WCAP-11818

SLIDE PRESENTATION MATERIAL

NRC MEETING MARCH 31. 1988

KEWAUNEE NUCLEAR POWER PLANT

STEAM GENERATOR TUBE SLEEVE

INSTALLATION

APRIL, 1988

WORK PERFORMED UNDER SHOP ORDER WP8I-7715

WESTINGHOUSE ELECTRIC CORPORATION
POWER SYSTEMS BUSINESS UNIT
P. O. BOX 355
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UPDATE ON

KEWAUNEE SLEEVING

MARCH 1988

WISCONSIN PUBLIC SERVICE

KEWAUNEE NUCLEAR POWER PLANT

AND

WESTINGHOUSE ELECTRIC CORPORATION

ENERGY SYSTEM SERVICE DIVISION

PITTSBURGH, PA.

DEFINITIONS

CORRECTIVE SLEEVE - SLEEVE INSTALLED IN A TUBE REQUIRING REPAIR AS DEFINED IN PLANT TECHNICAL SPECIFICATION BASED ON EXISTING TUBE DEGRADATION.

PREVENTIVE SLEEVE - SLEEVE INSTALLED IN A TUBE NOT REQUIRED TO BE REPAIRED BY TECHNICAL SPECIFICATIONS, BUT FOR POTENTIAL FUTURE TUBE DEGRADATION.

TUBE ROLLED SECTION - ORIGINAL TUBE ROLL IS NOMINALLY [ ]^{a,c} IN LENGTH FROM THE TUBE END.

TUBE ROLL TRANSITION - TRANSITION FROM ROLLED TUBE TO NOMINAL TUBE DIAMETER.

MEASUREMENT REFERENCE POINT
TUBE ROLL TRANSITION - MEASURED FROM THE TUBE END TO THE TOP OF THE ROLL TRANSITION BY EDDY CURRENT.

TUBE TO TUBESHEET JOINT

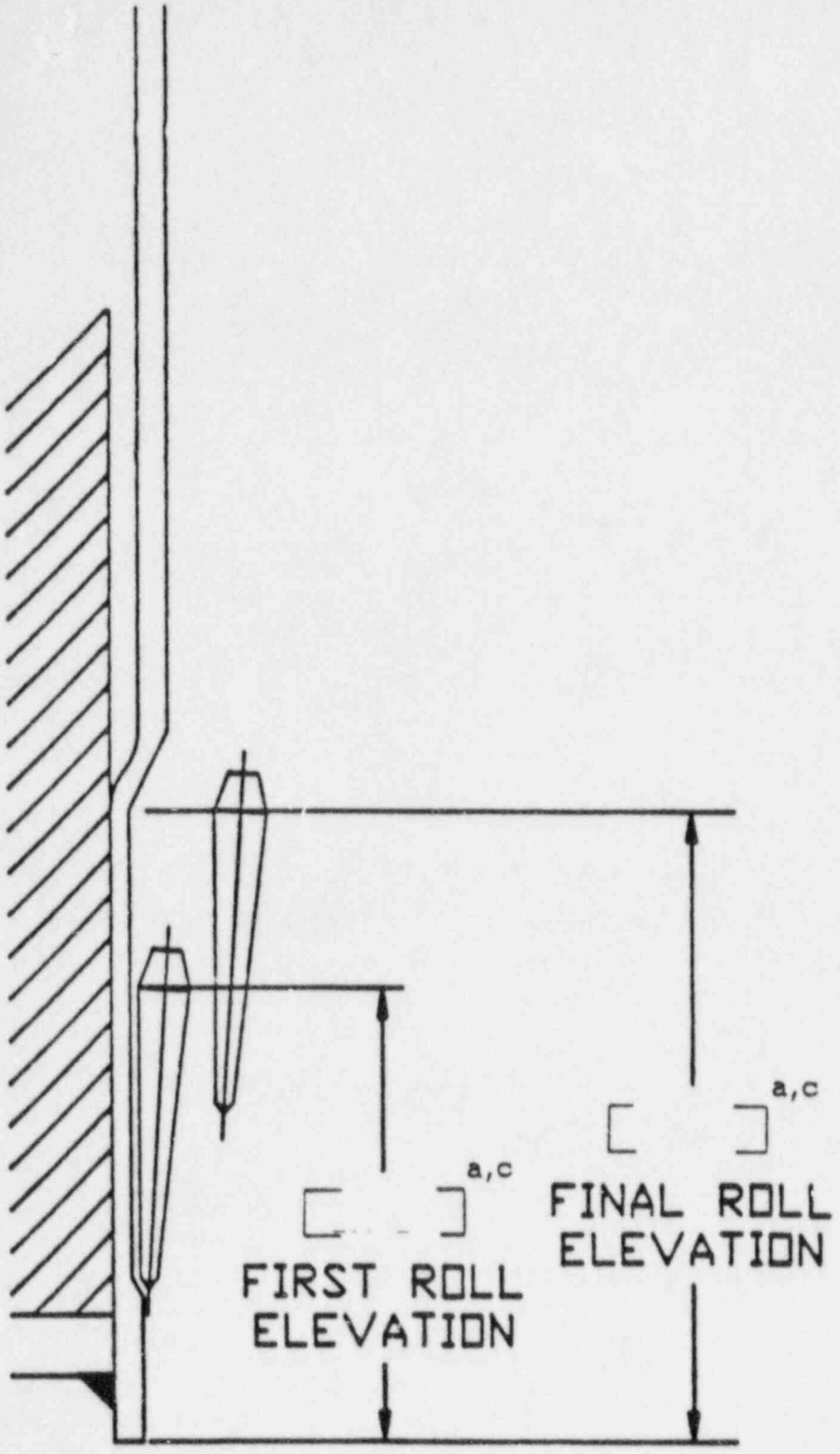
TUBE TO TUBESHEET WELD IS THE STRUCTURAL PRESSURE BOUNDARY BETWEEN THE TUBE AND TUBESHEET.

WELD IS ANALYZED WITHOUT TAKING CREDIT FOR TUBE ROLL.

TUBE ROLLING PROCESS

A TACK ROLL IS PERFORMED PRIOR TO WELDING TO PLACE TUBE IN CONTACT WITH TUBESHEET AND CLAD.

A TWO STEP HARD ROLL PROCESS IS USED TO OBTAIN A [ ]^{a,c} INCH LONG ROLL SECTION.



AS DESIGNED TUBE TO
TUBESHEET ROLL GEOMETRY

ADDITIONAL DEFINITIONS

SLEEVE HYDRAULIC EXPANSION - SLEEVE IS HYDRAULIC EXPANDED INTO INTIMATE CONTACT WITH THE TUBE. PLASTIC DEFORMATION OF UNEXPANDED TUBE MATERIAL OCCURS -[ ]a,b,e FOR LOWER JOINT THIS IS NOMINALLY[ ]a,c,e INCHES FROM THE SLEEVE END.

SLEEVE ROLL EXPANSION - FLAT AREA PRODUCED BY SLEEVE HARD ROLL IN TUBE, NOMINALLY[ ]a,c,e INCHES FROM SLEEVE END.

