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AUTH.NAME AUTHOR AFFILIATION
MAIER,J.E. Rochester Gas & Electric Corp.

RECIP.NAME RECIPIENT AFFILIATION
CRUTCHFIELD,D. Operating Reactors Branch 5

SUBJECT: Forwards proprietary version of "Steam Generator Sleeve Development Program." Addl revision to inservice insp program to permit sleeving for defective tubes will be submitted.Rept withheld (ref 10CFR2.790).
SEE Proprietary Rept. # 8104280470

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ROCHESTER GAS AND ELECTRIC CORPORATION • 89 EAST AVENUE, ROCHESTER, N.Y. 14649

JOHN E. MAIER
VICE PRESIDENT

TELEPHONE
AREA CODE 716 546-2700

April 23, 1981

Mr. Dennis M. Crutchfield, Chief
Operating Reactors Branch No. 5
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Steam Generator Sleeve Test Program
R. E. Ginna Nuclear Power Plant, Unit No. 1
Docket No. 50-244

Dear Mr. Crutchfield:

By letter dated November 6, 1980 we submitted a report describing our steam generator sleeve test program. As indicated in that letter, test sleeves were installed in several steam generator tubes during the November, 1980 outage at Ginna. Since that time, additional work has been accomplished on the sleeve development program.

We are now planning to install additional sleeves in steam generator tubes at Ginna. The attached report provides updated information on our sleeve development program. The report is deemed to be proprietary by its owner, Babcock and Wilcox. Consequently, it is supported by an affidavit signed by Babcock and Wilcox, the owner of the information. The affidavits set forth the basis on which the information may be withheld from public disclosure by the Commission and address with specificity the considerations listed in paragraph (b)(4) of Section 2.790 of the Commission's regulations.

Accordingly, it is respectfully requested that the information which is proprietary to Babcock and Wilcox be withheld from public disclosure in accordance with 10 CFR Section 2.790 of the Commission's regulations.

The limited installation of sleeves has been reviewed by the Plant Operations Review Committee and Nuclear Safety Audit and Review Board; and it has been determined that no changes in Technical Specifications are required and no unreviewed safety questions are presented.

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ADD: LE 1 1
MATL ENG BR 1 1
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E MURPHY 1 1
D HUANG 1 1
W COLLINS (IE) 1 1

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It has been determined that an additional change is required to the Ginna Inservice Inspection Program to permit sleeving instead of plugging for tubes which have defects exceeding the allowable. The required revision is being submitted by separate letter.

Very truly yours,

John E. Maier

J. E. Maier

DOCKET NO. 50-244

DATE: 4·29·81

NOTE TO NRC AND/OR LOCAL PUBLIC DOCUMENT ROOMS

The following item submitted with letter dated 4·23·81

from Rochester Gas & Elec. Corp. is being withheld from public disclosure in accordance with Section 2.790.

PROPRIETARY INFORMATION

Prop. version of "Steam Generator Sleeve Development Program"

Sharon Hunt
M/S-016

Distribution Services Branch

STEAM GENERATOR

SLEEVE DEVELOPMENT PROGRAM

R. E. GINNA NUCLEAR POWER PLANT

(B&W PROPRIETARY)

Babcock & Wilcox

AFFIDAVIT OF JAMES H. TAYLOR

A. My name is James H. Taylor. I am Manager of Licensing in the Nuclear Power Generation Division of Babcock & Wilcox, and as such I am authorized to execute this Affidavit.

B. I am familiar with the criteria applied by Babcock & Wilcox to determine whether certain information of Babcock & Wilcox is proprietary and I am familiar with the procedures established within Babcock & Wilcox, particularly the Nuclear Power Generation Division (NPGD), to ensure the proper application of these criteria.

C. In determining whether a Babcock & Wilcox document is to be classified as proprietary information, an initial determination is made by the unit manager who is responsible for originating the document as to whether it falls within the criteria set forth in Paragraph D hereof. If the information falls within any one of these criteria, it is classified as proprietary by the originating unit manager. This initial determination is reviewed by the cognizant section manager. If the document is designated as proprietary, it is reviewed again by Licensing personnel and other management within NPGD as designated by the Manager of Licensing to assure that the regulatory requirements of 10 CFR Section 2.790 are met.

D. The following information is provided to demonstrate that the provisions of 10 CFR Section 2.790 of the Commission's regulations have been considered:

(i) The information has been held in confidence by the Babcock & Wilcox Company. Copies of the document are clearly identified as proprietary. In addition, whenever Babcock & Wilcox transmits the information to a customer, customer's agent, potential customer or regulatory agency, the transmittal requests the recipient to hold the information as proprietary. Also, in order to strictly limit any potential or actual customer's use of proprietary information, the following

provision is included in all proposals submitted by Babcock & Wilcox, and an applicable version of the proprietary provision is included in all of Babcock & Wilcox's contracts:

"Purchaser may retain Company's Proposal for use in connection with any contract resulting therefrom, and, for that purpose, make such copies thereof as may be necessary. Any proprietary information concerning Company's or its Suppliers' products or manufacturing processes which is so designated by Company or its Suppliers and disclosed to Purchaser incident to the performance of such contract shall remain the property of Company or its Suppliers and is disclosed in confidence, and Purchaser shall not publish or otherwise disclose it to others without the written approval of Company, and no rights, implied or otherwise, are granted to produce or have produced any products or to practice or cause to be practiced any manufacturing processes covered thereby.

Notwithstanding the above, Purchaser may provide the NRC or any other regulatory agency with any such proprietary information as the NRC or such other agency may require; provided, however, that Purchaser shall first give Company written notice of such proposed disclosure and Company shall have the right to amend such proprietary information so as to make it non-proprietary. In the event that Company cannot amend such proprietary information, Purchaser shall, prior to disclosing such information, use its best efforts to obtain a commitment from NRC or such other agency to have such information withheld from public inspection.

Company shall be given the right to participate in pursuit of such confidential treatment."

(ii) The following criteria are customarily applied by Babcock & Wilcox in a rational decision process to determine whether the information should be classified as proprietary. Information may be classified as proprietary if one or more of the following criteria are met.

a. Information reveals cost or price information, commercial strategies, production capabilities, or budget levels of Babcock & Wilcox, its customers or suppliers.

b. The information reveals data or material concerning Babcock & Wilcox research or development plans or programs of present or potential competitive advantage to Babcock & Wilcox.

c. The use of the information by a competitor would decrease his expenditures, in time or resources, in designing, producing or marketing a similar product.

d. The information consists of test data or other similar data concerning a process, method or component, the application or which results in a competitive advantage to Babcock & Wilcox.

e. The information reveals special aspects of a process, method, component or the like, the exclusive use of which results in a competitive advantage to Babcock & Wilcox.

f. The information contains ideas for which patent protection may be sought.

