340	.264
ERCW	N3-67-09A	16.000	CS	312	.375	2.538	15000	1588	.131	.263	.176	.198	.504	.355
ERCW	N3-67-09A	16.000	CS	312	.375	2.538	15000	1588	.155	.269	.180	.195	.504	.364
ERCW	N3-67-09A	16.000	CS	314	.375	1.900	15000	1588	.128	.199	.132	.139	.266	.211
ERCW	N3-67-09A	16.000	CS	318	.375	3.225	15000	1588	.132	.213	.142	.152	.359	.268
ERCW	N3-67-09A	16.000	CS	318-C	.375	3.225	15000	1588	.134	.223	.149	.160	.500	.354
ERCW	N3-67-09A	16.000	CS	31C	.375	2.100	15000	1588	.137	.235	.157	.170	.623	.429
ERCW	N3-67-09A	16.000	CS	31D	.375	1.800	15000	1588	.125	.180	.120	.123	.397	.288
ERCW	N3-67-09A	18.000	CS	Q69	.375	3.500	15000	1801	.191	.295	.197	.205	.153	.168
ERCW	N3-67-09A	18.000	CS	Q72	.375	4.050	15000	2441	.252	.335	.223	.219	.111	.168
ERCW	N3-67-09A	18.000	CS	519	.375	3.500	15000	1801	.167	.184	.123	.111	.299	.246
ERCW	N3-67-09A	18.000	CS	533	.375	1.900	15000	1801	.138	.267	.178	.204	.241	.200
ERCW	N3-67-09A	18.000	CS	536	.375	1.000	15000	1801	.181	.261	.174	.181	.116	.142
ERCW	N3-67-09A	18.000	CS	538A	.375	2.100	15000	1801	.142	.258	.172	.192	.216	.186
ERCW	N3-67-09A	18.000	CS	539	.375	3.500	15000	1801	.139	.185	.123	.123	.356	.269
ERCW	N3-67-09A	18.000	CS	539-C	.375	3.500	15000	1801	.151	.194	.130	.130	.348	.269
ERCW	N3-67-09A	18.000	CS	541	.375	3.500	15000	1801	.160	.215	.143	.147	.307	.248
ERCW	N3-67-09A	18.000	CS	549	.375	3.500	15000	1801	.148	.293	.195	.223	.013	.067
ERCW	N3-67-09A	18.000	CS	557	.375	3.500	15000	1801	.167	.386	.257	.305	.235	.208
ERCW	N3-67-09A	18.000	CS	Q906	.375	1.000	15000	4780	.322	.284	.189	.149	.011	.135
ERCW	N3-67-09A	20.000	CS	87	.375	3.766	15000	2014	.187	.230	.153	.148	.309	.260
ERCW	N3-67-09A	20.000	CS	87-C	.375	3.766	15000	2014	.172	.184	.123	.111	.405	.312
ERCW	N3-67-09A	20.000	CS	94Q	.375	1.800	15000	2014	.152	.220	.147	.153	.788	.533
ERCW	N3-67-09A	20.000	CS	275	.375	2.100	15000	2014	.223	.324	.216	.220	.038	.112
ERCW	N3-67-09A	20.000	CS	275A	.375	1.000	15000	2014	.220	.268	.179	.170	.027	.104
ERCW	N3-67-09A	20.000	CS	277	.375	1.000	15000	2014	.175	.237	.158	.158	.020	.082
ERCW	N3-67-09A	24.000	CS	211	.375	3.343	15000	2441	.225	.339	.226	.233	.746	.537
ERCW	N3-67-09A	24.000	CS	243	.375	4.050	15000	2441	.366	.639	.426	.468	.991	.741
ERCW	N3-67-09A	24.000	CS	247	.375	5.596	15000	2441	.207	.361	.241	.261	.832	.582
ERCW	N3-67-09A	24.000	CS	229	.375	1.900	15000	2441	.381	.524	.349	.353	.367	.373
ERCW	N3-67-09A	24.000	CS	018	.375	4.050	15000	2441	.359	.511	.341	.350	.396	.381