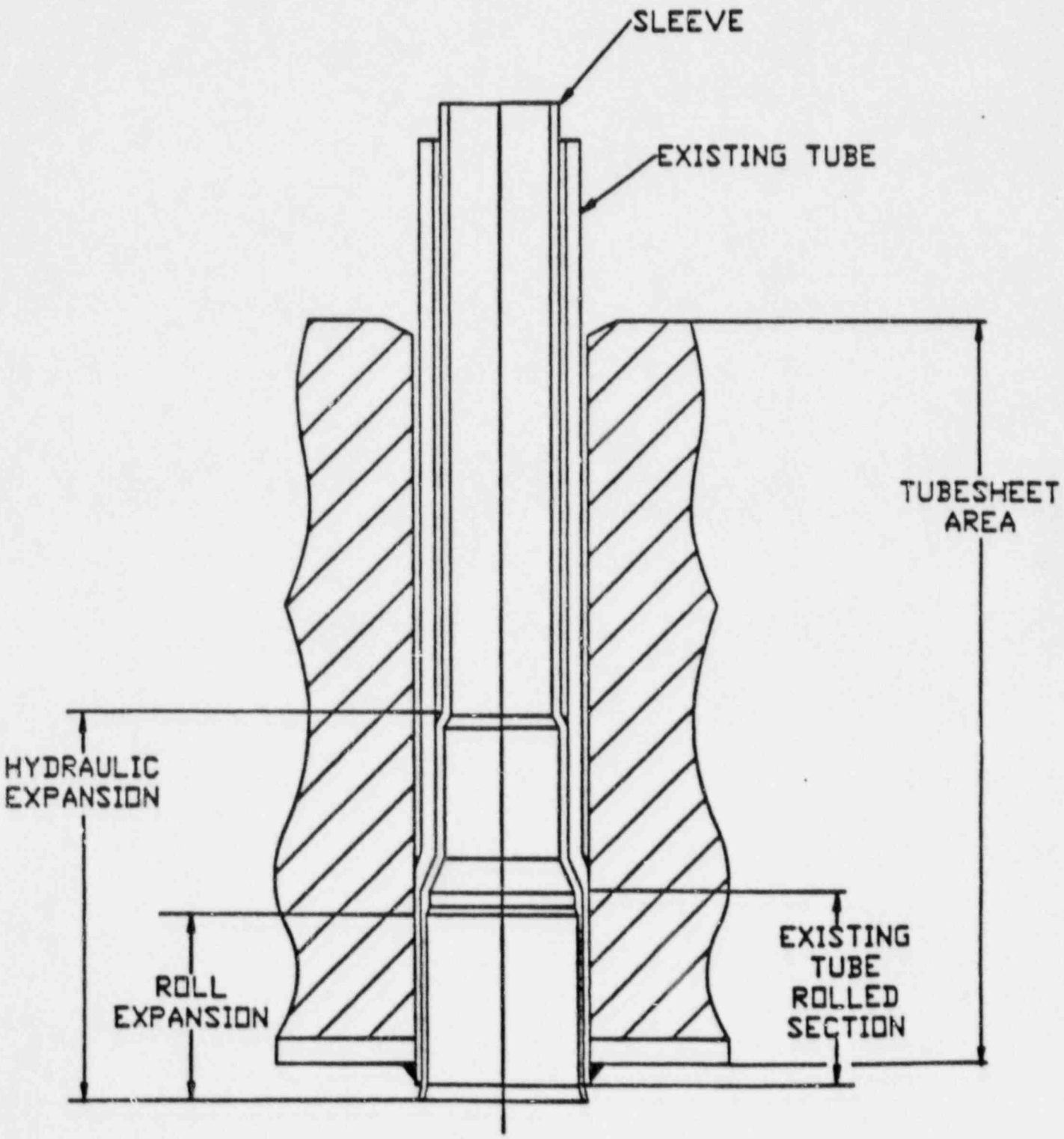
MEASUREMENT REFERENCE POINT
SLEEVE ROLL TRANSITION - MEASURED FROM THE SLEEVE END TO THE TOP OF THE SLEEVE ROLL TRANSITION BY EDDY CURRENT.

REFERENCE SLEEVE LOWER HARD ROLL PROCESS ASSUMPTIONS

TUBE ROLLED SECTION IS A MINIMUM OF [ ]^{a,c} INCHES IN LENGTH.

NO PLUGGABLE INDICATIONS EXIST IN THE TUBE IN THE SLEEVE ROLL EXPANSION REGION.

Sleeve Lower Joint Configuration



LOWER SLEEVE MECHANICAL JOINT ACCEPTANCE CRITERIA

LOWER JOINT HYDRAULIC EXPANSION HAS OCCURRED AND MEETS DIMENSIONAL REQUIREMENTS.

LOWER ROLL JOINT HAS BEEN PERFORMED AT PROPER TOOL TORQUE SETTING.

LOWER ROLL IS CONTAINED WITHIN THE SLEEVE HYDRAULIC EXPANSION REGION.

VERIFICATION OF SLEEVE INSTALLATION

LOWER HYDRAULIC EXPANSION

EXPANSION CONTROLLER REGISTERS "SWAGE" LIGHT.

POST INSTALLATION EDDY CURRENT DIMENSIONAL DATA IS COMPARED TO ACCEPTANCE CRITERIA.