AFFIDAVIT OF JAMES H. TAYLOR (Cont'd)

The document(s) listed on Exhibit "A", which is attached hereto and made a part hereof, has been evaluated in accordance with normal Babcock & Wilcox procedures with respect to classification and has been found to contain information which falls within one or more of the criteria enumerated above. Exhibit "B", which is attached hereto and made a part hereof, specifically identifies the criteria applicable to the document(s) listed in Exhibit "A".

(iii) The document(s) listed in Exhibit "A", which has been made available to the United States Nuclear Regulatory Commission was made available in confidence with a request that the document(s) and the information contained therein be withheld from public disclosure.

(iv) The information is not available in the open literature and to the best of our knowledge is not known by Combustion Engineering, EXXON, General Electric, Westinghouse or other current or potential domestic or foreign competitors of B&W.

(v) Specific information with regard to whether public disclosure of the information is likely to cause harm to the competitive position of Babcock & Wilcox, taking into account the value of the information to Babcock & Wilcox; the amount of effort or money expended by Babcock & Wilcox developing the information; and the ease or difficulty with which the information could be properly duplicated by others is given in Exhibit "B".

E. I have personally reviewed the document(s) listed on Exhibit "A" and have found that it is considered proprietary by Babcock & Wilcox because it contains information which falls within one or more of the criteria enumerated in Paragraph D, and it is information which is customarily held in confidence and protected as proprietary information by Babcock & Wilcox. This report comprises information utilized by Babcock & Wilcox in its business which afford Babcock & Wilcox an opportunity to obtain a competitive advantage over

those who may wish to know or use the information contained in the document(s).

JAMES H. TAYLOR

State of Virginia)
) SS. Lynchburg
City of Lynchburg)

James H. Taylor, being duly sworn, on his oath deposes and says that he is the person who subscribed his name to the foregoing statement, and that the matters and facts set forth in the statement are true.

JAMES H. TAYLOR

Subscribed and sworn before me
this 22nd day of April 1981.

Natalie M. Lampman

Notary Public in and for the City
of Lynchburg, State of Virginia

My Commission Expires Sept. 29, 1981

EXHIBIT A

STEAM GENERATOR

SLEEVE DEVELOPMENT PROGRAM

R. E. GINNA NUCLEAR POWER PLANT

(B&W PROPRIETARY)

EXHIBIT B

STEAM GENERATOR SLEEVE DEVELOPMENT PROGRAM

R. E. Ginna Nuclear Power Plant

(B&W PROPRIETARY)

Proprietary Nature of Material

Description of Material	Applicable Criteria
The document in its entirety as titled in Exhibit A and listed above	b, c, d, e, f

PROPRIETARY DATA

DOCUMENTATION

Document Identifier	12-1125055-00
Title:	Steam Generator Sleeve Test Program R. E. Ginna Nuclear Power Plant April 1981 Report to NRC (B&W Proprietary)
Date·	April 20, 1981
Customer:	Rochester Gas and Electric
Customer Order Number:	BE-09253
Contract Number:	582-7174
Case File Number:	A-19

Issued By: M. W. Henig 21 APR 81
M. W. Henig Date

TABLE OF CONTENTS

PREFACE

In July of 1980, Rochester Gas and Electric (RG&E) initiated a Research and Development Program with the Babcock and Wilcox Company to develop a sealable sleeve design directed toward resolution of the steam generator tube sheet intergranular attack. The initial sleeve development program consisted of three phases: development, design verification and implementation. A report on the initial sleeve development program to support the November, 1980 installation of test sleeves was provided in the Rochester Gas and Electric letter of November 6, 1980 to Mr. Dennis M. Crutchfield, USNRC.

In November, 1980, five (5) nickel plated bimetallic test sleeves were installed in the "B" Steam Generator at Ginna Station. The objective of the November, 1980 test sleeve installation was to confirm laboratory developed techniques, processes and procedures. This successful installation demonstrated that sleeves can be installed in an operational steam generator.

During May, 1981, the installation of co-extruded bimetallic sleeves in the Ginna "B" Steam Generator is planned. The basic sleeve design and processes are the same as described in the November, 1980 installation. The primary differences at this time are the remote tooling, sleeve material, and mechanical test results.

The purpose of this report is to provide an update of the Ginna Steam Generator sleeve development program.

I. INTRODUCTION

A. Background

Ginna Station is a Westinghouse two (2) loop pressurized water reactor plant owned by Rochester Gas and Electric. It is licensed for 1520 megawatts thermal and has a net electrical capacity of 490 megawatts.

The steam generators are Westinghouse series 44 vertical shell and U-tube units each rated at 3,130,000 lbs/hr steam flow at 725 psig. The steam generator tubing is Inconel 600 (SB-163-61T). The tubes are partially rolled into the tubesheet and seal welded.

Phosphate secondary water chemistry control was utilized from initial operation through November, 1974. In December, 1974 secondary water chemistry control was converted to all volatile treatment (AVT). AVT was maintained through condenser integrity and steam generator blowdown until December, 1977. From January, 1978 until the present full flow, deep bed condensate demineralizers have been in operation.

Steam generator tube wastage, caustic cracking, and ID cracking have been experienced at Ginna. Between March, 1974 and October, 1980, 121 tubes were plugged in the A-steam generator and 68 in the B for these reasons. During the Spring 1979 refueling outage, the first indications of OD intergranular attack (IGA) of tubes in the tubesheet crevice region were discovered. In December 1979 eleven (11) tubes were plugged in the B steam generator for IGA conditions. In March, 1980 an additional 31 tubes were plugged, and in November, 1980 3 tubes with IGA indications were sleeved.

A total of 47 tubes now have been repaired in the B steam generator due to IGA conditions. A total of 112 tubes (3.4%) have now been plugged in the B steam generator for all reasons. No IGA

I. INTRODUCTION (Continued)

A. Background (Continued)

indications have yet been discovered in the A steam generator. All of the IGA indications to date have been below the top of the tubesheet and above the expanded area at the tube end. In addition, all of the indications have been in hot leg tubes.

