

WESTINGHOUSE

WESTINGHOUSE CLASS 3 (Non-Proprietary)

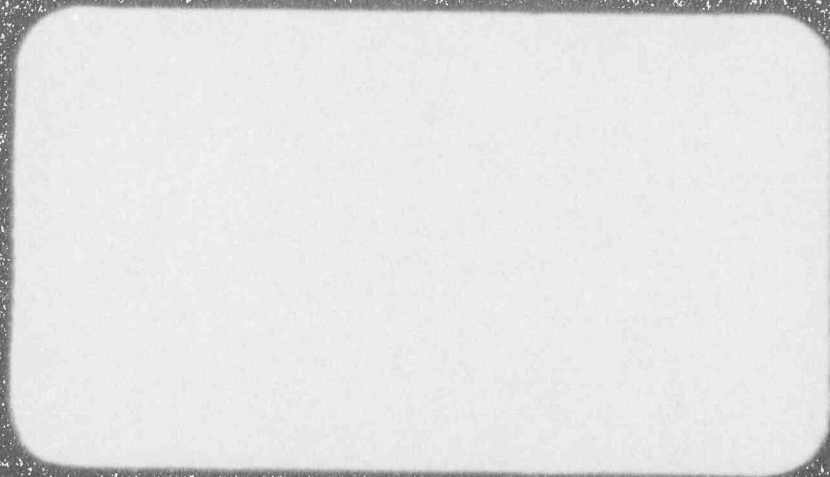


Westinghouse Energy Systems



9308040222 930728  
PDR ADDCK 05000339  
P PDR

WESTINGHOUSE CLASS 3 (Non-Proprietary)



Westinghouse Energy Systems



9308040222 930728  
PDR ADOCK 05000339  
P PDR

WCAP-13620  
Revision 1

SPECIFIC APPLICATION OF LASER WELDED  
SLEEVES FOR NORTH ANNA UNIT 2  
STEAM GENERATORS

July 1993

WESTINGHOUSE ELECTRIC CORPORATION  
NUCLEAR SERVICES DIVISION  
P.O. BOX 355  
PITTSBURGH, PENNSYLVANIA 15230

©1993 WESTINGHOUSE ELECTRIC CORPORATION  
ALL RIGHTS RESERVED

## ABSTRACT

Under Plant Technical Specification requirements, steam generator tubes are periodically inspected for degradation using non-destructive examination techniques. If established inspection criteria are exceeded, the tube must be removed from service by plugging, or the tube must be brought back into compliance with the Technical Specification criteria. Tube sleeving is one technique used to return the tube to an operable condition. The purpose of this evaluation is to establish the applicability of a generic laser welding sleeving analysis for Series 44 and 51 steam generators (WCAP-13088, Rev. 2) to the North Anna Unit 2 steam generators.

All of the sleeve design, mechanical testing, stress corrosion resistance testing, installation processes and nondestructive examination discussed in the generic report apply directly to North Anna Unit 2.

Based on the combined results of this evaluation and the generic evaluation (WCAP-13088, Rev. 2), the laser welded sleeves are concluded to meet applicable ASME Boiler and Pressure Vessel Code requirements for North Anna Unit 2. The allowable plugging limit for sleeve degradation is 27%.

## TABLE OF CONTENTS

| Section | Title  | Page |
|---------|--|------|
| 1.0     | Introduction   | 1    |
| 2.0     | Sleeve Design and Description                          | 1    |
| 3.0     | Analytical Verification                                | 1    |
| 3.1     | Applicable Loading Conditions                          | 1    |
| 3.2     | Primary Stress Limits                                  | 2    |
| 3.3     | Maximum Range of Stress and Fatigue                    | 3    |
| 3.4     | Minimum Wall Thickness Requirements                    | 3    |
| 3.5     | Conclusions  | 4    |
| 4.0     | Mechanical Tests                                       | 4    |
| 5.0     | Stress Corrosion Testing of Laser Welded Sleeve Joints | 4    |
| 6.0     | Installation Process Description                       | 5    |
| 7.0     | Nondestructive Examination (NDE) Inspectability        | 5    |
| 8.0     | References   | 5    |

## LIST OF TABLES

| Table | Title  | Page |
|-------|--|------|
| 1     | Umbrella Pressure Loads for Design, Faulted, and Test Conditions   | 6    |
| 2     | Summary of Maximum Primary Stress Intensity Full Length Tubesheet Laser Welded Sleeve [ ] <sup>a,c</sup>                         | 7    |
| 3     | Summary of Maximum Primary Stress Intensity Full Length Tubesheet Laser Welded Sleeve [ ] <sup>a,c</sup>                         | 8    |
| 4     | Comparison of Transient Cycles Generic Series 44 and 51 Steam Generators versus North Anna Unit 2                                | 9    |
| 5     | Maximum Range of Stress Intensity and Fatigue  | 10   |
| 6     | Comparison of Minimum Wall Thickness Calculations for Sleeves Generic Series 44 and 51 Steam Generators versus North Anna Unit 2 | 11   |

