FINAL REPORT

BEAM TO COLUMN CONNECTIONS

## I. SUMMARY

### A. Synopsis of the Incident

On October 25, 1978, Houston Lighting & Power Company (HL&P) notified the Nuclear Regulatory Commission (NRC) of a potentially reportable deficiency under 10CFR50.55(e). This deficiency concerned the failure of Brown & Root, Inc. (B&R) to properly consider the application of certain postulated loads in the interior structural steel beams design for the Reactor Containment Building (RCB) of the South Texas Project Electric Generating Station (STPEGS). The beams in question were designed to generally serve as support floor grating with capability to restrain postulated breaks of high-energy piping should a need ever arise to anchor such pipes to these beams. This deficiency was discovered during the design verification of the end connections for these beams by B&R Engineering, and HL&P was notified. Subsequently, in mid-November, an audit of the B&R design verification program and an engineering review of B&R design calculations were simultaneously conducted by HL&P. The audit revealed that the B&R design verification program satisfied regulatory requirements and was being followed by design personnel. Review of the design calculations, however, produced similar examples of the failure to properly consider loadings and loading combinations in RCB internal steel design. HL&P considered the deficiency to be reportable and notified the NRC on November 27, 1978.

### B. Postulated Cause of the Incident

The deficiency was caused by human error and inadequate procedural training. The designer did not consider the postulated pipe break loads because there was no high-energy piping attached to these structural members, misunderstanding the requirement that "...all regions of walls and slabs are designed for a minimum pipe rupture load of 130 kips with associated bending moments". The beams in question were located in grating areas, and through interpretation by the designer, this requirement was not deemed applicable. The design verifier did not review the design manual to determine that the design inputs were correctly selected and incorporated into the design even though the procedure for design verification contains such a requirement.

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C. Corrective Measures

Concerning the correction of those physical defects resulting from this deficiency, B&R Engineering has reanalyzed the beams in each of the areas in the RCB where loadings and loading combinations had not been properly considered, as described in Ia, above. Where errors were found, the errors were corrected and the calculations were design verified in accordance with the new procedure, as described in the following paragraph. As a result of these calculations, it has not been necessary to make any design changes to compensate for the misapplied loadings.

Regarding the recurrence control, B&R Engineering has revised the entire design verification program. During the investigation of this deficiency, it was discovered that one of the root causes of this problem was that engineers with design responsibility were being used as design verifiers and were, therefore, placed under unusual schedule pressures to complete the design verification task. The procedure for design verification now requires that individulas whose prime responsibility is that of design verification be identified, and that these individuals be afforded the necessary time to complete the design verification task in an accurate and professional manner. All such design verifiers were afforded additional training to ensure that they understood the importance of this assignment. This program has been in effect for approximately three months.

D. Safety Evaluation

To date, no safety implications have been discovered as a result of this deficiency. Immediately following the discovery, the affected beams were reanalyzed using simple beam theory and it was discovered that if the effects of a high-energy pipe rupture were added to one of these members, the resulting loads would produce bending stresses beyond the yield strength of the material, but less than the ultimate strength. Thus, deflection would occur, but failure would not.

This type of structural behavior is stipulated in the STPEGS Final Safety Analysis Report (FSAR) Subsection 3.8.3.4.5. Since these beams only support floor grating, no safety hazard would be produced. These calculations, however, were previously determined to be "preliminary" within the B&R design control system pending receipt of the final-verified NSSS piping loads and separation criteria. Thus, no other stiffening will be added.

## II. DESCRIPTION OF DEFICIENCY

In August 1978, B&R began a set of calculations to verify the adequacy of certain beam connections for Category I structural steel. The steel specification required that the majority of the connections be selected from standard conncections in Table I, Section 4 of the AISC Manual of Steel Construction. For some of these connections, however, certain calculations were specified to be made by the fabricator, but the specification failed to require that such calculations be retained or approved by B&R. Recognizing this inconsistency, B&R decided to design verify the connections by preparing separate calculations, and it was discovered that some additional weld material was necessary.