The IGA appears to be a caustic stress corrosion phenomena. Since the Spring of 1980 Rochester Gas and Electric has initiated several programs directed toward resolution of this problem. These programs have included more extensive eddy current examinations, crevice flushing, water lancing, tube pulling, laboratory testing, and sleeving.

The sleeving development program was initiated with Babcock and Wilcox in July, 1980. The primary objective of the program was to develop a sealable sleeve suitable for a minimum service life of 30 years in the crevice environment. Equipment and tooling are being developed to allow implementation of sleeving as a permanent fix for tubesheet IGA on a schedule consistent with normal plant operation and refueling outages. It is planned to use sleeving both as an alternative repair technique to plugging, and as a preventive maintenance procedure.

B. Overview of Sleeve Development Program

With the installation of five (5) test sleeves during the November, 1980 outage, the technical adequacy of the basic sleeve design and installation processes was verified. However, the tooling, equipment, and procedures used were not designed for installing a large number of sleeves in a reasonable time with an acceptable amount of radiation exposure. Also, because of

I. INTRODUCTION (Continued)

B. Overview of Sleeve Development Program (Continued)

manufacturing problems, we were not able to utilize co-extruded bimetallic sleeves.

Since November, 1980 the major work on the sleeving development program has been tooling and NDE development. In addition, some technical changes have been made to the installation processes to provide desired improvements. A goal has been established to develop equipment capable of allowing installation of five (5) to ten (10) sleeves per work shift with an exposure of 400 mr per sleeve. This would eventually allow installation of 50 to 100 sleeves in a 5-day period with a total exposure of 20 to 40 man rem. The primary purpose of additional sleeve installation during the Spring 1981 refueling outage is to verify the adequacy of the new tooling and equipment; and begin getting service experience with co-extruded bimetallic sleeves.

In November, 1980 five (5) nickel plated bimetallic sleeves (Figure 1) were installed in the Ginna B steam generator. In the next planned outage, it is expected to install co-extruded bimetallic sleeves (Figure 2) in the Ginna B steam generator. The co-extruded sleeve differs from the previously installed nickel plated sleeve only in that the outer nickel layer is diffusion bonded over the entire length of the Inconel core as an integral part of the tube making process. This improved product allows the nickel layer to be carried into the upper end attachment, thus providing a continuous barrier to secondary side caustic attack. The development program to support this installation will consist of five major parts:

I. INTRODUCTION (Continued)

B. Overview of Sleeve Development Program (Continued)

1. Improve Installation System and Methods for Field Deployment - The objective is to convert the steam generator tube sleeving process to a remote operation thus achieving lower personnel exposure in compliance with the guidelines of the ALARA program.

2. Provide Co-Extruded Bimetallic Sleeves - The objective is to provide co-extruded bimetallic sleeves whose design configuration is based on results from an R&D program and design verification testing.

3. Design Verification - The objective is to perform mechanical testing and corrosion testing necessary to ensure the adequacy of the co-extruded bimetallic sleeve design.

4. Develop NDE Capabilities - The objective is to provide enhanced probe designs based on past experience and results from laboratory samples of the tube/sleeve combination, including the braze expanded area. The results will allow for examination of the tube, sleeve and braze joint.

5. Implementation - Co-extruded bimetallic sleeves will be installed in the B steam generator. They will be installed within tubes having tubesheet crevice indications or in tubes located in a region susceptible to IGA. Schedule for initial implementation is the Spring of 1981.

II. SLEEVE DESIGN

A. General Design

The Babcock and Wilcox co-extruded bimetallic sleeve design to be employed (see Figure 2) is 36 inches long, thin walled, composite alloy sleeve attached to the steam generator tube at both the upper and lower ends. The co-extruded sleeve design differs from the nickel plated sleeves installed in November, 1980 in that approximately 4 mils of nickel extends over the entire length of the sleeve including the area of the end attachments. The nickel on the earlier plated test sleeve design was approximately 2 mils thick and did not extend to the end attachments. The co-extruded sleeve design offers greater assurance against caustic corrosion attack at the attachments. These bimetallic sleeves are fabricated from a seamless tubular product which consists of an outer nickel layer diffusion bonded to an inner core of Inconel 600 material. The co-extruded sleeve is produced by high temperature extrusion followed by cold finishing to achieve the final dimensions. The nickel on the earlier plated test sleeve design was deposited using an electroplating process followed by a diffusing bonding process. Inconel 600 heat treated at 1300°F was chosen for the base sleeve material in both designs as this provides the same mechanical and thermal properties as the original tube. The 1300°F heat treatment for Inconel tends to optimize its corrosion behavior; therefore, this sleeve material has corrosion resistance superior to the present mill annealed steam generator tubing material. Nickel was chosen for the sleeve OD because of its resistance to caustic corrosion. The nickel surface will protect the Inconel sleeve from caustic attack should a leak in the original pressure boundary material occur. This should give the sleeve a much better chance of remaining in service for the full operating lifetime of the unit than would Inconel 600 or any other known structurally satisfactory material.

II. SLEEVE DESIGN (Continued)

A. General Design (Continued)

The upper end of the sleeve will be hydraulically expanded and brazed using multiple braze rings. The expansion length has been increased in the co-extruded bimetallic sleeve design to reposition the transition between the expanded and non-expanded portion of the sleeve wall such that grain growth in this localized area during the brazing process is minimized. In addition, temperatures are high enough to relieve tensile residual stresses introduced by the expansion process. The length of the sleeve (36 inches) will ensure the braze joint is positioned above the sludge region atop the tubesheet. The tubesheet is 22 inches thick and the sludge affected zone extends approximately 3 to 6 inches above the tubesheet. A non-brazed section of the sleeve will extend about 1 inch into the tube above the brazed area of the sleeve to provide mechanical restraint in the unlikely event of tube failure at the braze joint.

The lower end of the sleeve will be explosively welded to the tube within the tubesheet roll expanded region. Explosive welding will substantially reduce the time required to install sleeves and personnel exposure to radiation. Although not anticipated to be used a GTAW weld procedure was developed as a backup to the explosive technique for installation of sleeves in November, 1980.

B. Co-Extruded Bimetallic Sleeve

The co-extruded bimetallic sleeve is a seamless composite tube of nickel and Inconel 600 alloy manufactured by high temperature extrusion. The external nickel layer conforms to the ASME Code chemical composition for SB-163 Nickel Alloy and the internal Inconel 600 alloy tubing to SB-163 Nickel-Chromium-Iron Alloy. The material is electric furnace melted and the tubing annealed at 1800°F minimum.

