The Light company
Houston Lighting & Power South Texas Project Electric Generating Station P. O. Box 289 Wadsworth, Texas 77483

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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

South Texas Project
Units 1 & 2
Docket Nos. STN 50-498 & STN 50-499
Request for Relief from ASME Boiler and Pressure Vessel Code,
Section XI Requirements (Relief Request RR-ENG-14)

In accordance with the provisions of 10 CFR 50.55a(g), the South Texas Project requests relief from IWA 5250 of Section XI of the ASME Boiler and Pressure Vessel Code (ASME XI) in order to defer permanent repair of flaws recently identified in the Essential Cooling Water System piping. The flaws were detected in the Essential Cooling Water System in Unit 1 and in Unit 2 during scheduled visual leak detection inspections of the Essential Cooling Water System. The South Texas Project intends to perform a code repair of the flaws in Unit 1 and Unit 2 as soon as practical, but not until the subsequent scheduled outage exceeding 30 days and no later than the subsequent scheduled refueling outage of the affected unit.

The South Texas Project has evaluated the Essential Cooling Water System flaws and determined that the operability and functionality of the system have been maintained and that deferring repair of the flaws will not affect the health and safety of the public.

The South Texas Project has evaluated the condition of the Essential Cooling Water System piping in accordance with the guidance of Generic Letter 90-05. Deviations from that guidance have been identified and justified. Attached is an evaluation providing the basis for the requested relief.

If there are any questions, please contact Mr. A. W. Harrison at (512) 972-7298 or me at (512) 972-7162.

S. E. Thomas
Manager,
Design Engineering

PLW/

Attachment: Request for Relief from ASME Boiler and Pressure Vessel Code, Section XI Requirements (Relief Request RR-ENG-14)

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Leonard J. Callan
Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

Thomas W. Alexion
Project Manager, Mail Code 13H3
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

David P. Loveless
Sr. Resident Inspector
c/o U. S. Nuclear Regulatory Comm.
P. O. Box 910
Bay City, TX 77404-0910

J. R. Newman, Esquire
Morgan, Lewis & Bockius
1800 M Street, N.W.
Washington, DC 20036-5869

M. T. Hardt/W. C. Gunst
City Public Service
P. O. Box 1771
San Antonio, TX 78296

J. C. Lanier/M. B. Lee
City of Austin
Electric Utility Department
721 Barton Springs Road
Austin, TX 78704

Central Power and Light Company
ATTN: G. E. Vaughn/C. A. Johnson
P. O. Box 289, Mail Code: N5012
Wadsworth, TX 77483

Rufus S. Scott
Associate General Counsel
Houston Lighting & Power Company
P. O. Box 61067
Houston, TX 77208

Institute of Nuclear Power
Operations - Records Center
700 Galleria Parkway
Atlanta, GA 30339-5957

Dr. Joseph M. Hendrie
50 Bellport Lane
Bellport, NY 11713

Richard A. Ratliff
Bureau of Radiation Control
Texas Department of Health
1100 West 49th Street
Austin, TX 78756-3189

U. S. Nuclear Regulatory Comm.
Attn: Document Control Desk
Washington, D. C. 20555-0001

J. R. Egan, Esquire
Egan & Associates, P.C.
2300 N Street, N.W.
Washington, D.C. 20037

J. W. Beck
Little Harbor Consultants, Inc.
44 Nichols Road
Cohassett, MA 02025-1166

REQUEST FOR RELIEF FROM ASME BOILER AND PRESSURE VESSEL CODE, SECTION XI REQUIREMENTS (RELIEF REQUEST RR-ENG-14)

References:

1. Letter to NRC dated November 1, 1988, with attached Bechtel National/Aptech report 8804-06FA Rev. 3 (ST-HL-AE-2748)

2. Aptech Engineering Services Calculation AES-C-1964-1, "Calculation of Critical Bending Stress for Dealloyed Aluminum-Bronze Castings in the ECW System".