This discovery was not classified by B&R as a reportable deficiency because the error was discovered during the normal design verification process. However, during this process, it was also discovered that a required load was not included in the design of a beam. The missing load was a 130 kip force that could result from the postulated break of a high-energy line if this line was supported by the beam in question. These beams function to support floor grating. The governing loads used in the beam design occur during construction when the floor space is used for storage. The present design does not require these beams to support any high-energy piping. However, HL&P has established a design criterion that all such beams be designed to carry postulated pipe break loads so that the structure has the capability to accommodate high-energy piping without major modification, should it become necessary or desirable to add or reroute such piping at a later date. These pipe break loads were identified in the design manual.

When the omission was discovered, the Structural Discipline promptly notified HL&P and B&R Project Quality Engineering. An Engineering Design Deficiency report was issued and an investigation began. The deficiency report was issued on October 25, 1978 and a response was received on November 11, 1978.

The bending stresses in the beam were calculated analytically by applying the postulated 130 kip load at midspan of a typical member. The calculated stresses were 46.5 ksi. ASTM A36-74 shows the yield strength of A36 steel to be 36 ksi and the ultimaze to be 54 to 80 ksi.

Shortly after the deficiency was reported, the Owner (HL&P) simultaneously conducted a Quality Assurance (OA) audit and an engineering design review. In general, the QA audit showed that B&R was following their procedures and that the procedures complied with regulatory requirements.

## III. CORRECTIVE ACTION

This section is presented in two parts; correction of the hardware and recurrence control.

a) Correction of the Hardware

The HL&P structural steel design review team reviewed calculations for the Fuel Handling Building (FHB), Mechanical-Electrical Auxiliary Building (MEAB), and the RCB. The review of the structural steel calculations for the FHB, and MEAB established no areas of concern. The review of the structural steel calculations in the RCB, did however, establish inadequacies in six specific areas. These areas were identified to B&R by HL&P in writing, and an Engineering Design Deficiency report was issued to the Structural Discipline. The stress calculations for the beams, columns, and framing in each of these areas were redone, and design verified. The revision of the calculation to correct the errors discovered by the HL&P design review team did not result in any revisions to the design of structural steel members. Regarding the initial deficiency, no modifications have been made for these members. The design of these members was based upon certain assumed pipe break loads and the design has included provisions for possible modifications should the final loads be found to be higher than those that were assumed. All of the calculations for the columns in areas of concern have been redone. It was found that it was not necessary to make any structural modifications to the columns.

b) Recurrence Control

B&R Engineering has revised their procedure for design verification to preclude recurrence of this deficiency. During the investigation of this deficiency, it was discovered that the original design verification had been performed by an engineer, who was also responsible for other design activities. He had been given the assignment to perform the design verification without having been given any relief on the due dates for his design assignment. To ensure that those engineers performing design verification have an adequate amount of time to perform this task, the Engineering Procedure for Design Verification was revised. Each discipline was required to assign individuals to a full time assignment as design verifiers. Each individual was required to attend special training sessions covering procedural requirements and emphasized the importance of the design verification task. The primary design verifiers were required to sign a form which attested to his understanding of the design verification task. The revised design verification procedure also states that each design verifier, while being responsible to his individual Discipline Project Engineer administratively and for work assignments, is responsible to the Project Quality Engineer for the quality of his work. This system has been in effect for 3 months. The Project Quality Engineering staff has carefully reviewed the work of the design verifiers under this modified procedure and has determined that this program has been extremely effective.

## IV. SAFETY IMPLICATIONS

Houston Lighting and Power has determined that this deficiency, if left uncorrected, would not have resulted in a significant safety hazard. The loading combinations omitted from these calculations are extreme postulated conditions, and their application to the structures would cause possible deformations in the structural steel, but as designed, would not cause a structural failure. Hence, if left uncorrected, the deficiency could not adversely affect the safety of operations of the plant.

## V. CONCLUSIONS

This deficiency has been thoroughly investigated and corrective measures have been taken to compensate for the errors in design and to preclude recurrence of similar errors in the future. The magnitude of these errors resulted in a minimum impact upon the physical construction of the plant. One of the reasons that the impact was minimal is because a substantial amount of the RCB internal framing design is based upon assumed values and design steps have been taken to allow for additional stiffening should any of the assumed design values later be found not to be conservative. The analysis of the worst case condition has failed to produce a situation where, if left uncorrected, the safety of operations would be adversely affected.