II. SLEEVE DESIGN (Continued)

B. Co-Extruded Bimetallic Sleeve (Continued)

The tubing nominal outside and inside diameters are 0.745 inches and 0.634 inches, respectively, including approximately 0.004 inches of nickel.

The outside surface is centerless ground and the internal and external surface finish is 63 RMS or better. The composite tube has a metallurgical bond between the nickel and Inconel 600 alloy as verified by ultrasonic testing. Ultrasonic testing is performed on the entire tube volume utilizing the straight beam method in one radial direction and angle beam method in two opposite axial directions from the outside surface. Acceptance is based on indications not exceeding a flat bottom hole 1/16 inch in diameter at the interface between the nickel and Inconel 600 alloy. A tension test (35,000 psi minimum yield and 80,000 psi minimum tensile for Inconel 600) and hardness test is also performed on the tubing as well as a hydrotest at 3110 to 3125 psig per ASME Code.

The co-extruded bimetallic sleeve is certified to the ASME Boiler and Pressure Vessel Code and is Class I pressure boundary material. It possesses the strength of Inconel 600 alloy tubing and provides a nickel outer layer to resist a caustic attack. However, the minimum wall thickness of the sleeve for design loads is based solely on the Inconel base material.

C. Upper End Attachment

Oxides will be removed from the steam generator tube ID using a remotely operated motor driven brush prior to the brazing operation to assure a good bond. About 0.001 inch of metal will be removed from the interior tube surface to obtain an area suitably free of oxide thereby ensuring an adequate braze bond.

II. SLEEVE DESIGN (Continued)

C. Upper End Attachment (Continued)

The upper end of the sealable sleeve is designed to be hydraulically expanded into the steam generator tube and attached by brazing. The braze joint design consists of two pre-brazed rings, 1/4 inch wide, 1/4 inch apart; the upper edge of the upper ring will be 1 inch away from the top of the sleeve. The grooves on the sleeve will be pre-brazed with filler material using a vacuum or inert gas furnace. Braze filler material selected is BAu-4 (melting temperature 1740°F). Selections of the braze joint configuration, parameters, procedural techniques and filler material were made based on the results of laboratory brazing trials and mechanical property tests. During these development efforts, several heating methods were evaluated and induction heating with an Argon purge was selected as the best heating method. The joints were cut apart and evaluated by metallographic examination. Bend and pull tests were performed to select the best joint configuration. The leak tightness of the joint was verified by hydrotest. The selected joint design achieved a braze length of 1/2 inch versus the minimum length of 1/4 inch required by the ASME Code.

D. Lower End Attachment

The lower end of the sealable sleeve will be attached to the steam generator tube by explosive welding. B&W has considerable experience with explosive welding in steam generator tubes - holding U.S. Patent 3,590,877 for explosive plugging. This well proven plug design and explosive method provides the basis for the explosive procedure for attachment of the lower end of the sealable sleeves. The explosive welding process involves a parallel sided stand-off of about one-half the sleeve wall thickness and an explosive device consisting of a plastic cartridge, an explosive load of 3.5 grams

II. SLEEVE DESIGN (Continued)

D. Lower End Attachment (Continued)

and an exploding bridge wire detonator. The explosive cartridge will be inserted into the sleeve with its upper end 2-1/2 inches inside the sleeve. After detonation, the sleeve is welded to the tube over a one-inch length, from 1-1/2 to 2-1/2 inches from the tube end. The explosive welding process also expands the sleeve so that it touches the tube for a length of 1/2 inch above and below the one inch welded region.

This weld configuration was developed during a series of tests in which the size and position of the explosive charge and the standoff was varied until the desired configuration was achieved. The weld joints were sectioned, and evaluated by standard metallographic techniques.

B&W is licensed by the ATF Bureau of the U.S. Treasury Department as both a manufacturer and importer of high explosives (license numbers 40H07620C1-00048 and 40H07620C1-00052, respectively). For transportation purposes, the B&W explosive plugs are classified as class "C" explosive by the Bureau of Explosives. B&W has requested a similar classification for the Ginna explosive welding device.

III. SLEEVE INSTALLATION

A. Tubes to be Sleeved

Tubes to be sleeved in the "B" steam generator hot leg will be selected by RG&E. In order to provide for a good test, sleeves will be installed either in tubes which have indications of intergranular attack in the tubesheet crevice region, or in tubes which would be expected to be subject to intergranular attack based on past inspection results and operating history.

B. Remote Tooling

Equipment used in November, 1980 was not designed for remote installation of sleeves; consequently, excessive time was required by personnel in the steam generator channel head. A significant number of comments and recommendations for improving the sleeve installation process were generated in meetings and submitted in individual reports following that installation. These "lessons learned" have been incorporated into the design and fabrication of the remote tooling to be employed in subsequent sleeve installations. In addition, a conscientious attempt was made to maintain simplicity in tooling design in order to minimize the possibility of malfunction.

The key item of the remote tooling is a satellite plate which is installed at the hot leg opening of the steam generator tube which has been designated for sleeving. This plate is used to position and hold the end of snorkels used in the honing and swabbing operations. This concept allows the entire operation including the installation and removal of the snorkels to be performed from outside the steam generator head. The satellite plate is also used to position and hold the sleeve until completion of the expansion process and to hold and position the induction

III. SLEEVE INSTALLATION (Continued)

B. Remote Tooling (Continued)

braze wand. The plate itself is also installed and removed from outside the steam generator head. Extensive use of video equipment is utilized to aid in the tooling manipulations and to monitor the sleeving process.

The induction brazing equipment, with the exception of the wand/heater assembly and its connector cable, have been removed from the vicinity of the steam generator. This equipment, in addition to the control/monitoring portion of the hydraulic expansion system will be positioned in an area of low radiation exposure. The final major piece of equipment to be used in the sleeve installation is the tube vacuum-purge-pressure test system. The control board for this system will also be positioned in an area of low radiation exposure. The system has the capability of evacuating, purging or pressure testing up to five steam generator tubes individually, simultaneously or in groups. These operations are all conducted through hollow expandable plugs remotely inserted in cold leg tube ends.

The remaining pieces of tooling are comprised of gripper or holder type devices which are manipulated from outside the steam generator near the manway opening. Again, the use of video equipment is employed in order to minimize time expended in high radiation areas.