3. Aptech Engineering Services Calculation AES-C-1964-4, "Evaluation of 6-Inch Flange Test".

4. Aptech Engineering Services Calculation AES-C-1964-5, "Evaluation of the Significance of Dealloying and Subsurface Cracks on Flaw Evaluation Method".

5. Engineering Report #91-201-12 Revision 0, "ECW System Failures and Their Analysis".

6. STP Calculation CC-06401, "Flaw Evaluation of ECW Cast Flanges on lines 8"-EW-1186-WT3 & 8"-EW-2186-WT3".

7. Bechtel Calculation RC9890, Revision 0, "Stress Summary for Large Bore ECW Piping (2 ½" and Above)".

Reference Code: ASME Boiler and Pressure Vessel Code, Section XI
1983 Edition through Summer 1983 Addenda

A. Introduction

A1. Components For Which Exemption Is Requested:

(a) Name and Identification Number: Class 3, moderate energy piping in the Essential Cooling Water system:

- Unit 1 ECW line 8"-EW-1186-WT3
- Unit 2 ECW line 8"-EW-2186-WT3
- Unit 2 ECW line 6"-EW-2221-WT3

(b) Function: The Essential Cooling Water system is designed to supply cooling water to various safety-related systems for normal plant operation as well as normal shutdown and during and after postulated Design Basis Accidents. See Section 9.2.1.2 of the South Texas Project UFSAR for additional information.

(c) Class: ASME Code Class 3

(d) Description of the problem:

Unit 1: A crack is located on the 8" cast pipe flange immediately above the weld connecting the 8" x 10" piping tee. The location is just downstream of valve 1-EW-1002.

Unit 2: A crack is located on the 8" cast pipe flange immediately above the weld connecting the 8" x 10" piping tee. The location is just downstream of valve 2-EW-1002.

Unit 2: Two small spots of dealloying are located at weld joint EW2221 FW0004, a 6" cast flange to cast tee joint. The dealloying is on the tee side of the weld joint.

A2. <u>Code Requirement From Which Relief is Requested:</u>

Relief is requested from IWA-5250 of ASME Section XI in order to defer repair or replacement of Essential Cooling Water piping containing through-wall flaws.

A3. <u>Basis for Relief Request:</u>

The South Texas Project has analyzed the effect of through-wall flaws in Essential Cooling Water piping and found that, since the degradation is slow, rapid or catastrophic failure is not a consideration, and determined that the leakage can be detected before the flaw reaches a limiting size that would affect the operability of the Essential Cooling Water System. A monitoring and inspection program provides confidence in the ability to detect the leakage. Additional discussion is provided in the South Texas Project UFSAR Appendix 9A, "Assessment of the Potential Effects of Through-Wall Cracks in ECWS Piping."

This relief request is submitted in accordance with NRC Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping", which observes that required code repairs may be impractical for a flaw detected during plant operation unless the facility is shut down, and that relief may be granted pursuant to 10CFR50.55a(g)(i). The following information and justification is provided in accordance with the guidelines of Parts B and C of Enclosure 1 to GL 90-05.

This relief request is similar to South Texas Project Relief Request RR-ENG-10 submitted by letter ST-HL-AE-3984 on January 17, 1992. The corresponding NRC Safety Evaluation for Relief Request RR-ENG-10 was dated April 12, 1993.

B. Scope, Limitations and Specific Considerations

B1. Scope

The scope consists of two 8-inch diameter cast pipe flanges discovered with cracks located immediately above the weld joint in the cast material. The material of the pipe flange is ASME SB 271 CA 952 and the weld filler metal SFA 5.7 CuA1-A2. The above items were welded at Southwest Fabricating Company as part of a shop-fabricated component. Both weld joints were fabricated without a backing ring. It is believed that a preexisting flaw was present to enable initiation of the dealloying processes.