LOWER ROLL EXPANSION

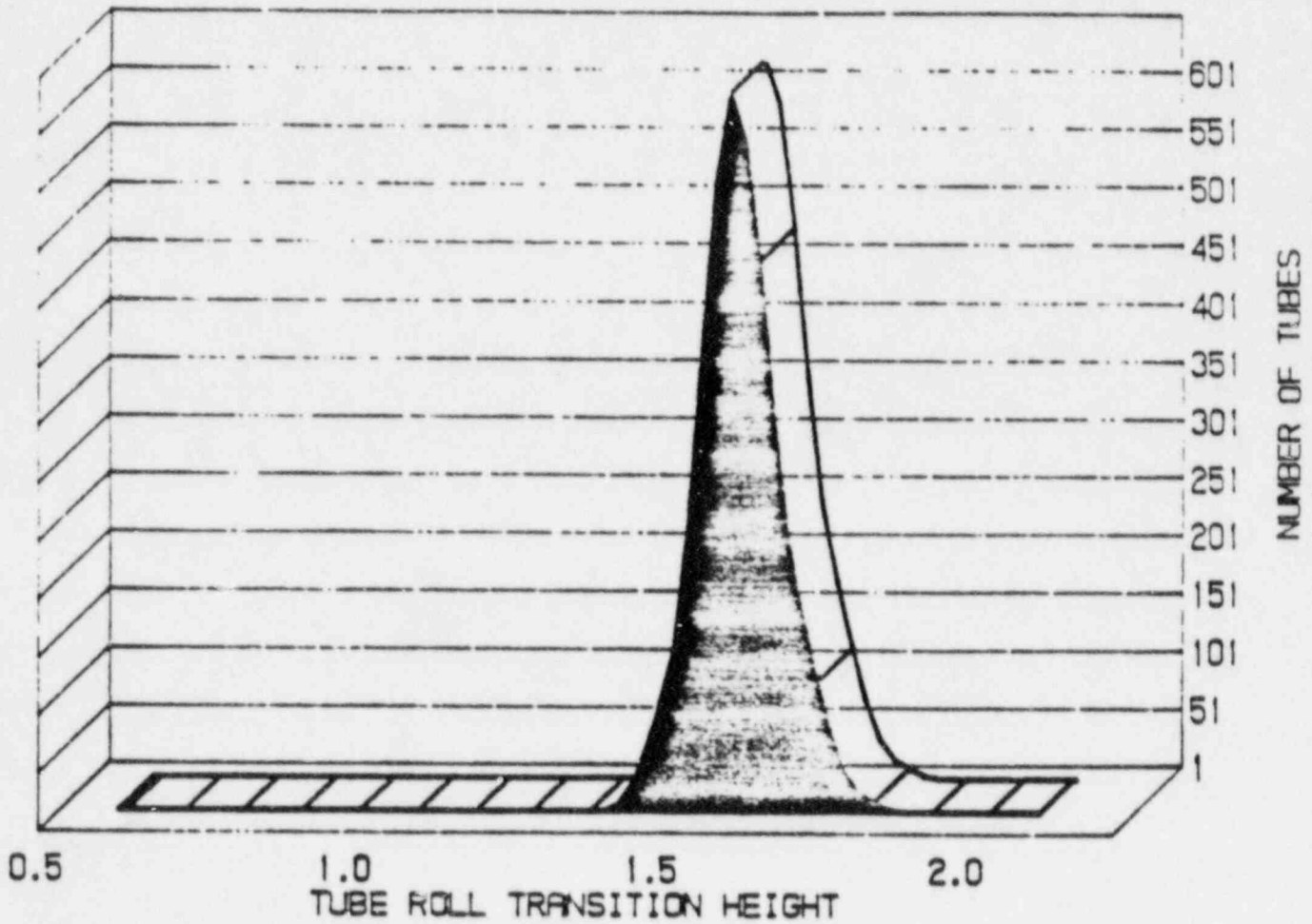
TOOL TORQUE IS PERIODICALLY EXAMINED ON A CALIBRATED TORQUE ANALYZER.

TOOL REGISTERS "TORQUE OUT" CONDITION.

POST INSTALLATION EDDY CURRENT DIMENSIONAL DATA IS COMPARED TO ACCEPTANCE CRITERIA.

DISTRIBUTION OF TUBE ROLL TRANSITION

ELEVATIONS IN STEAM GENERATOR A



ISSUES

THE EFFECT OF SHORT TUBE ROLLED SECTION ON THE REFERENCE SLEEVE LOWER ROLL EXPANSION PROCESS.

THE EFFECT OF TUBE DEGRADATION WITHIN THE REFERENCE SLEEVE LOWER ROLL EXPANSION PROCESS.

EDDY CURRENT DATA RESULTS

1. THE SLEEVE LONG LOWER HARD ROLL HAS EXPANDED THE SLEEVE AND TUBE.

2. THE SLEEVE MOUTH OF SOME ROLLS DID NOT REACH FULL ROLL DIAMETER.

3. THE SHORT LOWER ROLL EFFECTIVELY FORMED THE SLEEVE MOUTH.

4. NO INCREASE IN ROLL DIAMETER WAS SEEN BECAUSE OF THE SHORT ROLL.

CONCLUSION FROM EDDY CURRENT DATA

1. LONG SLEEVE ROLL IS PRODUCING JOINTS OF UNIFORM DIAMETER WHEN COMBINED WITH SHORT ROLL PROCESS.

a,e

This page is a reproduction of the output from the equipment used to analyze the eddy current tests.

MODIFIED LOWER SLEEVE JOINT INSTALLATION PARAMETERS

PURPOSE

TO ADDRESS SITE CONDITIONS WHICH DIFFER FROM QUALIFICATION BASE OF REFERENCE JOINT DESIGN.

BACKGROUND

THE REFERENCE JOINT DESIGN IS BASED ON [ ]^{a,c} INCH LONG HARD ROLLS IN THE BASE TUBE MATERIAL.

IN STEAM GENERATOR A THE TUBE ROLLS OCCUR AT APPROXIMATELY [ ]^{b,c} INCH.

THIS CONDITION WAS DISCOVERED DURING REVIEW OF EDDY CURRENT DATA DURING SLEEVING OPERATIONS.

SITE MEASUREMENTS (PRE-SLEEVING EDDY CURRENT) WERE REVIEWED TO DETERMINE THE ROLL TRANSITION HEIGHT IN THE PARENT TUBE MATERIAL IN STEAM GENERATORS A AND B. STEAM GENERATOR B HAD ONLY 5 TUBES WITH LOW TRANSITIONS, STEAM GENERATOR A HAD ALMOST ALL LOW TRANSITIONS.

NINETEEN TUBES DISPLAY INDICATIONS IN THESE LOW ROLL TRANSITIONS.

LOWER JOINT VERIFICATION PROGRAM

TEST SPECIMENS WERE MADE TO SIMULATE THE SITE CONDITIONS AND ARE BEING SUBJECTED TO TESTING.

SHORT TERM TESTING IS IN PROGRESS TO SHOW ACCEPTABILITY FOR UNIT STARTUP.

LONG TERM TESTING WILL BE PERFORMED TO SUPPORT ACCEPTABILITY FOR EXTENDED OPERATION.

FROM PAST DATA, THE SHORT TERM TESTS ARE INDICATIVE OF LONG TERM ACCEPTABILITY.