## 1.0 INTRODUCTION

The purpose of this analysis is to evaluate the applicability of the generic laser welded sleeving analysis for Series 44 and 51 steam generators, documented in Reference (1), to the North Anna Unit 2 steam generators. In performing the generic analysis, transient loads are used that umbrella Series 44 and 51 steam generators. Included in the generic analysis are calculations to determine minimum wall thickness requirements for the sleeves. These calculations are a function of plant operating parameters, which vary from plant to plant, and which can change with the implementation of operating or system modifications. The purpose of this evaluation then, is to compare the current set of transient and operating parameters for North Anna Unit 2 to those used in the umbrella analysis, with the intent of confirming that the generic analysis provides a bounding analysis for North Anna Unit 2, and also to remove any conservatism in the generic analysis for minimum wall thickness, if possible.

In establishing the structural adequacy of the laser welded sleeves in the generic analysis, criteria were evaluated for primary stress limits, maximum range of stress intensity and fatigue, and minimum wall thickness requirements. The load conditions applicable to each of these areas are reviewed in this analysis to establish the applicability of the generic analysis. In general, the discussions to follow provide only a brief overview of each area. More in-depth discussions are contained in Reference (1) for the generic analysis.

## 2.0 SLEEVE DESIGN AND DESCRIPTION

The [

]'.c.

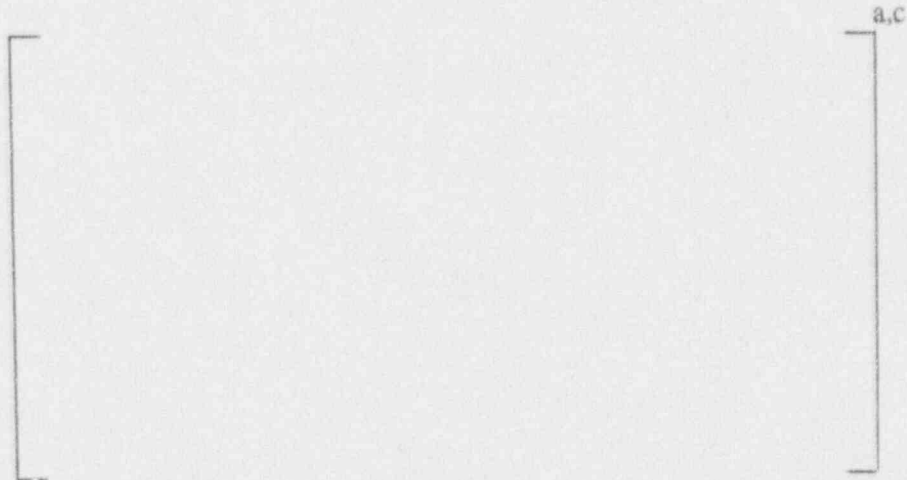
## 3.0 ANALYTICAL VERIFICATION

### 3.1 Applicable Loading Conditions

The umbrella loading conditions for the generic analysis are defined in Reference (2), and are based on a review of the applicable design specifications for Series 44 and 51 steam generators. The applicable loading conditions for North Anna Unit 2 steam generators are taken from the plant specific

design specification, Reference (3). The following set of parameters corresponding to full power operation have been provided by the customer in Reference (4).

Normal Operation Parameter Ranges



In addition, the following conditions have been defined in Reference (4) for the Loss of Load Upset transient.

Primary Pressure = 2676 psia

Secondary Pressure = 1166 psia

**3.2 Primary Stress Limits**

A summary of the limiting pressure loads used in the generic analysis for evaluating the sleeve primary stresses are provided in Table 1. In comparing the plant specific loads to the generic loads, the generic loads are found to umbrella the plant specific values.

A summary of the limiting stresses for primary stress limits are summarized in Tables 2 and 3. In performing the generic analysis, two conditions are evaluated relative to the tube integrity between the upper and lower welds for the tubesheet sleeve. [

]a,c



Note that for primary stress, the limiting condition for the sleeve is with the [

] <sup>acc</sup>

### 3.3 Maximum Range of Stress and Fatigue

In evaluating the maximum range of stress and fatigue, the number of transients, as well as the temperature and pressure fluctuations are significant. A comparison of the transient cycles considered in the generic analysis to the applicable transients for North Anna Unit 2 is provided in Table 4. This comparison shows that the generic analysis considers a larger number of transients, and in general, more transient cycles, than are applicable to North Anna Unit 2.