In addition, this scope includes two dealloyed spots on the Unit 2 6" cast tee at field weld joint EW2221 FW0004. The cast tee is ASME SB 148 CA952 and the welding filler metal SFA 5.7 CUAl-A2. This joint was fabricated with a backing ring. Radiographs of this area revealed indications which are consistent with casting defects. It is believed that the casting defects are the initiation points for the dealloying process.

The problem of dealloying of castings has been described in previous communications with the NRC (Reference 1). The South Texas Project has also performed laboratory analyses, calculations, and proof testing on cast aluminum bronze material to address cracking in dealloyed aluminum bronze castings. Flaw evaluation is addressed in paragraph C3.

The material properties used for flaw evaluation in castings were derived from fracture mechanics-based crack-opening displacement tests summarized in Reference 1.

B2. Limitations

During scheduled Essential Cooling Water System visual inspections of Unit 2 to detect leakage, corrosion deposits consistent with dealloying were found on the 8-inch cast flange and 6-inch cast tee to flange weld joint. A similar 8-inch cast flange in Unit 1 was also found to exhibit corrosion deposits in the cast material immediately above the weld. Under this relief request, the defects will be permitted to leak, based on existing evaluations of structural integrity and consequences of leakage. A Code repair will be deferred until the subsequent scheduled outage exceeding 30 days, but no later than the subsequent scheduled refueling outage, for the affected unit.

B3. Specific Considerations

System interactions, including consequences of flooding and spray on equipment as well as potential significance of loss of flow to the system, have been evaluated and are bounded by Appendix 9A of the South Texas Project UFSAR.

The structural integrity of welds with cracks and dealloying has been evaluated for all design loading conditions, including dead weight, pressure, thermal expansion, and seismic loads. Flaw evaluation is addressed in Paragraph C3.

The structural integrity is monitored by the following methods:

- Weekly monitoring for qualitative assessment of leakage (quantitative if measurable leaks are observed: currently there is no measurable leakage).
- Monthly Volumetric Examination of the defects by radiographic or ultrasonic testing.
- Continuation of the Essential Cooling Water System monthly walkdown. This walkdown is a regularly scheduled VT-2 examination of the Essential Cooling Water System including all cast components. This inspection technique has proven to be an effective means of identifying dealloyed/cracked components prior to deterioration of structural integrity margins below ASME Section XI requirements (Reference 5).

Significant changes found during this monitoring will be followed by a reevaluation of structural integrity and the monitoring frequency.

The temporary non-Code repair consists of leaving the identified flaws as is, until permanent Code repairs can be made at the subsequent scheduled outage of the affected unit that exceeds 30 days, but no later than the subsequent scheduled refueling outage, subject to monitoring as described above, and subject to meeting the criteria for consequences and for structural integrity as described above.

C. Evaluation

C1. Flaw Detection During Plant Operation and Impracticality Determination

The flaws were detected during plant operation. Code repairs are intended to be performed on them as soon as practical, but not until the subsequent scheduled outage exceeding 30 days, and no later than the subsequent scheduled refueling outage for the affected unit. Performance of Code repairs with assurance of completion within the time period permitted by the limiting condition for operation may not be practical due to a number of factors including:

- Potential for fit-up problems during repair, which may extend the schedule beyond the limiting condition for operation time;
- Potential need for access to the inside surface, which may require disassembly of additional equipment;
- Extended time required for draining these portions of the Essential Cooling Water System.

The South Texas Project prefers to perform the Code repairs under controlled conditions during a scheduled outage longer than allowed by a limiting condition of operation, provided the structural integrity is assured in the interim.

C2. Root Cause Determination and Flaw Characterization

The root cause of dealloying has been studied in several previous laboratory failure analyses. The dealloying process normally initiates from a crevice such as a backing ring, a fabrication-induced flaw, or a casting flaw. A dealloying area may include cracks as were experienced in the 8-inch flanges. Failure analysis indicates that the crack propagation occurred by a process of dealloying along the crack front. Previous examples of such cracks were found to have initiated from pre-existing flaws exposed to Essential Cooling Water.