The concepts and guidelines of the ALARA program have been incorporated in the development of the sleeve installation tooling. The end product may be modified where a large number of tubes (in excess of a hundred during an outage) require sleeving. The simple approaches utilized in the tooling operations satisfy the ALARA guidelines while maintaining high tool reliability.

III. SLEEVE INSTALLATION (Continued)

C. Installation Sequence

The following installation sequence will be used to install sleeves in the preselected steam generator tubes.

1. Steam Generator Preparation

(a) Water in the primary system must be drained below the centerline of the reactor vessel outlet nozzle.

(b) Water must be drained from the secondary side prior to brazing and explosive welding.

(c) Both primary manway covers and inserts will be removed.

(d) The channel head area and tubesheet must be dry.

(e) Air samples from inside the steam generator will be analyzed.

(f) Radiation levels inside the channel head area will be mapped and general levels and hot spots identified.

2. Television Camera Installation

A closed circuit television camera will be installed in order to monitor activities that are transpiring in the steam generator head. The camera will be mounted on a hinged plate which is recessed in the Reactor Coolant piping connection and is equipped with a control pan and tilt as well as a remote operated zoom lens. This system has proven invaluable as a contributor to reduced man rem exposure.

III. SLEEVE INSTALLATION (Continued)

C. Installation Sequence (Continued)

3. Gauging Tube I.D.

In preparation for sleeving the selected tubes, the ID will be gauged using a "GO-gauge" with a 0.757 ± .001 inch diameter Inconel 600 rod or sleeve. The gauge will be 40 inches long with a stop for 36 inch insertion. Insertion of the gauge will be made freely without force until the stop on the gauge contacts the lower end of the tube.

4. Verification of Tube Integrity

The tube to be sleeved is checked to ensure it is free of through wall defects. This is accomplished by pressurizing the tube to 500 psi with Argon and verifying no decrease in pressure over a two minute period. The tube is then evacuated and the Argon purge established. The accomplishment of this step also ensures the correct identification of tube ends (i.e., hot leg and cold leg).

5. Cleaning

Prior to the brazing operation the ID surface of the tube will be cleaned free of any oxides using an aluminum oxide ball flex hone tool. It is desirable to remove about 0.001 inch of metal from the surface to ensure removal of the oxides in preparation for brazing. The ID surface of the tube will then be cleaned with methanol soaked swabs from the tube end to a depth of 38 inches. Cleaning will continue until the swab is free of dirt or particles. The tube will then be dry swabbed to remove any methanol residue.

III. SLEEVE INSTALLATION (Continued)

C. Installation Sequence (Continued)

6. Expanding

After the tube ID surface has been adequately cleaned, the pre-brazed sleeve with an expanding tool in position will be inserted into the tube. The sleeve is then hydraulically expanded into the tube.

An instrumentation system has been developed for the hydraulic expansion system. Pressure of the working fluid and the displacement of the pump mandrell (which represents the volume change) will be monitored during the operation. A sharp increase in pressure on the pressure versus displacement curve after the sleeve has been yielded indicates the sleeve has touched the tube and they are being expanded together.

7. Brazing

The brazing process will be done in a welding quality inert gas (Argon) atmosphere. An Argon purge is initiated from the cold leg end of the tube prior to the start of the cleaning operation and is not terminated until the braze joint is pressure tested.

The heating phase of the brazing operation includes three steps. The joint will be heated up to 1325 $\pm$ 50°F for 1 to 2 minutes, increased to 1825 $\pm$ 50°F and held for 2 to 2.5 minutes to melt and flow the filler material. Then a post-braze heat treatment at 1325 $\pm$ 50°F for 10 minutes will be imposed on the joint to relieve the stress in the expanded region.

C. Installation Sequence (Continued)

The heating source for brazing is accomplished by induction heating. Induction heating method is capable of heating the joint to 1800°F in 2 minutes. In the induction heating system, a 0.550 inch OD internal coil is used.

8. Pressure Test of Braze

Following sleeve brazing, but prior to explosive welding of the lower end, a leak test will be performed to ensure braze integrity. The cold leg end of the tube and the lower end of the sleeve will be plugged and the tube pressurized to 500 psig. The tube pressure will be monitored to ensure the braze integrity. Should this pressure test fail, the capability to re-expand and rebraze the upper sleeve to tube joint has been developed and qualified.

9. Explosive Welding

The explosive cartridge will be inserted into the sleeve. The cartridge is positioned by an integral flange machined at the base and held by a spring clamped into an adjacent tube. The explosive cartridge will then be detonated. After detonation, the sleeve will be visually inspected.

10. System Pressure Test

A primary system pressure test will be performed prior to return to full power to demonstrate that system integrity has not been violated.

III. SLEEVE INSTALLATION (Continued)

D. Mockup Demonstration and Training

Sleeves will be installed in the Ginna steam generator mockup to demonstrate the tools, techniques, and equipment under realistic conditions. This is considered an integral and necessary part of the program to minimize delays and radiation exposure during prototype sleeve installation in the operating steam generator. Mockup installation will also serve as personnel training.

Complete procedures for tube cleaning, sleeve installation, expansion, brazing and welding will be perfected and demonstrated on the mockup prior to use in the operating steam generator.

E. Radiation Exposure Control and Estimates

All personnel to be engaged in the steam generated sleeving will receive instructions and training in and understand the radiation protection rules and guidelines in effect at the plant site. Based on several installations in a steam generator mockup, the following potential radiation exposure was determined:

Operation	Estimated Exposure
Gauging and Marking and Initial Setup	0.20 man-rem per tube
Hone and clean braze area	0.10 man-rem per tube
Insert sleeve and hyraulic expand	0.10 man-rem per sleeve
Braze	0.40 man-rem per sleeve
Pressure Test Sleeve	0.05 man-rem per sleeve
Explosive weld lower end	0.05 man-rem per sleeve
Inspect Sleeves	0.05 man-rem per sleeve
TOTAL	0.95 man-rem per sleeve

PROPRIETARY

III. SLEEVE INSTALLATION (Continued)

E. Radiation Exposure Control and Estimates (Continued)

Initial setup and removal of equipment in containment will add approximately 2.0 man-rem to the total exposure for the job.

IV. DESIGN VERIFICATION

A. Tests

During process development, a number of tests were performed including hydrostatic, tensile and peel, and metallographic examinations on the upper and lower attachments for the plated sleeve design installed in November, 1980 and for the co-extruded sleeve design now being utilized. Additionally, design verification testing was performed prior to the November 1980 installation and similar testing is now being performed for the co-extruded sleeve design. These tests are directed toward providing adequate assurance of the mechanical integrity of the test sleeves.