Relative to the temperature and pressure fluctuations, the transient definitions for both the generic and North Anna Unit 2 design specifications are defined in terms of changes in applicable parameters from an initial starting point, typically normal operation. Comparison of the pressure fluctuations shows the generic analysis and North Anna Unit 2 values to be comparable. Because the generic analysis considers more transients and generally more transient cycles than North Anna Unit 2, the generic analysis is concluded to be applicable to North Anna Unit 2. (Note also that the fatigue usage for the generic analysis is quite low (<0.10)).

A summary of the limiting stress ranges is shown in Table 5, along with the accumulated fatigue usage for the limiting cross section.

### 3.4 Minimum Wall Thickness Requirements

For computing  $t_{min}$ , the pressure stress equation NB-3324.1 of the ASME Code is used. That is,

$$t_{min} = \frac{\Delta P_1 \times R_1}{P_m - 0.5(P_1 + P_0)}$$

Where:

- $P_1$  = Primary side pressure
- $P_0$  = Secondary side pressure
- $\Delta P_1$  = Primary-to-secondary pressure differential
- $R_1$  = Sleeve inside radius
- $P_m$  = Allowable stress

A comparison of the calculations to determine the minimum required thickness for the generic effort and for North Anna Unit 2 is provided in Table 6. These results show the plugging limit for North Anna Unit 2 to be slightly higher than the generic value, 27% of the nominal sleeve thickness for North Anna Unit 2 versus 25% for the generic analysis.

### 3.5 Conclusions

Based on the results of the above evaluation, the generic analysis is concluded to form a bounding analysis for the North Anna Unit 2 steam generators for all conditions. Based on the combined results of this analysis and the generic evaluation, the following conclusions are made regarding the structural requirements for laser welded sleeves for the North Anna Unit 2 steam generators.

1. The laser welded sleeves are concluded to meet applicable ASME Code requirements.
2. The allowable plugging limit for sleeve degradation is 27%.

### 4.0 MECHANICAL TESTS

The mechanical tests [

] are. A portion of the mechanical tests in Section 4.0 of Reference (1) determined the resistance to primary-to-secondary leakage for tubesheet sleeve non-welded lower joints and the applicable leakage criteria.

### 5.0 STRESS CORROSION TESTING OF LASER WELDED SLEEVE JOINTS

The conclusions reached in Reference (1) for performance of laser welded joints, i.e., tubesheet sleeve lower joint, as well as free-span, apply directly to North Anna Unit 2.

## 6.0 INSTALLATION PROCESS DESCRIPTION

The outline of the installation processes in Reference (1) apply directly to North Anna Unit 2. The discussion in Reference (1) was intended to provide an overview; the detailed installation process verification steps are all specified in the individual applicable field service procedures that will be provided by Westinghouse as part of the job.

## 7.0 NONDESTRUCTIVE EXAMINATION (NDE) INSPECTABILITY

The NDE Section of Reference (1) was intended to specify the installation NDE plan logic and to define the principles of the NDE processes to be used. It applies directly to North Anna Unit 2.

## 8.0 REFERENCES

1. WCAP-13088, Rev. 2, "Westinghouse Series 44 and 51 Steam Generator Generic Sleeving Report - Laser Welded Sleeves," 6/93.
2. Design Specification 412A19, "Plants with Series 44 and 51 Steam Generators, Steam Generator Heat Transfer Tube Sleeving," ASME Boiler and Pressure Vessel Code, Section III, Code Case 1 Safety Class 1," 12/17/92.
3. Design Specification 677307, Revision 4, "Virginia Electric and Power Company North Anna Power Station Unit Numbers 1 and 2, 51 Series Steam Generator," R. L. Sylvester, 10/15/84.
4. Letter, E. W. Throckmorton, Virginia Power, to J. L. Houtman, Westinghouse, 2/15/93, Transmittal of North Anna Internal Letter NSA-93030, "Key Parameter Values for Use in Westinghouse Report of SG Sleeving Application to North Anna Unit 2," K. L. Basehore to E. W. Throckmorton, 2/4/93 and results of North Anna Units 1 and 2 Standing Order No. 179.

**Table 1**  
**Umbrella Pressure Loads for**  
**Design, Faulted, and Test Conditions**

a.c

Table 2  
Summary of Maximum Primary Stress Intensity  
Full Length Tubesheet Laser Welded Sleeve  
[ ]<sup>a,c</sup>

a,c

Table 3  
Summary of Maximum Primary Stress Intensity  
Full Length Tubesheet Laser Welded Sleeve  
[ ]<sup>a,c</sup>

a,c

**Table 4**  
**Comparison of Transient Cycles**  
**Generic Series 44 and 51 Steam Generators**  
**versus North Anna Unit 2**

a,c

**Table 5**  
**Maximum Range of Stress Intensity and Fatigue**

a,c



**Table 6**  
**Comparison of Minimum Wall Thickness Calculations for Sleeves**  
**Generic Series 44 and 51 Steam Generators**  
**versus North Anna Unit 2**

a,c