The flaws were measured by visual inspection. The outside diameter crack measurements were as follows:

Unit 1 8-inch flange = 1-3/8"
Unit 2 8-inch flange = 1-3/4"

The Unit 2 6-inch tee to flange joint was found to have two dealloyed spots.

Subsequent radiographic inspection revealed that the defects had the following overall subsurface lengths:

Unit 1 8-inch flange = 4-1/16"
Unit 2 8-inch flange = 3-1/16"

Radiographic inspection of the Unit 2 6-inch tee to flange joint found no linear indications. Indications found were consistent with casting defects which most likely were the initiation point for dealloying.

C3. Flaw Evaluation

Flaw evaluation is performed as described in Enclosure 1 to this attachment. The Unit 1 flaw is bounding and has been evaluated by three alternate methods: linear elastic fracture mechanics; limit load method; and Generic Letter 90-05 Flaw Evaluation Method.

The "Through-Wall Flaw" fracture mechanics method prescribed in Generic Letter 90-05 was used and the criteria of Generic Letter 90-05 were satisfied. The fracture mechanics methodology developed by Aptech was also used and these results were compared against ASME Section XI Safety Factors. This evaluation determined that safety margins exceeded Code requirements. (References 2 and 6)

To confirm the adequacy of the Aptech approach, a full scale proof test was performed on a 6-inch cast aluminum bronze flange containing dealloyed sections with cracks in the cast material. A comparison of calculated and measured critical bending stress indicates that the Aptech calculated methodology conservatively estimates critical bending stresses. (Reference 3)

A limitation in flaw size of 3 inches or 15% of the pipe circumference, whichever is smaller, as prescribed in Generic Letter 90-05, is not imposed. This exception is justified due to the existing condition being conservatively evaluated and still showing more than adequate safety margins, particularly considering that the material is highly ductile and that use of linear elastic fracture mechanics is considered to be conservative.

A previous evaluation of the Unit 2 6-inch tee to flange joint by Bechtel assumed that 100% of the joint had been dealloyed. Since dealloying was only visible in two spots, assuming 100% dealloying conservatively envelopes the problem. Even with this conservative assumption, the analysis showed that there was an acceptable margin to meet ASME Section III requirements. (Reference 7).

C4. <u>Augmented Inspection</u>

The South Texas Project has analyzed the effects of cracking/dealloying in castings and found that the degradation is slow so that rapid or catastrophic failure is not a consideration, and determined that the leakage can be detected before the flaw reaches a limiting size that would affect the operability of the Essential Cooling Water System. In addition, the Essential Cooling Water System is a low pressure system with normal operating pressures of approximately 50 psig and a design pressure of 120 psig. As a result, the severe failure consequences associated with high energy lines are not applicable for the Essential Cooling Water System.

The Essential Cooling Water System will be inspected monthly for leaks or indications of dealloying including all cast fittings. As demonstrated in this particular instance, the periodic visual inspection monitoring technique has identified problems well in advance of any structural concerns for the Essential Cooling Water System. Numerous destructive laboratory analyses have provided augmented inspection information on cracking and dealloying in castings.

Enclosure 1: Flaw Evaluations for 8" Diameter Cast Weld Neck Flanges and 6" Cast Tee to Flange Field Weld Joint

FLAW EVALUATIONS FOR 8" DIAMETER CAST WELD NECK FLANGES AND 6" CAST TEE TO FLANGE FIELD WELD JOINT

Note: References in this enclosure refer to the listing of references at the beginning of the Attachment to this letter.

6-INCH TEE TO FLANGE FIELD WELD JOINT

A previous evaluation of the Unit 2 6-inch tee to flange joint by Bechtel assumed that 100% of the joint had been dealloyed. In the evaluation, Bechtel used lower allowables which were obtained by actual tensile tests of dealloyed samples. Since dealloying was only visible in two spots, assuming 100% dealloying conservatively envelopes the problem. Even with this conservative assumption, the analysis showed that there was an acceptable margin to meet ASME Section III requirements . (Reference 7).