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-09A	24.000	CS	R57	.375	1.395	15000	2441	.200	.209	.139	.122	.475	.365
ERCW	N3-67-09A	24.000	CS	223	.375	1.000	15000	2441	.213	.229	.153	.138	.352	.296
ERCW	N3-67-09A	24.000	CS	17Z	.375	1.000	15000	2441	.233	.254	.169	.152	.065	.132
ERCW	N3-67-09A	24.000	CS	179D	.375	4.050	15000	2441	.250	.402	.268	.285	.147	.188
ERCW	N3-67-09A	30.000	CS	178A	.375	8.470	15000	3081	.305	.446	.298	.306	.918	.673
ERCW	N3-67-09A	30.000	CS	178A	.375	8.470	15000	3081	.103	.184	.122	.134	.466	.321
ERCW	N3-67-09A	30.000	CS	162	.375	4.710	15000	3081	.341	.479	.320	.329	.466	.416
ERCW	N3-67-09A	30.000	CS	777	.375	4.710	15000	3081	.342	.435	.290	.281	.147	.225
ERCW	N3-67-09A	30.000	CS	178	.375	8.666	15000	3081	.310	.472	.314	.328	1.094	.780
ERCW	N3-67-09A	30.000	CS	265	.375	8.470	15000	3081	.460	.527	.351	.329	.933	.744
ERCW	N3-67-09A	30.000	CS	268	.375	8.666	15000	3081	.524	.600	.400	.374	1.072	.853
ERCW	N3-67-09A	30.000	CS	492	.375	4.976	15000	3081	.319	.432	.288	.284	.203	.249
ERCW	N3-67-09A	30.000	CS	493A	.375	1.000	15000	3081	.237	.253	.169	.151	.026	.110
ERCW	N3-67-09A	36.000	CS	611A	.375	5.635	15000	3720	.365	.417	.278	.260	.834	.646
ERCW	N3-67-09A	36.000	CS	58	.375	5.635	15000	3720	.327	.729	.486	.647	.801	.612
ERCW	N3-67-09A	36.000	CS	318	.375	5.690	15000	3720	.292	.424	.283	.286	.791	.592
ERCW	N3-67-09A	36.000	CS	601A	.375	5.635	15000	3720	.357	.388	.258	.236	.733	.583
ERCW	N3-67-09A	36.000	CS	603	.375	5.635	15000	3720	.284	.338	.226	.216	.741	.558
ERCW	N3-67-09A	36.000	CS	595	.375	1.000	15000	3720	.284	.273	.182	.152	.149	.203
ERCW	N3-67-09A	36.000	CS	598	.375	1.000	15000	3720	.289	.273	.182	.151	.282	.285
ERCW	N3-67-09A	36.000	CS	598A	.375	1.000	15000	3720	.287	.267	.178	.146	.184	.225
ERCW	N3-67-09A	36.000	CS	50	.375	8.610	15000	3720	.160	.338	.225	.295	1.017	.674
ERCW	N3-67-09A	36.000	CS	12	.438	2.100	17500	3168	.246	.644	.429	.623	.413	.346
ERCW	N3-67-09A	36.000	CS	17	.438	5.069	17500	3168	.230	.639	.426	.621	.551	.422
ERCW	N3-67-09A	36.000	CS	17-C	.438	5.069	17500	3168	.237	.680	.453	.664	.600	.455
ERCW	N3-67-09A	36.000	CS	19	.438	5.069	17500	3168	.233	.656	.437	.637	.539	.417
ERCW	N3-67-09A	36.000	CS	36	.438	5.069	17500	3168	.384	.770	.513	.661	.592	.509
ERCW	N3-67-09A	36.000	CS	625	.438	5.069	17500	3168	.248	.340	.227	.235	.944	.666
ERCW	N3-67-09A	36.000	CS	551	.438	8.610	17500	397	.324	.460	.307	.317	1.434	.990
