NON-PROPRIETARY

CEN-629-NP
Addendum 1

COMBUSTION ENGINEERING, INC.

January, 1997

Repair of

Westinghouse Series 44 and 51

Steam Generator Tubes

Using Leak Tight Sleeves

FINAL REPORT

Combustion Engineering, Inc.
Nuclear Operations
Windsor, Connecticut

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ABSTRACT

This addendum details the assessment of steam generator tube sleeves operating under conditions outside of the bounding values originally used to assess the adequacy of this repair for installation in Westinghouse designed Series 44 and 55 steam generators.

The assessment contained herein verifies that the sleeves described in the original report remains an acceptable repair technique for these steam generator tubes.

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this addendum is to provide additional information to support a technical specification change allowing installation of repair sleeves in Westinghouse designed Series 44 and 51 steam generators that have made changes in their operating parameters beyond those specified in Reference 1.3.1.

1.2 BACKGROUND

As steam generators age, increased plugging limits result in operating parameters outside the bounds of the input parameters utilized in Reference 1.3.1. Additionally, changes in industry requirements that alter input parameters, specifically MSLB conditions, have been incorporated. This addendum addresses these changes and the resulting differences in sleeve loadings and stress levels associated with the sleeve/tube assembly.

1.3 REFERENCES

1.3.1 CEN-629-P, Revision 01, Repair of Westinghouse Series 44 and 51 Steam Generator Tubes Using Leak Tight Sleeves, Combustion Engineering Inc., November 1996.

1.3.2 WCAP-14790, Zion Increased Steam Generator Tube Plugging and Thermal Design Reduction Analysis Program

2. SUMMARY AND CONCLUSIONS

The changes in operating parameters described in this addendum have only a minimal effect on the loads and stresses experienced by any of the sleeve or sleeve plug designs described in Reference 1.3.1. As such the safety factors described therein as described in the analysis and verified by the testing performed, still provide more than adequate margin against operating and faulted conditions.

3. ACCEPTANCE CRITERIA

The conditions evaluated in conjunction with the design criteria contained in Reference 1.3.1 are as follows:

Primary Side:	596° F (operating) 650° F (design)	2235 psig (operating) 2500 psig (design)
Secondary Side	495° F (operating) 550° F (design)	653 psig (operating) 1085 psig (design)

Of the parameters described in Section 3.0 of Reference 1.3.1, only the operating conditions have been modified. Although included here for completeness, design parameters remain as described in the referenced report.

4. DESIGN DESCRIPTION OF SLEEVES AND INSTALLATION EQUIPMENT

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

5. SLEEVE EXAMINATION PROGRAM

5.1 ULTRASONIC INSPECTION

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

5.2 EDDY CURRENT EXAMINATION

Based on the revised calculations performed in Section 8 for R.G. 1.121 analysis, the eddy current testing acceptance criteria given in Section 5.2 of Reference 1.3.1 provides an adequate margin of 11.5% (vs 12%) with respect to growth and ECT uncertainty.

6. SLEEVE TUBE CORROSION TEST PROGRAM

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

7. MECHANICAL TESTS OF SLEEVED STEAM GENERATOR TUBES

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

8. STRUCTURAL ANALYSIS OF SLEEVE-TUBE ASSEMBLY

8.1 SUMMARY AND CONCLUSIONS

Based on the analytical evaluation contained in this section and the mechanical test data contained in Reference 1.3.1, Section 7.0, it is concluded that the Full Depth Tubesheet (FDTS) and the Tube Support (TS) sleeves described meet all the requirements stipulated in Section 3.0 and 8.0 with substantial margins. This addendum highlights the calculations affected by the operating and faulted condition parameter changes found in Section 3. of this Addendum. Calculations involving design conditions remain as described in Reference 1.3.1 Section 8.0.

Only the [ ] inch sleeve in the "worst" case envelopment which is not locked in the tube support will be discussed since it provided the most conservative results in Reference 1.3.1. As such the calculations in this addendum are more conservative or the same as those which would results from a complete analysis as presented in Reference 1.3.1 Section 8.0.