INTRODUCTION FOR THE 8-INCH FLANGES

The two through-wall flaws were evaluated for structural integrity by three alternate methods: linear elastic fracture mechanics; limit load; and the evaluation method prescribed by Generic Letter 90-05.

CRACK SIZING

Through visual examination, the following outer diameter crack lengths were measured:

Unit 1 8" 150# flange OD Crack Length = 1-3/8"

Unit 2 8" 150# flange OD Crack Length = 1-3/4"

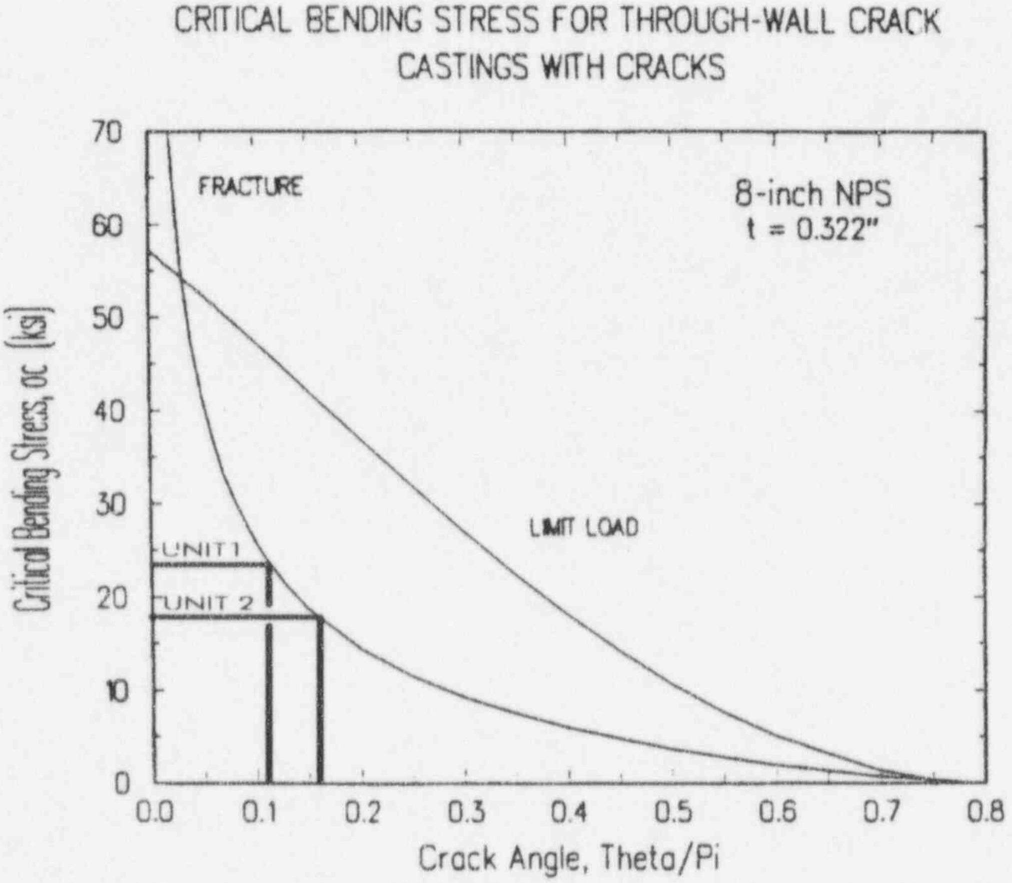
Through radiographic examination, the following crack lengths were measured:

Unit 1 8" 150# flange Crack Length = 4-1/16"

Unit 2 8" 150# flange Crack Length = 3-1/16"

The flaw evaluation procedure requires the through-wall crack angle 2θ, to be determined. Normally, this measurement would be at the mean radius; however, to conservatively ensure the extent of dealloying ahead of the crack face is considered, the crack angle is taken from the longest measured crack front. This conservative approach exceeds Aptech Flaw Sizing Curve which accounts for dealloying and subsurface cracks, based on previous destructive failure analysis of cast flanges. (Reference 4)

The critical bending stress for through-wall cracks in casting has been completed by Aptech in Calculation AES-C-1964-1 (Reference 2) and includes both limit load and linear elastic fracture mechanics. The following figure depicts the crack angle θ/π compared to the critical bending stress σ_c



Critical Bending Stress for 8-Inch Nominal Pipe Size Castings With Cracks.