ERCW	N3-67-09A	36.000	CS	49	.438	1.000	17500	3168	.276	.396	.264	.302	.219	.242
ERCW	N3-67-09A	36.000	CS	652	.438	1.000	17500	3168	.212	.416	.277	.328	.111	.151
ERCW	N3-67-23A	4.500	CS	A3A	.237	1.950	15000	642	.252	.446	.297	.330	.083	.150
ERCW	N3-67-23A	4.500	CS	A3B	.237	1.500	15000	642	.216	.372	.248	.273	.065	.126
ERCW	N3-67-23A	4.500	CS	A32	.237	1.900	15000	642	.131	.237	.158	.176	.066	.092
ERCW	N3-67-23A	4.500	CS	A36	.237	1.800	15000	642	.118	.232	.155	.177	.028	.064
ERCW	N3-67-23A	2.375	CS	44D	.154	1.430	15000	500	.033	.065	.044	.050	0.000	.013
ERCW	N3-67-23A	2.375	CS	44E	.154	2.100	15000	500	.033	.075	.050	.059	0.000	.013
ERCW	N3-67-23A	2.375	CS	44F	.154	2.100	15000	500	.033	.049	.032	.034	0.000	.013
ERCW	N3-67-23A	8.625	SS	M26	.322	2.000	15700	953	.132	.289	.193	.236	1.138	.736
ERCW	N3-67-23A	8.625	SS	M27	.322	2.000	15700	953	.119	.328	.220	.282	1.144	.734
ERCW	N3-67-23A	8.625	SS	885	.322	1.440	15700	953	.098	.199	.136	.158	1.388	.872
ERCW	N3-67-23A	8.625	SS	858	.322	2.000	15700	953	.128	.268	.180	.217	.990	.646
ERCW	N3-67-23A	8.625	SS	859	.322	1.800	15700	953	.119	.236	.158	.187	.818	.538
ERCW	N3-67-23A	10.750	CS	85A	.365	3.360	15000	1059	.122	.875	.584	.843	1.176	.754
ERCW	N3-67-23A	10.750	CS	856	.365	1.968	15000	1059	.111	.255	.171	.212	.875	.569
ERCW	N3-67-23A	10.750	CS	853	.365	1.800	15000	1059	.093	.378	.252	.346	.773	.501

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-23A	10.750	CS	856	.365	1.968	15000	1059	.091	.140	.093	.102	.749	.486
ERCW	N3-67-23A	10.750	CS	856	.365	1.968	15000	1059	.113	.205	.137	.160	.738	.488
ERCW	N3-67-23A	24.000	CS	850	.375	3.890	15000	2441	.341	.550	.368	.402	.706	.560
ERCW	N3-67-23A	24.000	CS	40	.375	2.000	15000	2441	.240	.388	.259	.291	.209	.221
ERCW	N3-67-23A	24.000	CS	47A	.375	1.800	15000	2441	.245	.354	.236	.250	.224	.232
ERCW	N3-67-23A	24.000	CS	47	.375	1.800	15000	2441	.245	.352	.235	.248	.202	.219
ERCW	N3-67-23A	30.000	CS	27	.375	4.980	15000	3081	.342	.904	.602	.840	.433	.396
ERCW	N3-67-23A	30.000	CS	34	.375	4.980	15000	3081	.328	.902	.601	.845	.397	.370
ERCW	N3-67-23A	30.000	CS	22-C	.375	4.976	15000	3081	.349	.908	.605	.844	.445	.406
ERCW	N3-67-23A	30.000	CS	22	.375	4.980	15000	3081	.354	.974	.649	.916	.395	.379
ERCW	N3-67-23A	30.000	CS	24	.375	4.980	15000	3081	.334	.790	.527	.718	.432	.393
ERCW	N3-67-24A	2.375	SS	F2	.154	2.100	15700	500	.104	.316	.211	.249	.899	.581
ERCW	N3-67-24A	2.375	SS	F8	.154	2.100	15700	500	.061	.187	.125	.147	.640	.408
