The Light company Houston Lighting & Power P.O. Box 1700 Houston, Texas 77001 (713) 228-9211

May 22, 1984
ST-HL-AE-1094
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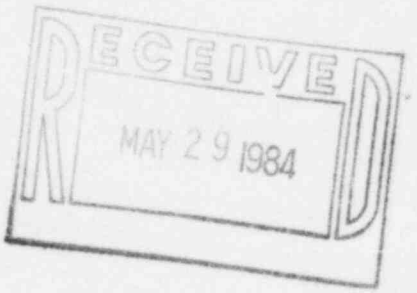

Mr. John T. Collins
Regional Administrator, Region IV
Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76012

Dear Mr. Collins:

South Texas Project
Units 1 & 2
Docket Nos. STN 50-498, STN 50-499
Final Report Concerning
Vendor-Fabricated Structural Steel

On January 8, 1981, pursuant to 10CFR50.55(e), Houston Lighting & Power Company (HL&P) notified your office of an item concerning non-conformances of welds in vendor-fabricated Category I structural steel. These welds were performed at the fabricators facility and were not associated with the on-site welding program. Attached is the final report concerning this item.

If you should have any questions concerning this matter, please contact Mr. Michael E. Powell at (713) 993-1328.

Very truly yours,

D. N. Barker for

G. W. Oprea, Jr.
Executive Vice President

MEP/mg
Attachment: Final Report Concerning Vendor-Fabricated Structural Steel

W2/NRC2/a

IE-27
1/1

cc:

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Final Report Concerning
Vendor-Fabricated Structural Steel

I. SUMMARY

In November 1980 Brown & Root (B&R) identified a concern regarding welding in structural steel fabricated by the vendor (American Bridge) and received at the site for use in the construction of safety-related (Category I) structures at the South Texas Project (STP), Units 1 and 2. The welded connections of concern were performed at the vendor's facility and were not associated with the on-site welding program. The discovery of the problem was documented in an Audit Deficiency Report (ADR). As a result of the ADR, a reinspection program was initiated for the Category I structural steel. This program resulted in the identification of weld conditions which deviate from design drawings, specifications, and/or welding Code (AWS D1.1) requirements.

II. DESCRIPTION OF DEFICIENCY

On November 4, 1980, Brown & Root (B&R) QA was performing a site audit to verify traceability and documentation on American Bridge fabricated steel. While verifying the physical piece-numbers on steel in the laydown yard, an auditor noticed weld irregularities with some of the vendor-fabricated steel. As a result of this observation, ADR No. 49.5 was written on November 13, 1980 identifying a weld problem on two beams and the corresponding Non-Conformance Report (NCR) was issued on December 10, 1980.

On January 8, 1981, pursuant to 10 CFR 50.55(e), Houston Lighting & Power Company notified your office of an item related to non-conformances of welds in vendor-fabricated Category I structural steel.

Subsequently, other American Bridge fabricated Category I structural steel connections in the laydown yard and in the building structures (Unit 1 & 2 RCB, MEAB and FHB) were subjected to a sample inspection by B&R. This reinspection covered approximately 20 percent of the vendor-fabricated structural steel members, and resulted in approximately 1000 NCRs related to weld irregularities in American Bridge fabricated structural steel.

The NCRs typically identified weld irregularities with respect to the AWS Code involving convexity, arc strikes, weld spatter and, more significantly, undersize and undercut welds.

III. CORRECTIVE ACTION

(A) Review of Inspection Findings

The sample inspection was performed by B&R on a random basis, and the results were tabulated in terms of the individual steel members inspected (this sample consists of the reinspection and reexamination programs which B&R performed). Each member inspected was documented by a Non-conformance Report (NCR) when non-conforming conditions with respect to the welding Code were identified. The total number of members subjected to the sample inspection was 1877, out of which 1058 NCRs[1] were issued.

Out of the 1058 NCRs that were issued, 956 NCRs were determined to be pertinent for the shop-welded connections by American Bridge. The NCRs identify specific weld irregularities such as convexity, arc strikes, weld spatter, undersize and undercut. One hundred and two NCRs were determined not to be applicable to the data base because of:

1) duplication of NCRs;

2) some of the NCRs did not pertain to welds made by American Bridge and had been dispositioned in other programs;

3) some of the NCRs did not pertain to welding; and

4) some of the NCRs were related to structural trusses which were determined to be a separate item (see ST-HL-AE-956) not relevant to the generic concern (for additional information, see Section III.C).