TEST PROGRAM

18 SPECIMENS REPRESENTING 6 CONDITIONS

1. NORMAL SLEEVE INSTALLATION IN A TUBE WITH A LOW ROLL.

2. NORMAL SLEEVE INSTALLATION IN A TUBE WITH A LOW ROLL AND A FULL CIRCUMFERENTIAL SEVERANCE.

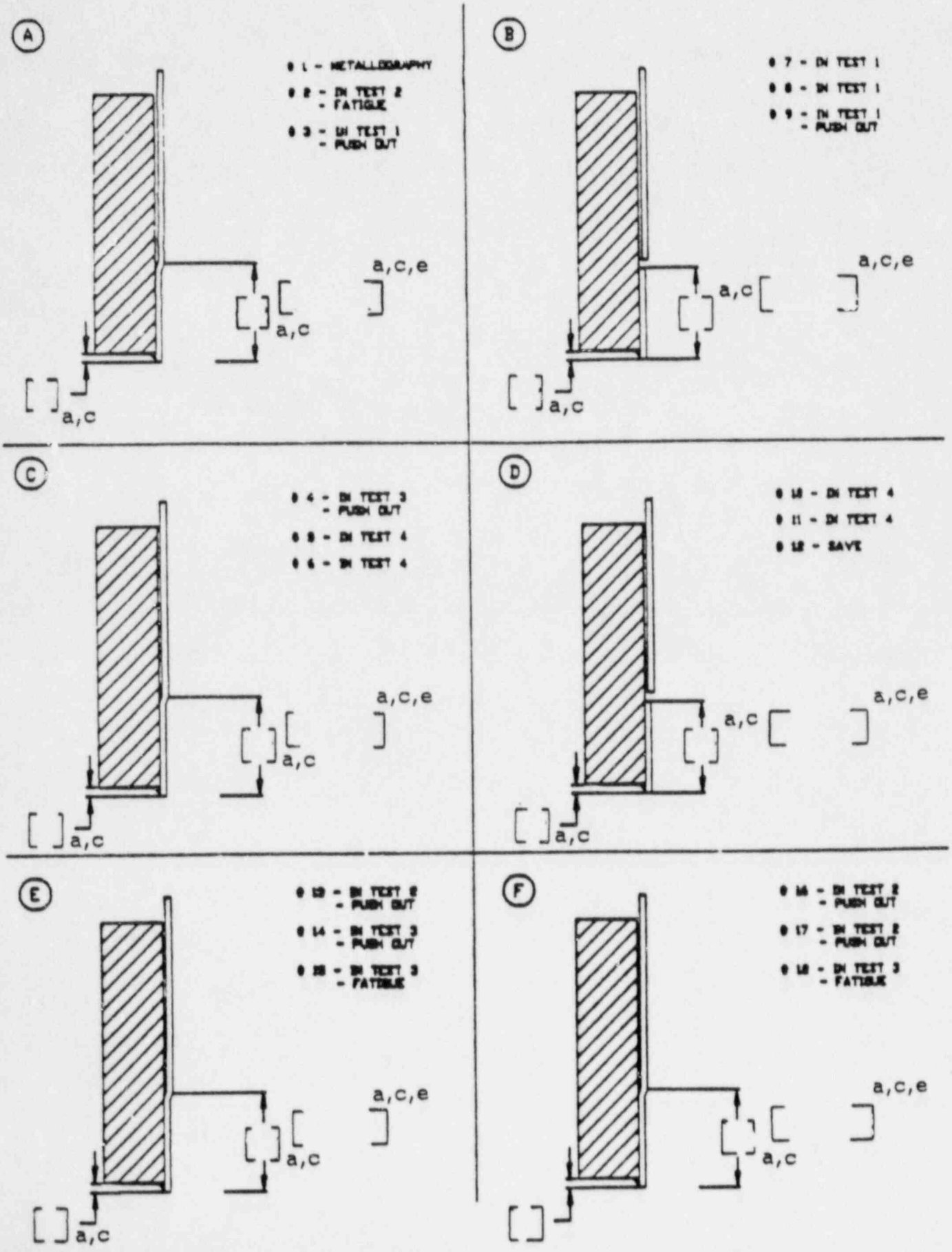
3. SLEEVE WITH SHORT ROLL AT HIGH TORQUE IN A TUBE WITH A LOW ROLL.

4. SLEEVE WITH A SHORT ROLL AT A HIGH TORQUE IN A TUBE WITH A LOW ROLL AND A FULL CIRCUMFERENTIAL SEVERANCE.

5. SLEEVE WITH A SHORT ROLL AT LOW END OF TOLERANCE BAND OF PROPORTIONED TORQUE IN A TUBE WITH A LOW ROLL.

6. SLEEVE WITH A SHORT ROLL AT A NOMINAL PROPORTIONED TORQUE IN A TUBE WITH A LOW ROLL.

LOWER ROLL TEST PROGRAM

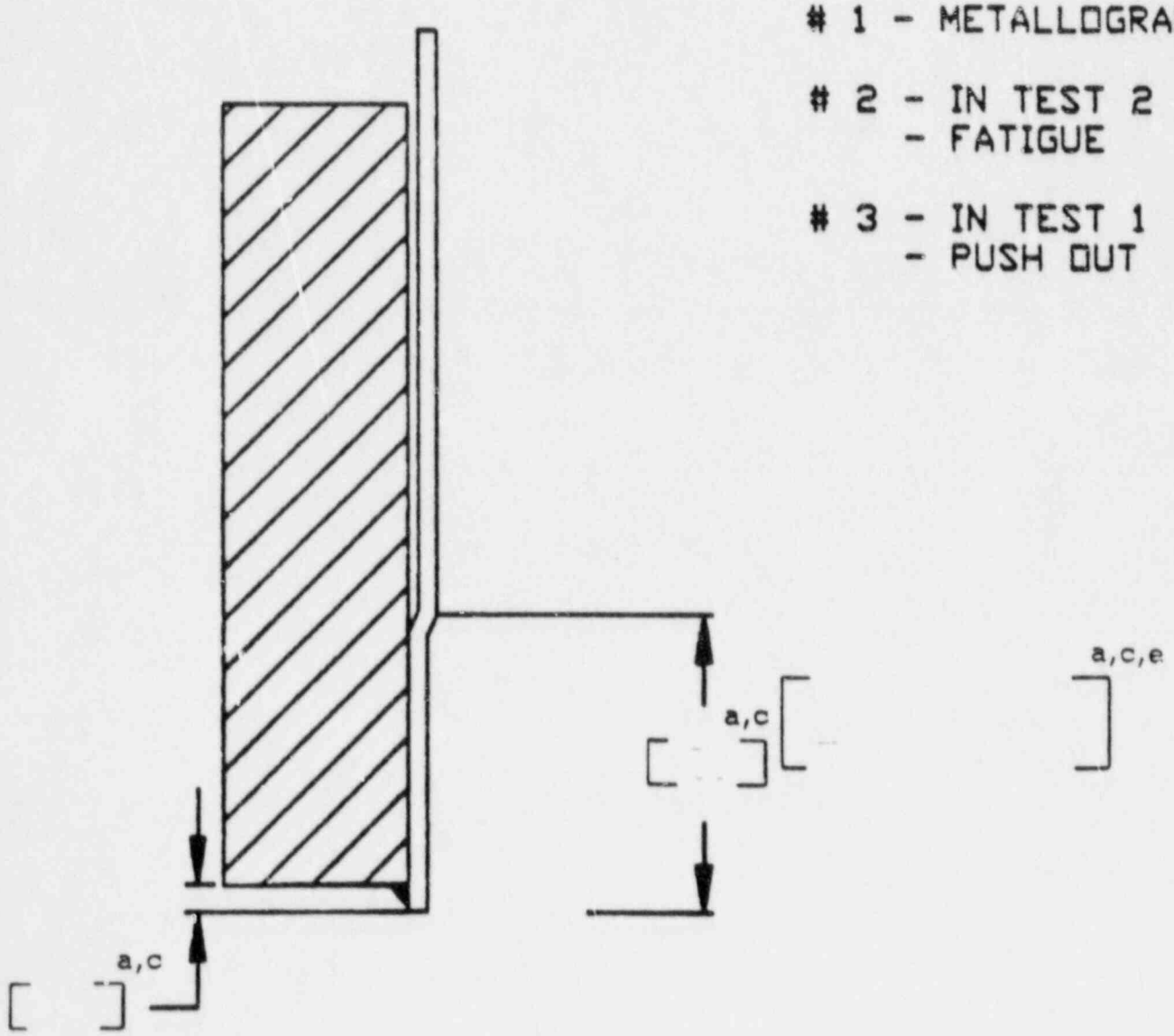


(A)