As shown above, linear elastic fracture mechanics provides the more limiting analysis for the crack angle to be analyzed; therefore, only the detailed linear elastic fracture mechanics were analyzed in South Texas Project Calculation CC06401 (Reference 6). In addition, since the Unit 1 flaw is bounding, and the same design stress values apply to both flaws, the presented results will only be for Unit 1.

LINEAR ELASTIC FRACTURE MECHANICS

The results of South Texas Project Calculation CC06401 (Reference 6) show that the Critical Bending Stress for fracture, σ_b^c equals 17.26 ksi. This is in agreement with the figure "Critical Bending Stress for 8" Nominal Pipe Size Casting with Cracks" shown on the previous page.

DETERMINATION OF MARGINS

The safety factors as specified in ASME Section XI are defined separately for normal/ upset conditions, and emergency/faulted conditions. Thermal expansion stresses are to be included in the evaluation when non- nit load conditions are dominant. In the case of dealloying a casting, it is prudent to include thermal expansion stress. Following, in general, the flaw evaluation procedure of ASME Section XI, Appendix H, the following Safety Factors have been calculated (Reference 6):

Safety Factor for the Upset Condition = 12.47

Safety Factor for the Faulted Condition = 8.22

Below are the Section XI-required Safety Factors:

Safety Factor ≥ 2.77 (Normal/Upset)
Safety Factor ≥ 1.39 (Emergency/Faulted)

As shown above, the calculated safety factors far exceed the Section XI requirements. With these large margins, the limitation in flaw size of 3 inches or 15% of the pipe circumference, whichever is smaller, as prescribed in Generic Letter 90-05, will not be imposed.

GENERIC LETTER 90-05 "THROUGH-WALL FLAW" APPROACH

This approach assumes a through-wall flaw and evaluates the flaw stability by a linear elastic fracture mechanics methodology.

The maximum length of the portion of the flaw that extends beyond "t min", independent of orientation with respect to the pipe, is the through-wall flaw length "2a". In Calculation CC06401 (Reference 6), the through-wall flaw length was conservatively assumed to be 4-1/16" which was the longest flaw observed by radiographic testing.

The stress "s" at the flaw location was determined from the combination of deadweight, pressure, thermal expansion, and safe-shutdown earthquake. For evaluation purposes, the through-wall flaw length "2a" was conservatively assumed to be in the circumferential direction and the stress "s" was assumed to be a bending stress.

A safety factor of 1.4 was applied to the stress. Based on linear elastic fracture mechanics and assuming a pipe thickness of "t min", the stress intensity factor "K" resulting from the flaw under the applied load is:

STRESS INTENSITY FACTOR "K" = 40,285 psi $in^{1/2}$ (Reference 6)

For flaw stability, linear elastic fracture mechanics methodology specifies "K" to be less than the critical stress intensity factor which represents the fracture toughness of the material.

"K" for Aluminum Bronze Cast CA952 = 65,000 psi $in^{1/2}$ (Reference 2)

If the flaw satisfies the criteria of this evaluation approach, a temporary non-code repair of the code Class 3 piping may be proposed. It is noted that the rate of degradation is not considered in this approach because the flaw is assumed to have grown through the pipe wall and the temporary non-code repair is applicable, at maximum, until the next scheduled refueling outage.

CONCLUSION

Analysis of the flaws by Limit Load, linear elastic fracture mechanics, and Generic Letter 90-05 fracture mechanics methodology shows that more than adequate structural margins exist to allow temporary non-code repairs.