B&R concluded and Bechtel, after review and evaluation of the inspection findings, agreed that of these non-conformances, only undersize and undercut have a significant effect on structural integrity. The effects of convexity, arc strikes, and spatter had been found to be minor in other studies conducted by Battelle Columbus Laboratories and McCauley Associates (References 1 and 2). This was discussed in our fifth interim report (ST-HL-AE-893).

The effect of undercut of the order of magnitude reported in the NCRs was studied by Battelle Columbus Laboratories and McCauley Associates. They concluded that ASTM A36 was fracture safe with respect to undercut conditions and temperatures found at the STP. Bechtel has concurred with the conclusions of Battelle Columbus Laboratories and McCauley Associates.

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(1) An earlier report (sixth interim report, ST-HL-AE-956) identified a total number of 1102 NCR's. This has been updated based on the final compilation.

Tables 1 and 2 summarize the structurally significant conditions (undercut and undersize) that were documented in the 956 NCRs.

Table 1 gives the percentages of welded connections found to have various portions of their length affected by structurally significant irregularities. Table 2 gives the total inches of each irregularity found and its percentage with respect to the total inches of inspected weld. The data from Tables 1 and 2 were used to define the most prevalent amount of weld undercut. This amount of undercut was used as the general case in the calculation of derated load capacities for weld connections reported as having excessive undercut. Since the structural capacity of the connections is governed by the amount of weld undersize, the amount undersize used in the calculation of derated load capacity for welded connections reported as having excessive undersize was the extreme case (3/32").

B) EVALUATION OF NCRs

The conditions documented on the NCRs were evaluated by Bechtel to determine the consequences of the non-conforming weld irregularities on the structural integrity and on the required margin of safety for the welded connections. The derated load carrying capacity dictated by the defective welds was calculated and compared to the design load required for the connections. For this calculation of derated load capacity the allowable stresses for fillet welds and for base metal were applied to the undersized and undercut welds, respectively. For the calculation of required design loads the floor loadings as prescribed in the project design criteria were used without resorting to any lower loadings that would be associated with the actual floor occupancies which are lighter than the design criteria loading. The NCRs were dispositioned by either "use-as-is" or "rework".

Bechtel reviewed the 956 relevant NCRs and concurred with the B&R disposition of 725 of the NCRs which documented defects which were either of insignificant length or did not significantly exceed Code allowables. Therefore, the B&R original disposition of "use-as-is" for these NCRs was accepted without analysis, or reliance on B&R calculations, based on an overall comparison to the NCRs for which Bechtel did specific calculations for structural adequacy.

The remaining 231 NCRs which were reanalyzed by Bechtel (approximately 24%), indicated significant undersize and/or undercut over a major portion of the weld length. For these cases, as an expedient but conservative iterative approach, a structural evaluation was performed by considering the general case undercut or the extreme case undersize as existing over the entire weld length. This conservative first iteration resulted in a "use-as-is" disposition for 221 of the 231 NCRs. The remaining 10 NCRs were then reanalyzed on an actual defect and design load basis. Seven were found to be acceptable, and three were found to be stressed in excess of Code allowables. The worst case overstress was 18% in excess of Code allowable. It should be noted, however, that this analysis is conservative since it is based on design loadings as opposed to actual loadings.

(C) ANALYTICAL EVALUATION

The shop-welded connections were categorized into the following broad types.

1. Framed beam and strut connections
2. Bracing and column connections
3. Miscellaneous connections
4. Truss connections

Types (1), (2), and (3) are the only pertinent connections for the generic evaluation of shop-welded connections. Type (4) connections are restricted to the Fuel Handling Building (FHB), and are covered in a separate set of NCRs that have been dispositioned or identified in the sixth interim report (reference ST-HL-AE-956, dated 5/10/83). Those FHB NCRs address weld defects together with weld design deficiencies and cover all of the type (4) connections. Therefore none of the type (4) connections represent inaccessible or uninspected connections and were thus excluded from the evaluation and statistical projection for uninspected connections.