8.1.1 Design Sizing

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

8.1.2 Detailed Analysis Summary

A summary of the detail analysis changes brought about by the changes in operating parameters and MSLB conditions is as described below and in Tables 8-1 and 8-2.

FORMULAS FOR GENERAL MEMBRANE STRESSES SUMMARIZED IN TABLE 8-1

(Note: All SI equations below are a derivation of the formula in Par. NB-3324.1.)

1. GENERAL PRIMARY MEMBRANE STRESS (DESIGN TUBESHEET DELTA PRESSURE)

   The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

2. MAIN STEAM LINE BREAK

3. PRIMARY PIPE BREAK (LOCA)

   The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1.

TABLE 8-1
SUMMARY OF SLEEVE AND WELD ANALYSIS RESULTS

TABLE 8-2

SUMMARY OF LOWER JOINT (WELDED AND ROLLED) DESIGN, ANALYSIS AND TEST RESULTS

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8.2 LOADINGS CONSIDERED

8.2.1 Upper Sleeve Weld Pullout Load

In the event of a main steam line break (MSLB), the pressure differential would be 2560 psi per NRC Generic Letter 95-05: "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking", Page 3 of Attachment 1 as applied to the Westinghouse Plants. Postulating a main steam line break (MSLB) accident, the maximum pullout load would be:

[

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8.2.2 Lower Sleeve Rolled or Weld Section Pushout Load

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1

8.2.3 Weld Fatigue

The contents of this paragraph in Reference 1.3.1 do not change.

8.3 EVALUATION FOR ALLOWABLE SLEEVE WALL DEGRADATION USING REGULATORY GUIDE 1.121

8.3.1 Normal Operation Safety Margin

[

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8.3.2 Postulated Pipe Rupture Accidents

[

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8.3.3 Average Minimum Weld Height Requirements

A change in the MSLB ΔP described in Section 8.2.1 affects the following calculation for minimum weld height

[

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8.4 EFFECT OF TUBE LOCK-UP ON SLEEVE LOADING

[

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8.4.1 Sleeved Tube in Operating Steam Generator , Free at Tube Support

This condition was not reanalyzed.

8.4.2 Sleeved Tube in "Worst" Case Envelopment, Free at Tube Support

Axial Loads at the Tube Bundle Periphery

[

]

[ ]

8.4.3 Sleeved Tube in Operating Steam Generator, Lock-up at First Tube Support

This condition was not reanalyzed.

8.4.4 Sleeved Tube in "Worst" Case Envelopment, Lock-up at First Tube Support

This condition was not reanalyzed.

8.4.5 Effect of Tube Prestress Prior to Sleeving

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1

8.4.6 Lower Sleeve Rolled or Weld Section Pushout Due to Restrained Thermal Expansion

[ ]

8.5 SLEEVED TUBE VIBRATION CONSIDERATIONS

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1

8.6 STRUCTURAL ANALYSIS FOR NORMAL OPERATION

The changes in operating parameters result in increases in the cumulative usage factor for three of the four cases analyzed, however, none of these increases results in a usage factor greater than the allowed value of 1.0.

8.6.1 Fatigue Evaluation of Upper Sleeve / Tube Weld

[

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8.6.2 Evaluation of Lower Sleeve Rolled Section

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1

8.6.3 Fatigue Evaluation of Lower Stub Weld

For the Lower Sleeve Weld (FDTS) summarized in Table 8-1, page 8-4, of Reference 1.3.1

Primary Local Stress:

[

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[

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8.6.4 Fatigue Evaluation of Sleeved Tube Plug Weld

[

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9. SLEEVE INSTALLATION VERIFICATION

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1

10. EFFECT OF SLEEVING ON OPERATION

The changes in operating parameters described in Section 3 have no affect on the contents of this section of Reference 1.3.1

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