ERCW	N3-67-24A	2.375	SS	F15	.154	2.100	15700	500	.146	.301	.201	.222	1.233	.798
ERCW	N3-67-24A	2.375	SS	F17	.154	2.100	15700	500	.167	.318	.212	.233	1.495	.964
ERCW	N3-67-24A	2.375	SS	F18	.154	2.100	15700	500	.171	.303	.202	.219	1.492	.964
ERCW	N3-67-24A	2.375	SS	F20	.154	2.100	15700	500	.144	.249	.166	.179	1.229	.795
ERCW	N3-67-24A	2.375	SS	F25	.154	1.000	15700	500	.063	.165	.110	.126	.147	.113
ERCW	N3-67-24A	2.375	SS	F26	.154	1.000	15700	500	.047	.116	.077	.087	.071	.061
ERCW	N3-67-24A	3.500	SS	BB06	.216	2.000	15700	531	.296	.778	.519	.662	.247	.267
ERCW	N3-67-24A	3.500	SS	AB06	.216	1.000	15700	531	.215	.554	.369	.470	.126	.162
ERCW	N3-67-24A	3.500	SS	P11B-C	.216	1.800	15700	531	.109	.251	.167	.208	.133	.123
ERCW	N3-67-24A	3.500	SS	B08	.216	1.800	15700	531	.097	.251	.167	.214	.132	.118
ERCW	N3-67-24A	4.500	SS	759	.237	1.800	15700	642	.182	.219	.146	.141	.062	.110
ERCW	N3-67-24A	4.500	SS	B05	.237	1.000	15700	642	.147	.350	.233	.292	.071	.101
ERCW	N3-67-24A	4.500	SS	B06	.237	2.000	15700	642	.192	.477	.318	.402	.137	.159
ERCW	N3-67-24A	4.500	SS	AB06	.237	1.000	15700	642	.138	.316	.211	.261	.067	.096
ERCW	N3-67-24A	6.625	CS	702	.280	1.800	15000	828	.182	.306	.204	.228	.033	.093
ERCW	N3-67-24A	6.625	CS	702A	.280	1.800	15000	828	.173	.321	.214	.244	.017	.080
ERCW	N3-67-24A	6.625	CS	705	.280	1.800	15000	828	.222	.371	.248	.272	.034	.109
ERCW	N3-67-24A	6.625	CS	Z705	.280	1.800	15000	828	.204	.364	.243	.272	.036	.103
ERCW	N3-67-24A	6.625	CS	X710	.280	1.800	15000	828	.090	.320	.213	.268	.010	.042
ERCW	N3-67-24A	6.625	CS	710	.280	1.800	15000	828	.107	.332	.221	.274	.010	.048
ERCW	N3-67-24A	6.625	CS	711	.280	1.800	15000	828	.095	.317	.211	.264	.009	.043
ERCW	N3-67-24A	6.625	CS	720	.280	1.800	15000	828	.226	.437	.292	.330	.015	.100
ERCW	N3-67-24A	6.625	SS	C1	.280	1.800	15700	828	.075	.140	.093	.108	.493	.326
ERCW	N3-67-24A	6.625	SS	B03	.280	1.691	15700	828	.074	.148	.099	.117	.574	.374
ERCW	N3-67-24A	6.625	SS	P16B	.280	2.270	15700	828	.079	.133	.089	.098	.447	.300
ERCW	N3-67-24A	6.625	SS	P17B	.280	2.270	15700	828	.099	.314	.209	.261	.428	.296
ERCW	N3-67-24A	6.625	SS	C37	.280	1.800	15700	828	.240	.425	.283	.314	.022	.109
ERCW	N3-67-24A	6.625	SS	C38	.280	1.800	15700	828	.283	.492	.328	.362	.027	.129
ERCW	N3-67-24A	6.625	SS	C41	.280	1.800	15700	828	.119	.325	.217	.264	.426	.303
ERCW	N3-67-24A	6.625	SS	P19B-C	.280	2.270	15700	828	.131	.374	.249	.306	.501	.353
