INTERIM REPORT

RCB STRUCTURAL STEEL DESIGN DEFICIENCY

I. 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, Incorporated (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 (STP). The particular beams in question are designed to generally serve as support floor grating but they must have the 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 so notified. Subsequently, in mid-November, an audit of the B&R design verification program and an engineering review of B&R design calculations were conducted simultaneously by HL&P. The audit revealed that the B&R design verification program satisfied regulatory requirements and was 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 notified the NRC on November 27, 1978, that HL&P considered the deficiency to be reportable.

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 are located in grating areas, and through interpretation by the designer, this requirement was not deemed applicable. The design verifier apparently 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.

Corrective measures were taken immediately following discovery of this deficiency. B&R Project Quality Engineering conducted training sessions with all engineers who perform design verification on a discipline-by-discipline basis. Procedural requirements were reviewed with emphasis on the professional aspects of the verification function. An investigation of the entire design verification process is being conducted by B&R Engineering management.

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 STP FSAR Section 3.8.3.4.5. Since these beams only support floor grating, no safety hazard would be produced. These calculations, however, were determined previously 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 at this time. The final-verified loads are expected to be less than those currently used for design, requiring no modification of the beams.

Where misapplied loads on beams were identified by HL&P, only one case requires additional structural members. In this case, the redesign was not done to prevent a structural failure, but rather to ensure that yield allowables are not exceeded, and that any increased forces that may result from revised pipe rupture loading conditions will be witnstood.

The following work remains to close this deficiency. All RCB structural steel calculations must be reverified and corrected, as necessary. If the design proves inadequate as a result of this reverification process, it will also be changed. A number of the calculations for the other structures will be reverified to establish confidence. The design verification processed in the other disciplines will be reviewed to determine if the same causes of this deficiency exists. B&R Engineering will continue to investigate the adequacy of the design verification process and will make changes to it as required. All of this work is to be completed on or before May 1, 1979.

II. DESCRIPTION OF DEFICIENCY

In August 1978, B&R began a set of calculations to verify the adequacy of certain beam connections because of an inconsistency in the specification for Category I structural steel. The specification required that the majority of the connections be selected from standard connections 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 be 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 the 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 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 was begun. 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 show the yield strength of A36 steel to be 36 ksi and the ultimate to be 54 to 80 ksi.

Shortly after the deficiency was reported to HL&P, they conducted a QA audit and engineering design review simultaneously. In general, the audit showed that B&R was following their procedures and that the procedures complied with regulatory requirements. The design review, however, produced some additional anomalies. Upon receipt of the design review report, a second Engineering Design Deficiency report was issued to cover these anomalies. Investigation of this second Engineering Design Deficiency is continuing.

III. CORRECTIVE ACTION

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

A. In the previous section, two separate anomalies were discussed. The first anomaly concerned postulated pipe break loads that were not included in the analysis. The design of these members was classified

in the B&R design control system as "preliminary", i.e., they have not been subjected to final design verification. This practice is used when final design loads have not been received, and the design is based on conservative estimates of loads. Final verification of the calculation remains open so that the final design loads (generally from the NSSS manufacturer) can be compared to the loads used in the calculation. Except in unusual instances, the final loads are less than the design loads and the structure is designe conservatively. Where the loads are higher, beams can be stiffened or their load-carrying capability increased by the addition of steel in local areas. Thus, the beams in question will not be strengthened until all of the final loads have been received and analyzed, and a determination made that strengthening is required. There is a possibility that the 130 kip load may be conservative or the design criteria may be revised. The second anomaly was identified by HL&P during the design review and audit. Although the analysis is not complete, it appears that only one of these findings will require additional structural members to provide more lateral stiffness.

B&R Engineering is establishing a schedule for the reverification of all calculations for RCB structural steel. In addition, a representative sample of all other structural calculations will be reverified to establish confidence in their adequacy.

B. To control recurrence, all B&R personnel performing design verification have received extensive training through a program conducted by Project Quality Engineering. This consisted of a thorough review of the procedural requirements for design verification, and a recapitulation of the obligation of a design verifier to perform this task in a professional and responsible manner. B&R Engineering is also reviewing the effectiveness of the entire design verification program.

Based on the results of this investigation, it has been determined that the causes of this deficiency were limited to the Structural Discipline and occurred over a limited period. If, in the final analysis, this preliminary conclusion proves valid, a formal program for reverifying calculations from other disciplines will not be required.

IV. SAFETY IMPLICATIONS

At the present time, B&R Engineering has been unable to find that this deficiency, if left uncorrected, would become a safety hazard. The loading combinations omitted from these calculations are extreme postulated conditions, and their application to the structures could cause possible deformations in the structural steel but would, as designed, not cause a structural failure. It is not anticipated that a condition will be found where a total structural failure and a resulting safety hazard will occur.

V. CONCLUSIONS

The investigation of this deficiency is continuing. It appears that the breakdown in the design verification program was limited in scope, and that the results will have a minimum impact on STP plant construction.