1 - METALLOGRAPHY

2 - IN TEST 2
- FATIGUE

3 - IN TEST 1
- PUSH OUT

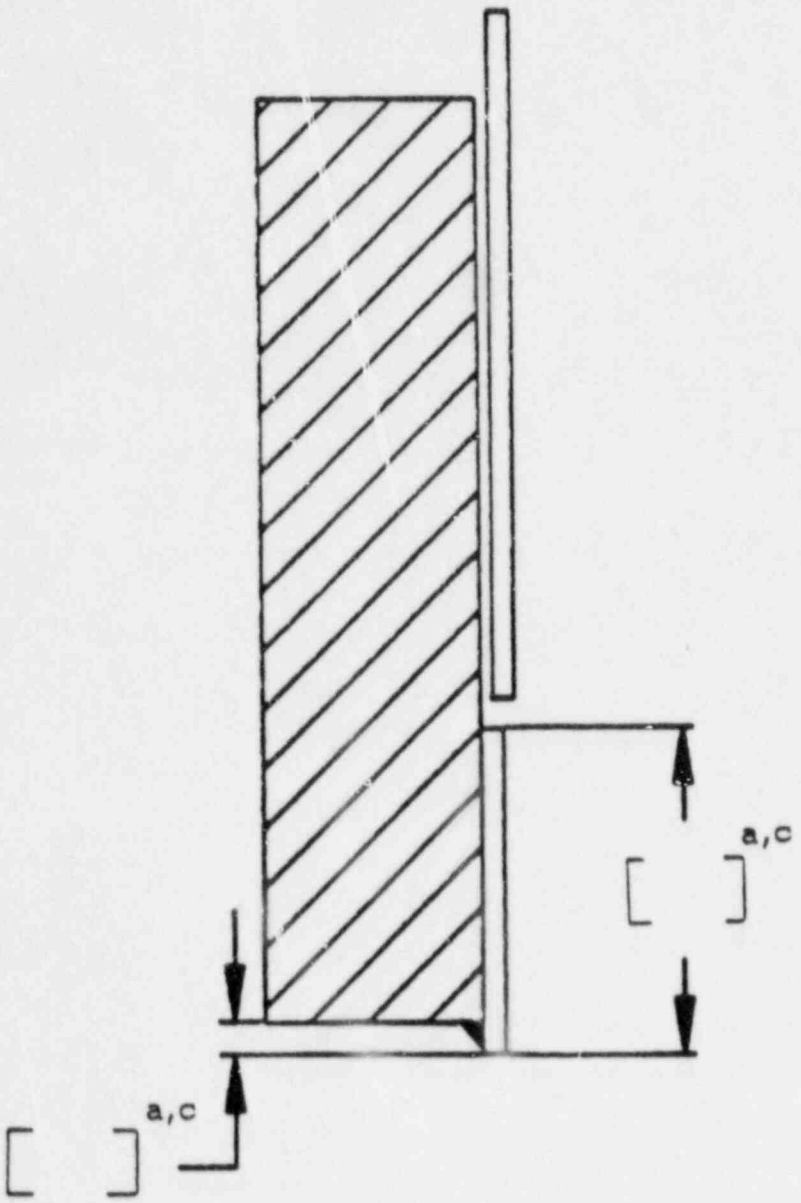


(B)

7 - IN TEST 1

8 - IN TEST 1

9 - IN TEST 1
- PUSH OUT

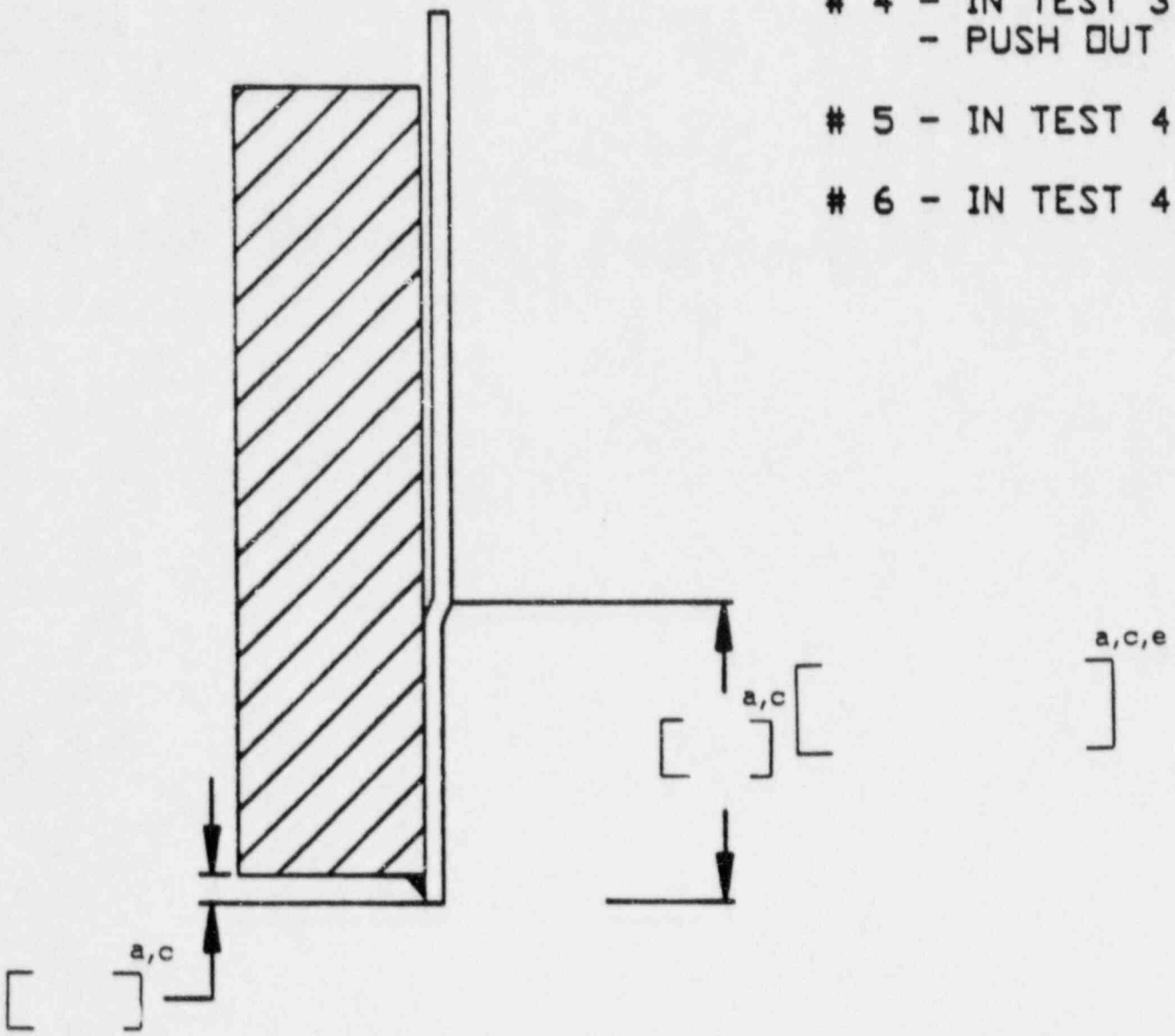


(C)