ERCW	N3-67-24A	6.625	SS	P19B	.280	2.270	15700	828	.135	.396	.264	.325	.537	.376
ERCW	N3-67-24A	6.625	SS	P19E	.280	2.270	15700	828	.120	.329	.219	.267	.411	.295
ERCW	N3-67-24A	8.625	CS	656	.322	1.800	15000	953	.143	.227	.151	.166	.896	.595

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-24A	8.625	CS	655	.322	1.400	15000	953	.125	.201	.134	.147	.758	.505
ERCW	N3-67-24A	8.625	CS	657	.322	1.800	15000	953	.152	.210	.140	.145	.795	.538
ERCW	N3-67-24A	8.625	CS	P1B	.322	2.440	15000	953	.132	.190	.127	.134	.129	.130
ERCW	N3-67-24A	8.625	CS	P2E	.322	2.440	15000	953	.159	.167	.112	.098	.171	.166
ERCW	N3-67-24A	8.625	CS	662	.322	1.800	15000	953	.083	.143	.095	.107	.115	.102
ERCW	N3-67-24A	8.625	CS	667	.322	1.800	15000	953	.079	.158	.105	.123	.078	.079
ERCW	N3-67-24A	8.625	CS	665	.322	1.800	15000	953	.085	.166	.110	.130	.071	.077
ERCW	N3-67-24A	8.625	CS	658	.322	1.843	15000	953	.158	.206	.137	.139	.750	.513
ERCW	N3-67-24A	8.625	SS	B05	.322	1.000	15700	642	.081	.111	.074	.078	.013	.040
ERCW	N3-67-24A	8.625	SS	B03	.322	1.843	15700	953	.101	.155	.103	.114	.322	.234
ERCW	N3-67-24A	8.625	SS	E46	.322	1.140	15700	953	.061	.053	.035	.035	.927	.580
ERCW	N3-67-24A	8.625	SS	E48	.322	1.000	15700	953	.061	.051	.034	.026	1.043	.650
ERCW	N3-76-34A	2.375	SS	16	.154	1.900	18600	625	.035	.956	.035	.037	1.135	.697
ERCW	N3-76-34A	2.375	SS	20	.154	2.333	18600	625	.040	.040	.027	.023	1.454	.891
ERCW	N3-76-34A	2.375	SS	21	.154	2.100	18600	625	.038	.037	.025	.022	1.190	.732
ERCW	N3-76-34A	2.375	SS	44	.154	2.100	18600	625	.053	.061	.041	.039	1.529	.938
ERCW	N3-76-34A	2.375	SS	46	.154	2.333	18600	625	.040	.044	.029	.027	1.388	.852
ERCW	N3-76-34A	2.375	SS	45	.154	2.100	18600	625	.039	.653	.042	.028	1.059	.653
ERCW	N3-76-34A	2.375	SS	27A	.154	2.100	18600	625	.064	.066	.044	.040	.323	.220
ERCW	N3-76-34A	2.375	SS	29	.154	1.000	18600	625	.051	.050	.033	.029	.145	.108
ERCW	N3-76-34A	2.375	SS	69	.154	1.210	18600	625	.036	.060	.040	.045	.584	.364
ERCW	N3-76-34A	4.500	CS	38	.237	2.000	15000	802	.058	.050	.033	.026	.060	.059
ERCW	N3-76-34A	4.500	CS	39	.237	1.450	15000	802	.058	.050	.034	.026	.069	.065
ERCW	N3-76-34A	4.500	CS	40	.237	1.800	15000	802	.063	.058	.039	.031	.130	.103
ERCW	N3-76-34A	4.500	CS	41	.237	1.000	15000	802	.630	.058	.039	.031	.063	.063
ERCW	N3-76-34A	4.500	CS	41A	.237	1.000	15000	802	.062	.055	.037	.029	.039	.048
ERCW	N3-76-34A	4.500	CS	41B	.237	1.000	15000	802	.063	.055	.037	.029	.030	.043