The testing completed prior to the November, 1980 installation of test sleeves and the test results are as follows:

(1) Mechanical Integrity Testing

Testing prior to the test sleeve installation was conducted on a simulated tube/sleeve assembly. Five test specimens were constructed using the same brazing process, explosive weld process, equipment and materials that were utilized in the installation of the plated test sleeves in November, 1980. These simulated tube/sleeve assembly specimens were tested as follows:

a. Primary Side Hydro Test - the specimens were subjected to a primary side (tube/sleeve ID) hydro of 3110 psig at room temperature. No leakage was observed.

b. Secondary Side Hydro Test - Upon successful completion of the above test, the specimens were subjected to a secondary side (tube ID/sleeve OD) pressure of 1360 psig at room temperature. No leakage was observed.

IV. DESIGN VERIFICATION (Continued)

A. Tests (Continued)

c. Structural Fatigue Testing - Upon successful completion of the above test, the tubes were severed to produce longitudinal gaps of 1/4 inch in the tubes. The specimens were subjected to axial fatigue loading cycles while at 600°F. The loading range and cycles were selected to model the combined pressure and thermal axial loadings at the normal operating conditions. There was no specimen failure.

d. Primary Side Hydro Test - Upon completion of the above test, the Primary Side Hydro test was repeated to verify the pressure boundary integrity of the tube/sleeve assembly. No leakage was observed.

e. Secondary Side Hydro Test - Upon completion of the above test, the Secondary Side Hydro Test was repeated to verify the pressure boundary integrity of the tube/sleeve assembly. No leakage was observed.

f. Tensile Test - Upon successful completion of the above tests, the specimens were pulled to failure under axial loading to establish the strength of the tube/sleeve assembly. In no case did failure occur in either the upper or lower attachments. All specimen failures occurred in the sleeve at the lower braze ring groove. The load at failure varied between 8,100 pounds and 9,400 pounds. In all cases, failure was ductile with no indication of shear failure at the braze joint.

IV. DESIGN VERIFICATION (Continued)

A. Tests (Continued)

(2) Corrosion Testing

Nickel is the material most often used for caustic corrosion resistance. The significant advantage of nickel over heat treated Inconel 600 is that nickel is not susceptible to caustic intergranular attack. Data of actual corrosion rates were not adequate in the range needed for sleeve application. To obtain data, coupons of nickel 200 and Inconel 600 heat treated at 1100°F and 1300°F were tested in a 50% caustic solution at 550°F.

The corrosion rates were measured as follows:

Nickel 200		
Coupon #1		0.050 mils per year
Coupon #2		0.061 mils per year
	Average	0.056 mils per year
Inconel 600 - heat treated to 1100°F		
Coupon #1		0.028 mils per year
Coupon #2		0.036 mils per year
	Average	0.032 mils per year
Inconel 600 - heat treated to 1300°F		
Coupon #1		0.028 mils per year
Coupon #2		0.037 mils per year
	Average	0.033 mils per year

From the above data, nickel is not superior to Inconel 600 for pure corrosion rate, but both are quite low. At the above rate, a 4 mil coating of nickel would last about 70 years.

IV. DESIGN VERIFICATION (Continued)

A. Tests (Continued)

(3) Tests for Co-Extruded Bimetallic Sleeves

The mechanical integrity tests performed for the plated test sleeves installed in November 1980 are being repeated for the co-extruded sleeve design. The same test parameters are being applied to testing the co-extruded sleeve design. Testing is now in progress. Results will be evaluated and the structural adequacy of the braze and explosive weld joints will be verified prior to installation of the bimetallic sleeves. Five test specimens were fabricated from the same bimetallic tubing using the same brazing process, explosive weld process, equipment and materials that will be used in the installation of the co-extruded sleeves. As with the plated sleeve design, the testing sequence will be:

a. Primary Side Hydro Test
b. Secondary Side Hydro Test
c. Structural Fatigue Testing
d. Primary Side Hydro Test
e. Secondary Side Hydro Test
f. Tensile test

Based on the previous test results, the adequacy of the co-extruded bimetallic tube/sleeve attachment is expected to be confirmed.

B. Analyses

Calculations were performed which demonstrate that the tube/sleeve design meets the internal design pressure and temperature requirements of paragraph NB-3324 of the ASME Code,

IV. DESIGN VERIFICATION (Continued)

B. Analyses (Continued)

Section III. Additional calculations were performed which demonstrate that the sleeve has a greater external pressure load carrying capacity than the original tube.

A review has been performed of all events analyzed in the Ginna Station Steam Generator Stress Report. The results of this review provided the basis for an evaluation demonstrating the structural integrity of the sleeved tube configuration for all anticipated normal operating events.

A review was performed utilizing the Ginna Station Steam Generator Stress Report to assess the impact of a seismic event on the tube/sleeve assembly. The installation of a sleeve in an undegraded tube produces a small increase in the resonant frequency of the original tube. This change in resonant frequency will have a negligible impact on the seismic loadings; therefore, the original tube design analyses confirm the adequacy of the tube/sleeve assembly.

For a case with sleeves installed in 100% of the generator tubes, the primary-side pressure drop was calculated to increase by approximately 7 percent over that in the unsleeved generator. A pressure drop of 7 percent corresponds to plugging approximately 3.3 percent of the generator tubes assuming the plugs are randomly distributed. With this 7 percent pressure drop across the steam generator, the effect on the total primary system pressure drop is small. Considering this increase, the effect on the RC pump flow and the heat transfer is negligible.

The present Ginna ISI Program requires plugging of any steam generator tube with a defect indication of 40% or greater through

B. Analyses (Continued)

wall. This was based on the possibility of cracking occurring on tubes with previous OD wastage above the tubesheet. Prior to that, a 50% tube plugging criteria had been used based on occurrence of a single phenomena such as wastage. For a single failure phenomena within the tubesheet, such as intergranular attack, a 50% tube plugging criteria is appropriate. To determine an appropriate plugging criteria for sleeves, calculations have been perfomred comparing a sleeve with a tube having 50% OD wastage. The results of these calculations are as follows:

TABLE 1

TUBE AND SLEEVE STRENGTH COMPARISONS

Parameters	Original Tube	Original Tube with 50% wastage on Tube OD	Sleeve
Thickness, t	0.050	0.025	0.046[1]
Outside Diameter D_o	0.875	0.825	0.727[1]
Inside Diameter Di	0.775	0.775	0.635
Hoop Stress Parameter (Di + 2t)/2t	8.75	16.50	7.90
Axial Stress Parameter (Di + 2t)/4t	4.38	8.25	3.95
Bending Stress Parameter (Di + 2t)/2I	39.54	81.98	63.43

IV. DESIGN VERIFICATION (Continued)

B. Analyses (Continued)

NOTE 1: Dimensions are minimums and correspond to Inconel base metal only. Sleeve has a nominal OD of 0.745 inch containing a maximum of 0.009 inch nickel.