4 - IN TEST 3
- PUSH OUT

5 - IN TEST 4

6 - IN TEST 4

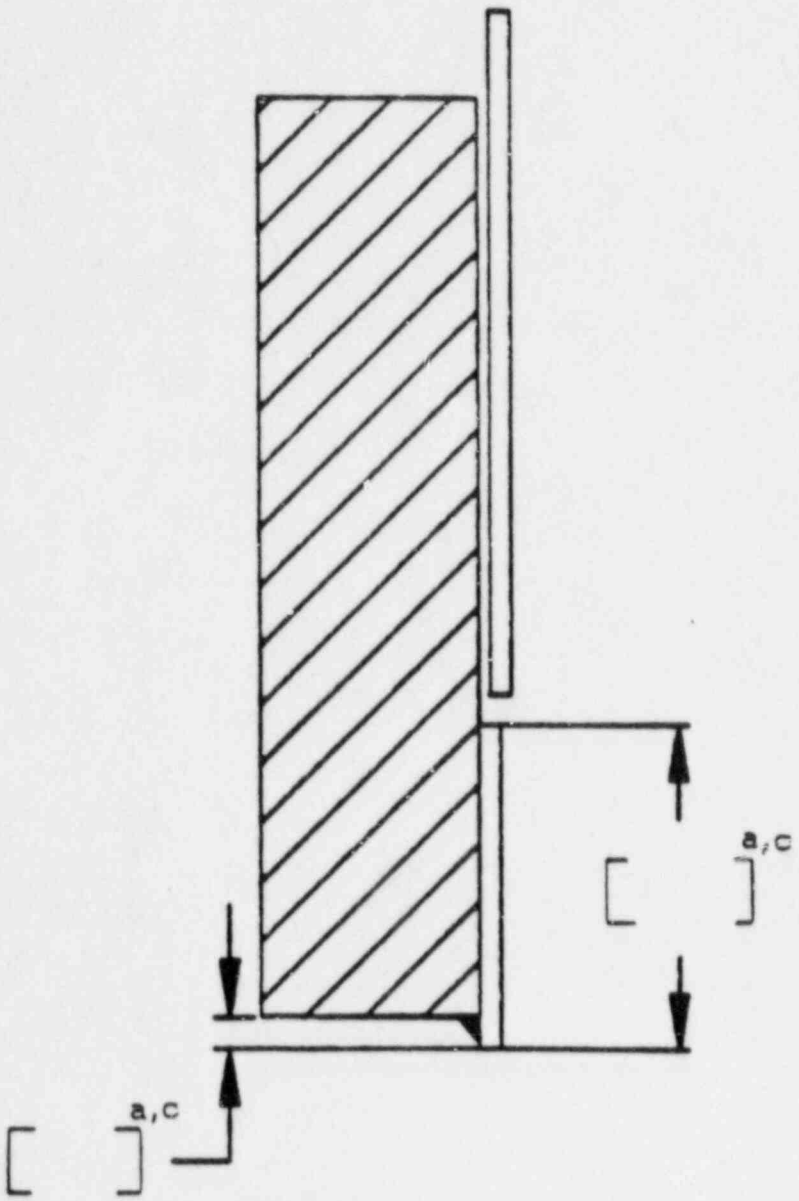


(D)

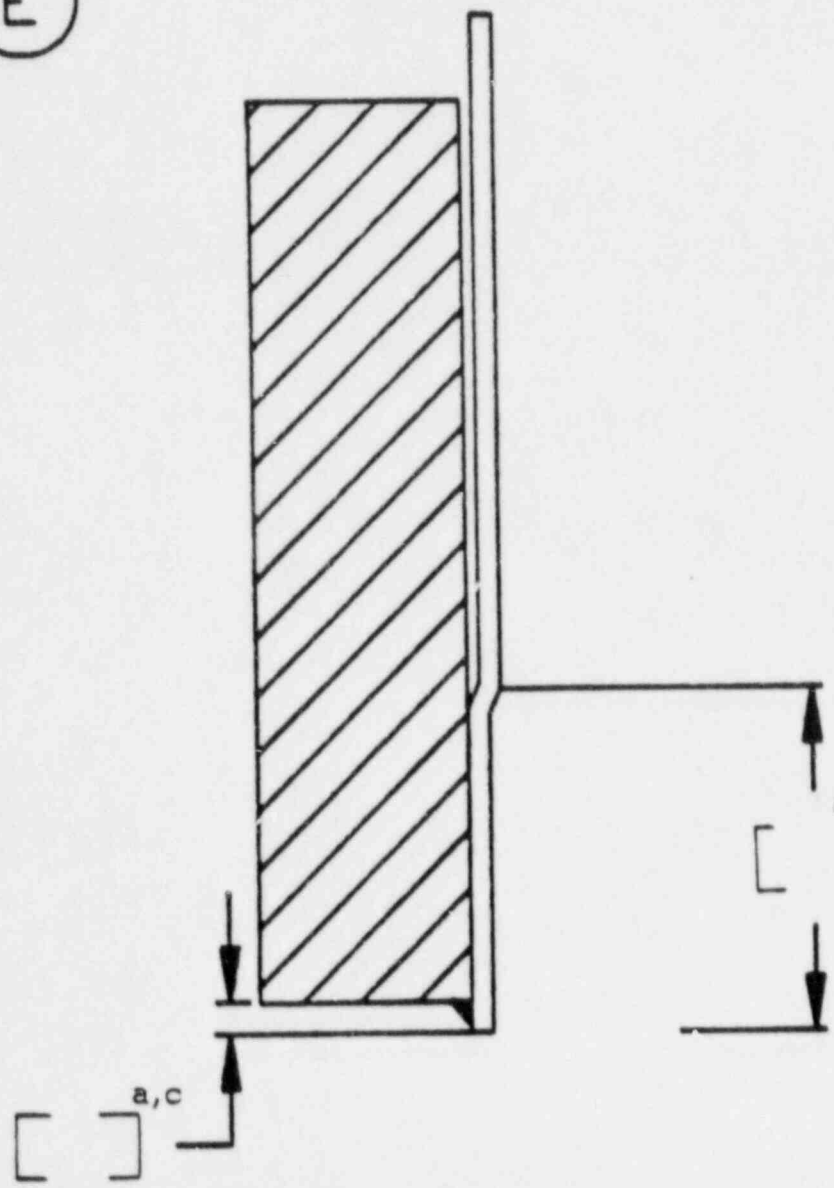
10 - IN TEST 4

11 - IN TEST 4

12 - SAVE



(E)