ERCW	N3-76-34A	4.500	CS	42	.237	2.020	15000	802	.056	.048	.032	.025	.029	.040
ERCW	N3-67-39A	2.375	SS	B08	.154	2.100	15700	500	.279	.492	.365	.335	.110	.178
ERCW	N3-67-39A	2.375	SS	B23	.154	2.100	15700	500	.359	.763	.535	.448	.103	.205
ERCW	N3-67-39A	2.375	SS	AV40	.154	2.100	15700	500	.241	.570	.409	.355	.082	.145
ERCW	N3-67-39A	2.375	SS	D05	.154	2.100	15700	500	.049	.094	.068	.059	.684	.430
ERCW	N3-67-39A	2.375	SS	WP3T	.154	2.100	15700	500	.047	.088	.062	.052	.594	.375
ERCW	N3-67-39A	2.375	SS	D08	.154	2.100	15700	500	.051	.074	.054	.047	.578	.367
ERCW	N3-67-39A	2.375	SS	D23	.154	2.100	15700	500	.042	.052	.038	.035	.596	.374
ERCW	N3-67-39A	2.375	SS	E19	.154	2.100	15700	500	.248	.523	.359	.284	.259	.255
ERCW	N3-67-39A	2.375	SS	E32	.154	2.100	15700	500	.068	.168	.121	.106	.726	.463
ERCW	N3-67-39A	2.375	SS	D23	.154	2.100	15700	407	.043	.066	.049	.049	1.024	.632
ERCW	N3-67-39A	2.875	SS	C20B	.203	1.800	15700	450	.051	.075	.053	.052	.223	.154
ERCW	N3-67-39A	2.875	SS	C20E	.203	1.800	15700	450	.050	.076	.053	.054	.211	.147
ERCW	N3-67-39A	2.875	SS	14C	.203	1.800	15700	450	.096	.173	.130	.138	.021	.051
ERCW	N3-67-39A	2.875	SS	B05	.203	1.800	15700	450	.128	.211	.160	.150	.039	.075
ERCW	N3-67-39A	3.500	SS	154B	.216	2.000	15700	531	.042	.116	.078	.096	.139	.100
ERCW	N3-67-39A	3.500	SS	190	.216	1.800	15700	531	.056	.124	.085	.067	.141	.107
ERCW	N3-67-39A	3.500	SS	200	.216	1.296	15700	531	.052	.105	.071	.056	.107	.085
ERCW	N3-67-39A	4.500	CS	C12B	.237	1.800	15000	642	.057	.074	.054	.052	.468	.304

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
ERCW	N3-67-39A	4.500	CS	C12B	.237	1.952	15000	642	.058	.078	.056	.054	.508	.328
ERCW	N3-67-39A	4.500	CS	C12B-C	.237	1.952	15000	642	.054	.076	.054	.054	.527	.337
ERCW	N3-67-39A	4.500	CS	C12E	.237	1.800	15000	642	.049	.067	.046	.046	.444	.286
ERCW	N3-67-39A	4.500	CS	C12E	.237	1.952	15000	642	.049	.070	.048	.049	.482	.309
ERCW	N3-67-39A	4.500	CS	C17B	.237	1.800	15000	642	.106	.301	.232	.266	.060	.078
ERCW	N3-67-39A	4.500	CS	C17B	.237	1.952	15000	642	.111	.324	.249	.287	.065	.084
ERCW	N3-67-39A	4.500	SS	25	.237	1.450	15700	642	.072	.089	.061	.058	.140	.113
ERCW	N3-67-39A	6.625	CS	99	.280	1.800	15000	828	.065	.077	.052	.050	.119	.098
ERCW	N3-67-39A	6.625	SS	131	.280	1.800	15700	828	.082	.078	.052	.044	.630	.411
ERCW	N3-67-39A	6.625	SS	P15M	.280	1.800	15700	828	.055	.050	.033	.027	.403	.263
ERCW	N3-67-39A	6.625	SS	137	.280	1.800	15700	828	.066	.065	.043	.038	.389	.260