The sample size used for the analytical evaluation and the statistical analysis was conservatively chosen to be the number of non-conforming members out of the original inspection sample. These non-conforming members are those documented on the 956 NCRs, and they represent 11 percent of the total population of 8,650 members. The connections within the sample are representative and have a distribution of connection types that is consistent with the distribution found in the total population.

The NCR findings were compiled to define generalized extreme case defects which were used to evaluate derated weld load capacities. These generalized defects derived from the data of Tables 1 and 2 are as follows:

- Weld undersize = 3/32 in. for all fillet weld sizes
- Base metal undercut = 3/64 in. for all material thicknesses and weld sizes

The analytical evaluation based on extreme case defects was performed on the connections documented on the 231 NCRs where severe undersize and/or undercut over a major portion of the weld length were reported. As a first iteration, the calculated derated-weld load capacity of each connection, designated herein as P', was checked to establish the acceptability of the connections by the following steps:

(1) P' is compared to the maximum reaction, R_1, dictated by the member's maximum load capacity which is determined from the member size and span based on load tables from the AISC Manual:

if: $P' \geq R_1$ The derated connection is adequate, and it is dispositioned "use-as-is".

$P' < R_1$ Further check by step (2) is necessary.

(2) P' is compared to the maximum design reaction, R_2, determined from the project design criteria load combination that governs the design of the member:

if: $P' \geq R_2$ The derated connection is adequate, and it is dispositioned "use-as-is".

$P' < R_2$ Further check by step (3) is necessary. (It is noted that the equivalent reaction based on a member's load capacity, R_1, is always higher than the maximum design reaction, R_2.)

As a second iteration, the calculated derated weld load capacity (designated as P") of the remaining connections using actual, rather than extreme case weld undersize and undercut, was evaluated to establish the final acceptability of the connections as follows:

(3) P" is compared to the maximum design reaction, R_2, determined from the project design criteria load combination that governs the design of the member:

if: $P'' \geq R_2$ The derated connection is adequate, and it is dispositioned "use-as-is".

if: $P'' < R_2$ The connection is not acceptable, and it is dispositioned "rework".

(D) STATISTICAL ANALYSIS

A statistical analysis was performed to project at a specific confidence level the rate of occurrence of rejections in the uninspected population based on the findings obtained from the inspection of a random sample representing a specific fraction of the total population. The analysis is based on a hyperbinomial distribution to project occurrence rates at specific confidence levels based on observed rates in small to moderate samples ranging from 5 to 15 percent of the population. This approach is more conservative than a simpler approach where the observed rate is used as a point estimate for the projected rate in a binomial distribution. For larger samples, the hyperbinomial distribution projections converge to the binomial distribution projections as a special case, but the hyperbinomial distribution remains a more conservative determination of the confidence level for the case of smaller samples.

The corresponding projections as a function of observed findings, for various sample sizes, at a 95% confidence level, are presented in Figure 1.

(E) RESULTS

The structural review of 956 non-conforming members resulted in the rejection of weld connections of three members on the basis of the derated load being less than the required design load ("F" on Figure 1 = 3/956 = .03%). The sample used for the design review, i.e., the non-conformances out of the inspection sample, represented approximately 11% of the population (S on Figure 1). As illustrated on Figure 1, based on a 95% confidence level statistical projection in accordance with the hyperbinomial distribution, the potential rate of occurrence of rejected members in the balance of the population was 3.4%. The projected occurrence rate of 3.4% is conservatively based on design load, whereas actual loads are typically significantly lower. Further, the worst case overstress in the sample was 18% over the AISC Code. To put this overstress in perspective, the AISC Code values have a 1.6 factor of safety to yield strength load capacity. Based on this analysis, Bechtel concluded and HL&P concurs that inspection of the balance of the population is not warranted. While not essential to ensure plant safety, the welded connections of the three members that were determined to exceed allowables will be reworked since they are accessible and the defects can be easily corrected.