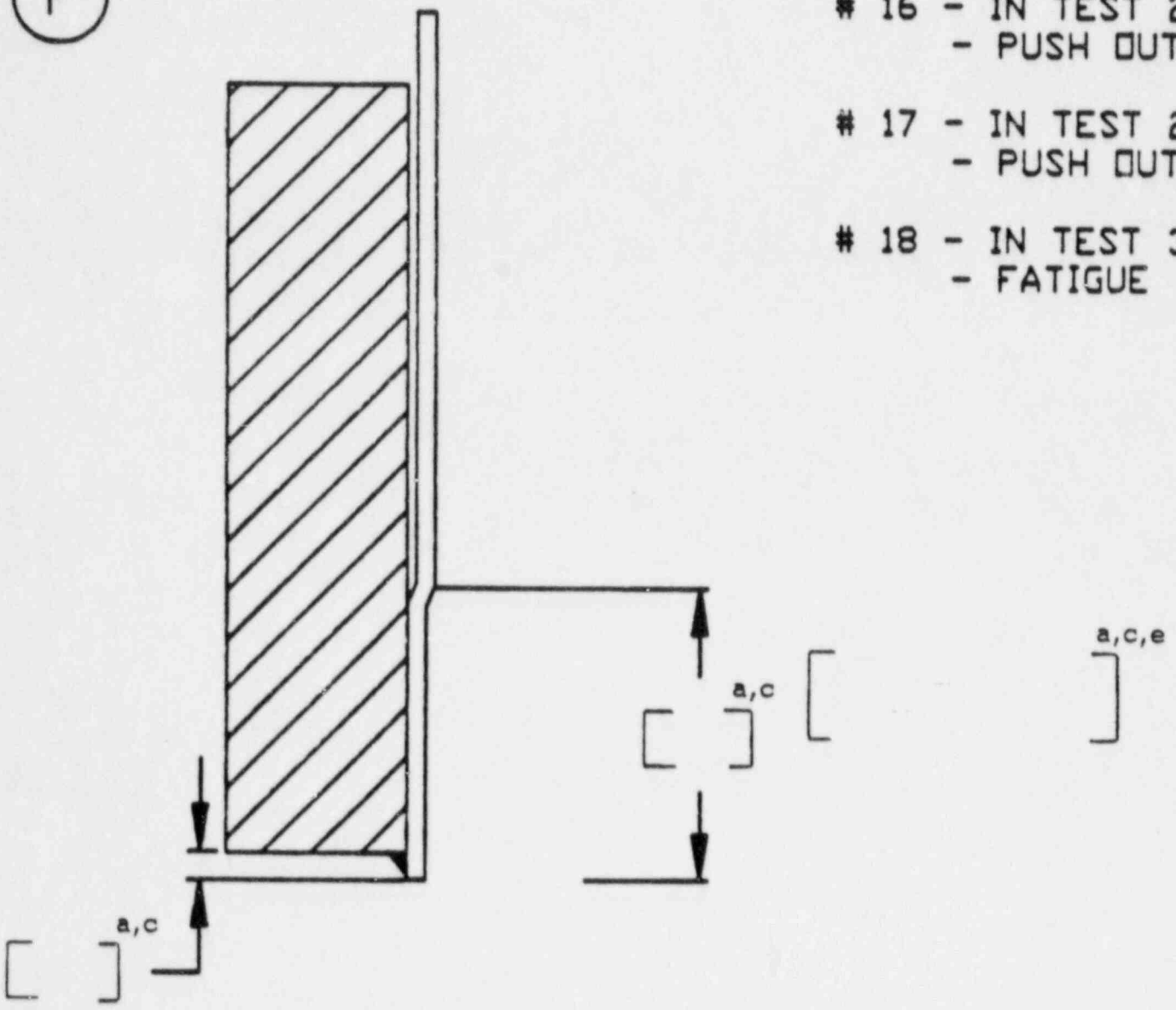


13 - IN TEST 2
- PUSH OUT

14 - IN TEST 3
- PUSH OUT

15 - IN TEST 3
- FATIGUE

(F)