ERCW	N3-67-39A	6.625	SS	C03B	.280	2.266	15700	828	.061	.056	.037	.031	.456	.298
ERCW	N3-67-39A	6.625	SS	146	.280	1.800	15700	828	.129	.133	.089	.082	.104	.114
ERCW	N3-67-39A	6.625	SS	145	.280	1.800	15700	828	.201	.224	.150	.147	.034	.100
SFC	N3-78-01A2	3.500	SS	450	.216	1.670	17800	498	.064	.103	.069	.073	.206	.151
SFC	N3-78-01A2	3.500	SS	452	.216	1.777	17800	498	.055	.098	.065	.072	.217	.154
SFC	N3-78-01A2	3.500	SS	454A	.216	1.900	17800	498	.035	.076	.051	.058	.203	.138
SFC	N3-78-01A2	3.500	SS	480	.216	1.000	17800	498	.040	.128	.085	.107	.188	.130
SFC	N3-78-01A2	3.500	SS	484	.216	1.670	17800	498	.075	.238	.159	.195	.200	.151
SFC	N3-78-01A2	3.500	SS	486	.216	1.777	17800	498	.069	.233	.155	.193	.207	.153
SFC	N3-78-01A2	8.625	SS	52	.322	1.900	17800	893	.060	.203	.135	.169	.057	.058
SFC	N3-78-01A2	8.625	SS	A53	.322	2.100	17800	893	.058	.252	.168	.216	.070	.065
SFC	N3-78-01A2	8.625	SS	64	.322	1.843	17800	893	.076	.251	.167	.208	.078	.077
SFC	N3-78-01A2	8.625	SS	68	.322	2.439	17800	893	.055	.259	.173	.231	.096	.080
SFC	N3-78-01A2	8.625	SS	588	.322	2.439	17800	893	.105	.275	.183	.221	.082	.091
SFC	N3-78-01A2	8.625	SS	575	.322	2.233	17800	893	.071	.286	.191	.245	.135	.110
SFC	N3-78-01A2	8.625	SS	577	.322	1.000	17800	893	.135	.274	.182	.208	.044	.080
SFC	N3-78-01A2	8.625	SS	581	.322	2.439	17800	893	.083	.310	.207	.261	.083	.083
SFC	N3-78-01A2	8.625	SS	2D-C	.322	2.439	17800	893	.063	.365	.243	.319	.173	.130
SFC	N3-78-01A2	8.625	SS	261	.322	1.741	17800	893	.075	.343	.228	.293	.106	.094
SFC	N3-78-01A2	8.625	SS	B260	.322	2.100	17800	893	.073	.373	.249	.323	.127	.106
SFC	N3-78-01A2	10.750	SS	76	.365	2.000	17800	993	.065	.120	.080	.092	.005	.028
SFC	N3-78-01A2	10.750	SS	78	.365	2.000	17800	993	.069	.124	.083	.095	.006	.031
SFC	N3-78-01A2	10.750	SS	78-C	.365	2.605	17800	993	.089	.165	.110	.126	.018	.045
SFC	N3-78-01A2	10.750	SS	80	.365	1.000	17800	993	.074	.110	.074	.078	.012	.036
SFC	N3-78-01A3	3.500	SS	500	.216	1.407	17800	498	.058	.214	.143	.192	.440	.292
SFC	N3-78-01A3	3.500	SS	502	.216	1.800	17800	498	.064	.255	.170	.230	.520	.342
SFC	N3-78-01A3	3.500	SS	504	.216	1.900	17800	498	.063	.249	.166	.224	.488	.322
SFC	N3-78-01A3	3.500	SS	512	.216	1.800	17800	498	.090	.108	.072	.070	.596	.399
SFC	N3-78-01A3	3.500	SS	906	.216	1.800	17800	498	.040	.046	.031	.029	.409	.266
SFC	N3-78-01A3	3.500	SS	908	.216	1.800	17800	498	.064	.085	.057	.058	.892	.570
SFC	N3-78-01A3	3.500	SS	600	.216	2.333	17800	498	.062	.310	.206	.279	.544	.357