IV. RECURRENCE CONTROL

As part of its actions in response to the identification of welding deficiencies at the American Bridge (AB) fabrication facility, B&R required 100% inspection of shop-welded connections at the AB shop prior to release of further shipments. In January 1981, B&R assigned to AB an individual qualified as a welding inspector for AWS weld criteria. Further, B&R revised the Surveillance/Inspection Plan for this facility to explicitly require a 100% weld inspection prior to release for shipment. Surveillance/Inspection Reports by B&R Shop Inspectors indicate the performance of these inspections by noting specific piece marks which were rejected because of AWS weld deficiencies.

The revised B&R Surveillance/Inspection Plan did not require documentation of piece marks for those members passing all AWS visual inspection criteria; therefore, HL&P directed Bechtel to further verify that these inspections were performed. Included in this verification was the development of a detailed list of members shipped to the STP jobsite after the imposition of the 100% inspection requirement; a review of existing inspection, material receiving and non-conformance records relating to this material; and a sample reinspection program. The purpose of the verification effort was to provide added assurance that actions taken by AB and B&R were sufficient to prevent recurrence of the conditions evaluated under the field reinspection program described in the summary above.

Bechtel has completed these verification efforts and concluded, by virtue of the results of the sample reinspection, that the quality of welded materials supplied from the AB shop subsequent to the imposition of corrective actions by both AB and by B&R shop inspection

personnel was sufficient to preclude recurrence of the non-conformances previously noted. Of 79 members reinspected (representing approximately 5% of the total population of welded members shipped after the requirement for 100% shop inspection was instituted), one connection was found with a defect in excess of 1975 Code allowables. This member was dispositioned "use-as-is" since this defect was within 1981 Code acceptance criteria. HL&P concludes, therefore, that the recurrence control actions taken met the desired objective of improved weld quality.

V. SAFETY ANALYSIS

No safety hazard has been identified relative to these non-conforming weld conditions. Since these non-conforming weld conditions were evaluated and did not constitute a substantial safety hazard, the deficiencies do not meet the criteria for reportability; however, because of the extensive evaluation that was performed, this item is reportable under 10CFR50.55(e).

V. ATTACHMENTS

Table 1 - Percentage of connections found to have structurally significant weld irregularities.

Table 2 - Total inches of each structurally significant weld irregularity found in the connections.

Figure 1 - Hyperbinomial distribution projections

VI. REFERENCES

Reference 1: [illegible]e Columbus Laboratories, "Final Report on AWS Inacce[illegible]uctural Weld Investigation". July 2, 1982

Refer[illegible] R. B. McCauley Associates, "Conclusions and Recomm[illegible]cions on the Structural Evaluation of Inaccessible Welds"

TABLE -1 PERCENTAGE OF CONNECTIONS FOUND TO HAVE
STRUCTURALLY-SIGNIFICANT WELD IRREGULARITIES (ALL TYPE CONNECTIONS)

Reported Condition	Percentage of Connections which exhibited irregularity for: 100 Percent of Length	Greater than 50 Percent of Length	Greater than 10 Percent of Length	Any Percent Length	Average Percent Length
Undersize Amount > 1/16"(1) (3/32" max)	4.7	14.9	38.4	51.6	32.0
Undersize Amount ≤ 1/16"	0.2	1.4	11.5	14.6	24.5
Undercut Amount > 1/16"	0.0	0.06	1.3	4.6	7.6
Undercut Amount = 1/16"	0.0	0.0	0.6	4.7	3.5
Undercut Amount > 1/32" < 1/16"	0.5	3.7	19.4	52.4	10.9
Undercut Amount = 1/32"	0.0	0.0	0.3	8.0	2.0

(1) The 956 members addressed in the non-conformance reports of the inspected sample contain a total of 1642 connections.

TABLE - 2 TOTAL INCHES OF EACH STRUCTURALLY-SIGNIFICANT WELD IRREGULARITY FOUND IN THE CONNECTIONS

Reported Condition	Number of Inches Found	Percent of Total Inches of Weld
Undersize Amount > 1/16" (3/32" max)	12,642	16.7
Undersize Amount ≤ 1/16"	3,092	4.1
Undercut Amount > 1/16"	314	0.4
Undercut Amount = 1/16"	134	0.2
Undercut Amount > 1/32" < 1/16"	4398	5.8
Undercut Amount = 1/32"	152	0.2

75,823 total inches of weld were inspected within the 956 members addressed in the non-conformance reports of the inspected sample.