From Table 1 the following equivalent sleeve thicknesses can be calculated using the parameters for a 50% wastage tube.

Sleeve thickness required due to internal pressure -

$$16.50 = (Di + 2t)/2t \qquad t = 0.021 \text{ inch}$$

Sleeve thickness required for equivalent bending strength -

$$81.98 = (Di + 2t)/2I \qquad t = 0.037 \text{ inch}$$

The bending strength parameter is the limiting value. A sleeve thickness of 0.037 inch corresponds to a 32% reduction in the total sleeve wall (nominal sleeve wall thickness = 0.055 inch).

The above comparisons demonstrate that the 50% wall degradation plugging criteria for existing tubes corresponds to a 32% wall degradation plugging criteria for the sleeves.

C. Conformance with License Conditions

The Technical Specifications and their bases have been reviewed to determine whether changes are required to employ steam generator sleeves. Technical Specification 3.1.5 establishes a limit on primary or secondary leakage of 0.1 gpm. This limit, which was reviewed and approved by the NRC in Amendment Number 16, transmitted on May 14, 1975, ensures steam generator tube integrity under postulated accident conditions. A comparison between pressure

IV. DESIGN VERIFICATION (Continued)

C. Conformance with License Conditions (Continued)

stresses in a steam generator tube, and stresses in a sleeve demonstrates that a sleeve can withstand the differential pressures better than a steam generator tube. Thus, a sleeve with a through-wall crack superimposed upon wastage will perform as well as, or better than, a steam generator tube with a through-wall crack superimposed upon wastage of the same magnitude (in terms of percent wastage). Therefore, since in either case the through-wall crack length is monitored by monitoring primary to secondary system leakage, the current Technical Specification and its Bases remain valid for test sleeve tubes.

Specification 4.2 governs the Inservice Inspection of steam generator tubes by references to the Ginna Station Inservice Inspection Program. The Inservice Inspection program is being revised to allow steam generator tube sleeving in lieu of plugging. This document is not a part of the plant Technical Specifications and may be revised pursuant to 10CFR 50.59. Indeed, changes and subsequent implementation pursuant to 10CFR 50.59 may, on some occasions, be required to conform to 10CFR 50.55a.

V. POST-INSTALLATION INSPECTIONS

A. Baseline Eddy Current Inspections - November, 1980

A Non-Destructive Examination (NDE) system including eddy current techniques, probes and driver was used as follows for the inspection of the nickel plated test sleeves. The entire sleeve with the exception of the explosive weld area in the tubesheet was scanned using a 0.610 inch diameter conventional annular differential type probe. The probe was inserted into the proper tube/sleeve using the positioner and pulled from the tube/sleeve at approximately 0.5 feet per second using a hand pull. The information was obtained using both a Zetec MIZ-12 multifrequency eddy current instrument and an Automation Industries EM-3300 single frequency instrument. Data collected simultaneously at four frequencies using the MIZ-12 was stored on an 8-channel magnetic tape recorder. The frequencies selected were 50 khz, 100 khz, 300 khz, and 600 khz (all differential). The reason for using four separate frequencies was to concentrate the inspection at specific areas, namely, the sleeve itself, the tube behind the sleeve, and the tubesheet component, all in a single scan. The EM-3300 was used at 50 khz, low sensitivity to look at the braze/expansion region alone. This was to answer such questions as: Was the braze centered in the expansion, and has the gold braze material flowed out of the reservoirs into the annulus between sleeve and tube? The extent (percentage of tube wall and/or percentage of sleeve wall) of any detected flaws were to be estimated by calibration curves constructed after initial system calibration.

After scanning with the annular probe, an axial differential probe, with centering collars and spring loaded coils, was used to interrogate the braze/expansion region of the sleeve. The probe, in this case, was driven using the Zetec SM-6 probe driver, rotating the probe while withdrawing it axially, resulting in a helical scan. An approximate scan rate of 0.5 inch per minute and 12 rpm was used.

V. POST-INSTALLATION INSPECTIONS (Continued)

A. Baseline Eddy Current Inspections - November, 1980 (Continued)

Again, a multifrequency scan was performed to allow simultaneous inspection of sleeve and tube. The frequencies were 100 KHz absolute, 110 KHz, 310 KHz, and 610 KHz, the latter three being differential. No calibration curves were used in this technique. Instead, a rough estimate of flow depth can be made by referring to calibration signals of flaws of known depth. Baseline inspection incorporated both the annular coil and axial differential coil techniques. Good baseline data was obtained on which to base all subsequent inspections of the sleeved tubes. The data was collected and analyzed and no significant defects were detected.

B. Baseline/Follow-On Eddy Current Inspections

The nickel-plated test sleeves installed in November, 1980 will be Eddy Current examined and the data evaluated prior to the installation of additional sleeves. As done in the November, 1980 installation, all installed co-extruded bimetallic sleeves will receive a baseline Eddy Current examination on which to base all subsequent inspections.

Follow-on inspections will continue to use the annular coil and axial differential techniques as described. However, improved probes will be used for both techniques as necessitated by the use of the bimetallic sleeve material. A high penetration, magnetic saturation, annular differential eddy current probe will be used to inspect the region of the sleeved tube between the explosive weld and braze/expansion. The same equipment, frequencies and techniques will be employed.