SFC	N3-78-01A3	3.500	SS	909	.216	1.800	17800	498	.055	.067	.045	.044	.616	.398
SFC	N3-78-01A3	3.500	SS	622	.216	1.800	17800	498	.035	.373	.248	.357	.037	.036
SFC	N3-78-01A3	4.500	SS	350	.237	1.759	17800	602	.219	.385	.256	.288	.136	.168
SFC	N3-78-01A3	4.500	SS	352	.237	1.900	17800	602	.217	.385	.257	.289	.144	.173

System	Calc package	O.D.	Mat'l	Node	Thick	SIF	Sigma a	Sigma p	Eq 8	Eq 9U	Eq 9E	Eq 9F	Eq 10	Eq 11
SFC	N3-78-01A3	4.500	SS	352	.474	1.900	17800	285	.102	.180	.120	.135	.067	.081
SFC	N3-78-01A3	4.500	SS	358	.237	1.900	17800	602	.137	.239	.159	.178	.127	.131
SFC	N3-78-01A3	4.500	SS	R3768	.237	1.000	17800	602	.095	.120	.080	.081	.021	.050
SFC	N3-78-01A3	4.500	SS	383	.237	1.800	17800	602	.120	.147	.098	.096	.017	.057
SFC	N3-78-01A3	8.625	SS	106	.322	1.901	17800	893	.058	.095	.063	.070	.107	.088
SFC	N3-78-01A3	8.625	SS	312	.365	2.000	17800	893	.060	.087	.058	.062	.032	.043
SFC	N3-78-01A3	8.625	SS	312	.322	1.901	17800	893	.057	.110	.073	.086	.055	.056
SFC	N3-78-01A3	10.750	SS	120	.375	2.592	17800	993	.075	.159	.106	.127	.503	.337
SFC	N3-78-01A3	10.750	SS	120A	.375	1.000	17800	993	.065	.108	.072	.081	.211	.155
SFC	N3-78-01A3	10.750	SS	120B	.375	1.000	17800	993	.072	.112	.075	.082	.201	.151
SFC	N3-78-01A3	10.750	SS	331	.375	1.000	17800	993	.062	.086	.057	.059	.149	.115
SFC	N3-78-01A3	10.750	SS	120	.375	2.592	17800	993	.060	.137	.091	.110	.492	.324
SFC	N3-78-01A4	10.750	SS	192	.250	1.000	17800	1051	.118	.226	.151	.179	.225	.183
SFC	N3-78-01A4	10.750	SS	176-C	.365	2.605	17800	993	.067	.352	.235	.307	.040	.050
SFC	N3-78-01A4	10.750	SS	176	.365	2.605	17800	993	.207	.520	.346	.413	0.000	.081
SFC	N3-78-01A4	10.750	SS	182	.365	1.000	17800	993	.066	.298	.199	.257	.015	.035
SFC	N3-78-12A	2.375	SS	160	.154	2.100	17800	468	.028	.032	.022	.021	.022	.024
SFC	N3-78-12A	2.375	SS	165	.154	2.100	17800	468	.029	.050	.033	.036	.039	.035
SFC	N3-78-12A	2.375	SS	310	.154	2.100	17800	468	.028	.031	.021	.019	.125	.087
SFC	N3-78-12A	2.375	SS	315	.154	2.100	17800	468	.029	.051	.034	.038	.257	.168
SFC	N3-78-12A	3.500	SS	30	.216	1.800	17800	498	.031	.037	.024	.023	.825	.516
SFC	N3-78-12A	3.500	SS	36	.216	1.800	17800	498	.030	.035	.023	.021	.758	.475
SFC	N3-78-12A	3.500	SS	37	.216	1.800	17800	498	.029	.032	.021	.019	.665	.417
SFC	N3-78-12A	3.500	SS	255	.216	1.800	17800	498	.029	.037	.025	.025	.468	.297
SFC	N3-78-12A	3.500	SS	55	.216	1.800	17800	498	.056	.054	.036	.030	.237	.167