RATES OF OCCURRENCE IN UNINSPECTED POPULATION, PROJECTED AT A 95% CONFIDENCE LEVEL, BASED ON THE FINDINGS OBTAINED FROM THE INSPECTION OF A RANDOM SAMPLE REPRESENTING A SPECIFIC FRACTION OF THE TOTAL POPULATION.

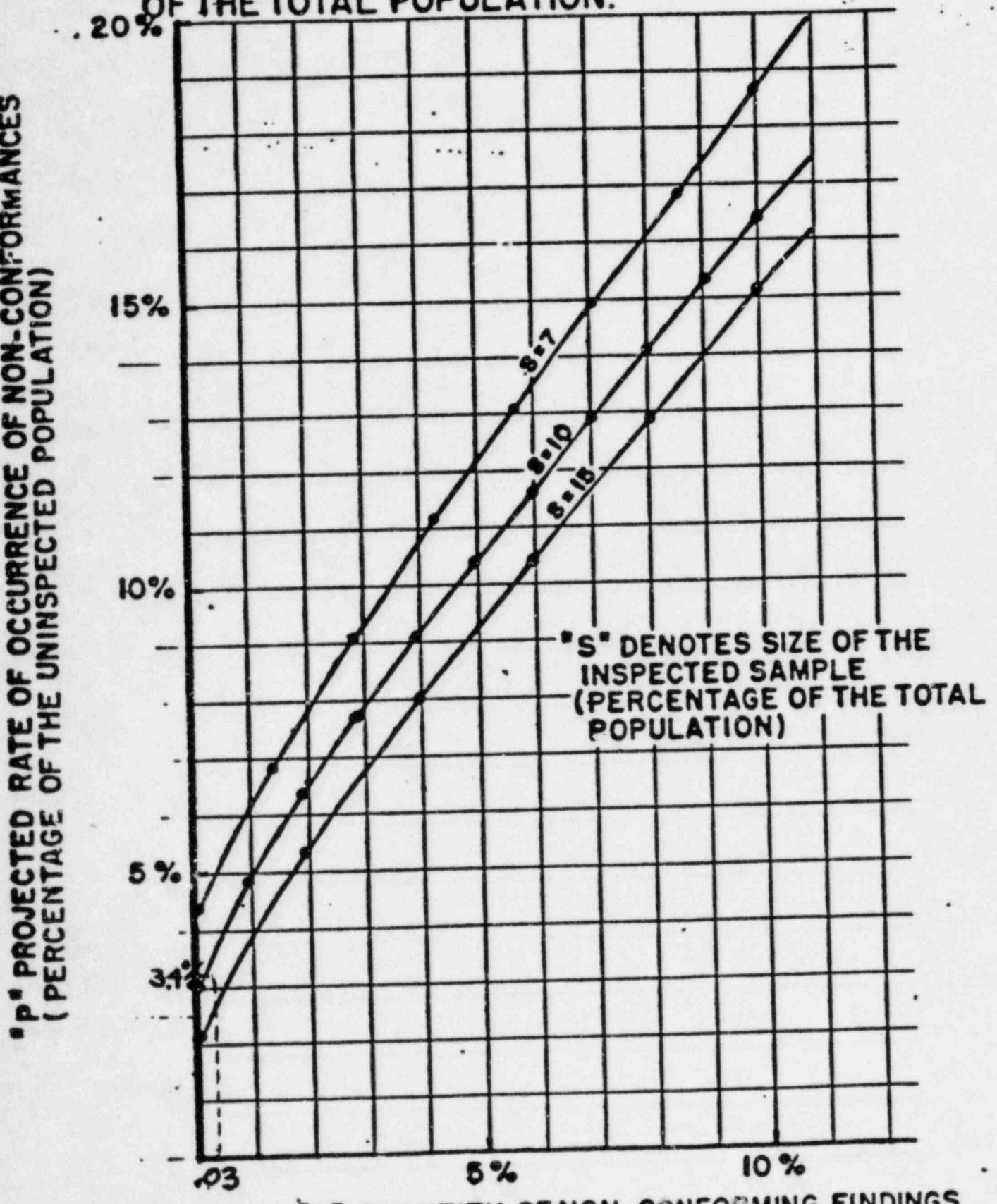

Figure 1