V. POST-INSTALLATION INSPECTIONS (Continued)

B. Baseline/Follow-On Eddy Current Inspection (Continued)

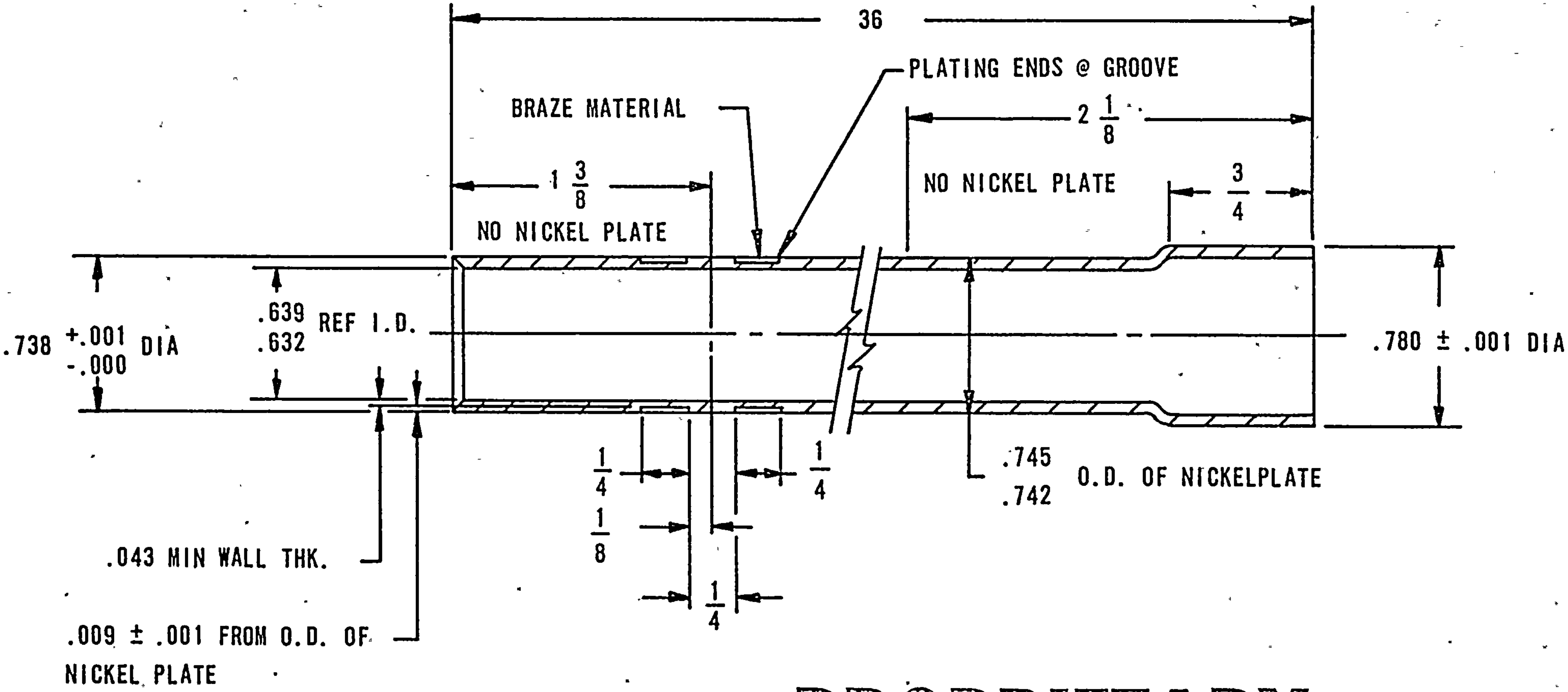
An improved version of the axial differential probe will be used to inspect the braze/expansion and explosive weld regions of the sleeved tube. The new probe will incorporate magnetic saturation and modified coil design to optimize defect detection in the parent tube. The same equipment, frequencies, and techniques as used in the November, 1980 baseline will be used.

VI. GOAL OF ADDITIONAL INSTALLATIONS

Additional sleeves are planned to be installed in the "B" steam generator during May, 1981. Mockup testing, demonstration and training is scheduled to be conducted in April, 1981.

The primary purpose of additional sleeve installation is to demonstrate field application of the co-extruded bimetallic sleeve and to show that sleeves can be remotely installed in an operational steam generator. Another important purpose is to provide actual operational information as a part of the design verification process for bimetallic sleeves.

Figure 1 NICKEL PLATED BIMETALLIC SLEEVE DESIGN



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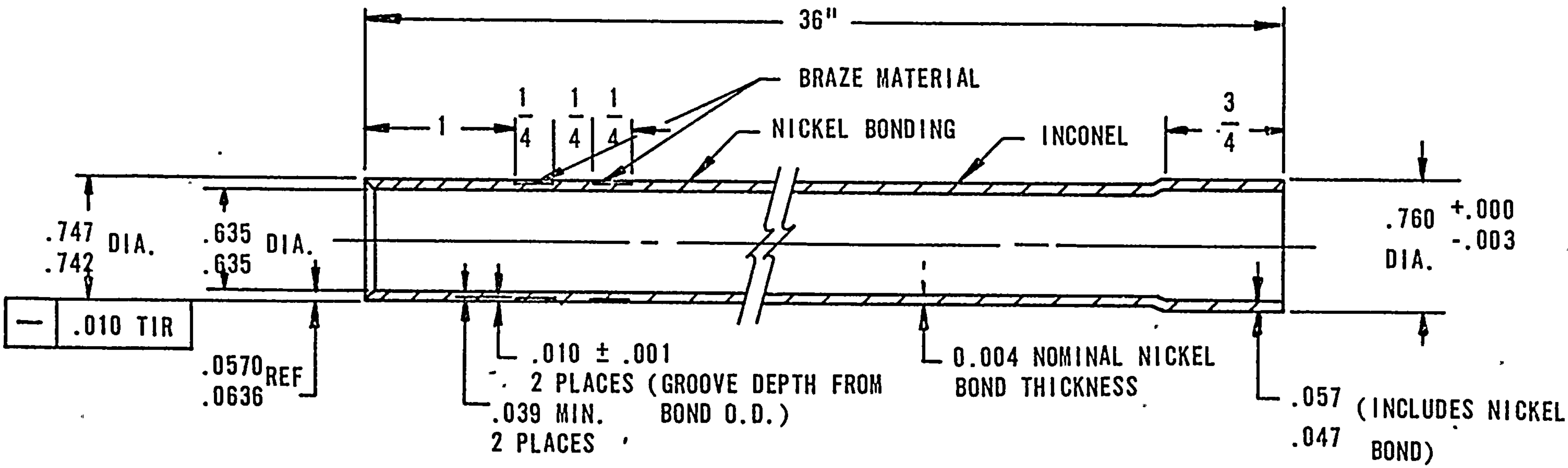
[illegible]

Figure 2 CO-EXTRUDED BIMETALLIC SLEEVE DESIGN



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