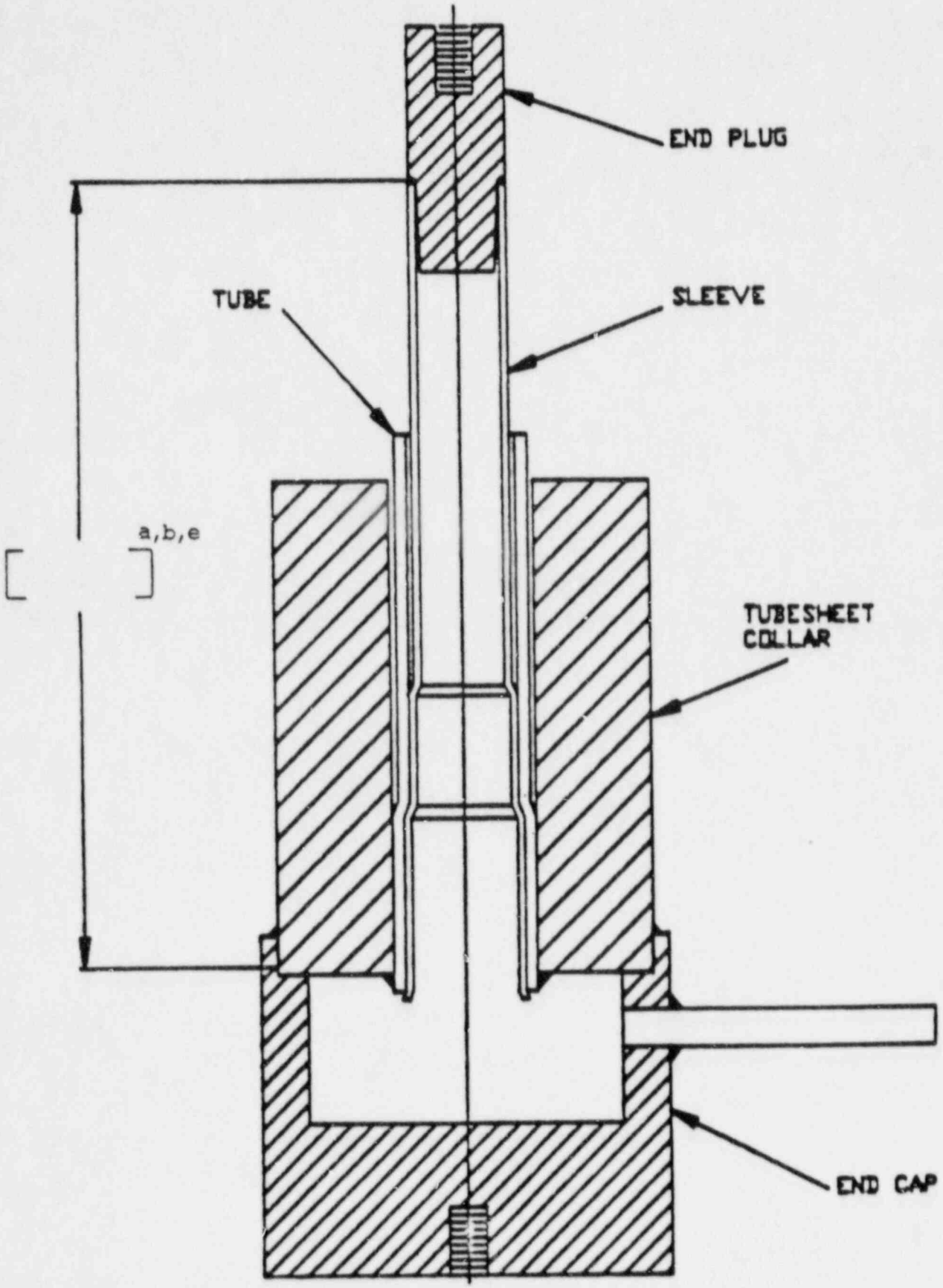


16 - IN TEST 2
- PUSH OUT

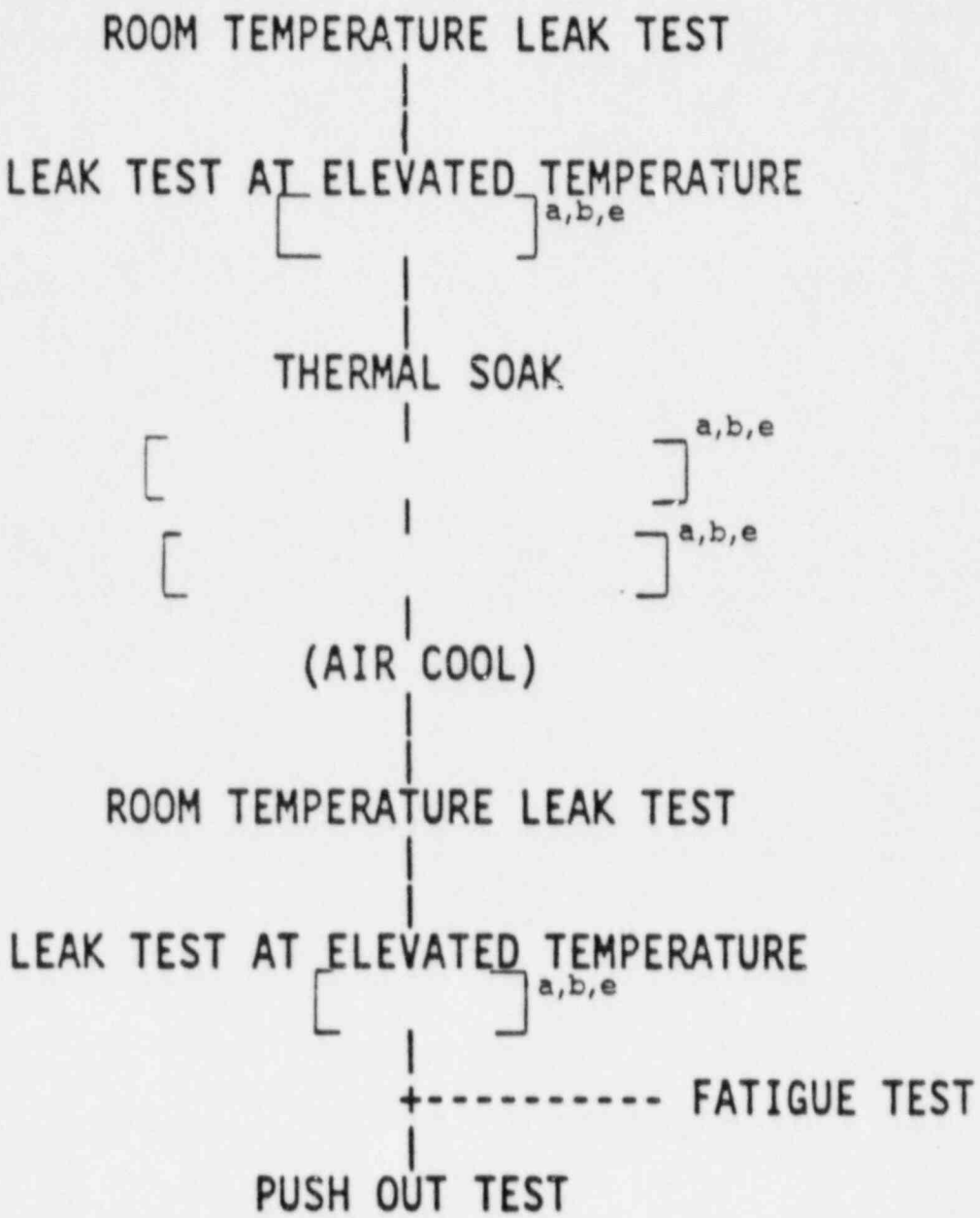
17 - IN TEST 2
- PUSH OUT

18 - IN TEST 3
- FATIGUE

LOWER JOINT TEST ASSEMBLY



SHORT TERM TEST PROGRAM



b

This page is a tabulation of the results of the short term leak testing and push out tests. The leak rates are given for room temperature and elevated temperatures before and after a thermal soak at elevated temperature. The push out loads are given for initial slippage and one inch of movement.

LOWER JOINT LEAK TEST DATA
(DROPS/MINUTE)

TABLE 3.3.4.3-1

MAXIMUM ALLOWABLE LEAK RATES FOR
KEWAUNEE STEAM GENERATORS

Condition	Allowable Leak Rate*	Allowable Leak Rate per Sleeve*
Normal Operation	.35 gpm (500 gpd)	[ ] d,e

	Limiting Leak Rate	Leak Rate per Sleeve
Postulated Accident Condition (Steamline Break)	[	] b,d,e

* Based on [2000]d,e sleeves per steam generator.

+ Standard Technical Specification Limit for 1 steam generator.

++ [

.]b,d,e

The analysis assumes primary and secondary coolant initial inventories of 1μCi/gm and 0.1μCi/gm of Dose Equivalent I-131, respectively. In addition, as a result of the reactor trip, an iodine spike is initiated which increases the iodine appearance rate in the primary coolant to a value equal to 500 times the equilibrium appearance rate.

RESULTS OF ANALYSIS AND TEST

CALCULATED LOADS:

NORMAL OPERATING = [ ]^{b,c,e}(end cap load)
STEAM LINE BREAK = [ ]^{b,c,e}(end cap load)

THEREFORE

1. THE [ ]^{a,c,e}INCH EFFECTIVE ROLL DISPLACEMENT RESISTANCE COMPARES FAVORABLY WITH THE ORIGINAL SLEEVE HARD ROLL DESIGN.

2. THE LOAD CAPACITY OF THE [ ]^{a,c,e}INCH EFFECTIVE ROLL EXCEEDS THE CALCULATED LOADS DUE TO NORMAL OPERATING AND STEAM LINE BREAK CONDITIONS.

CONCLUSION FROM LEAK TEST AND PULL OUT TESTS

1. LONG LOWER SLEEVE ROLL JOINT (BASE PROCESS) PRODUCES ACCEPTABLE RESULTS WHEN APPLIED OVER LOW TUBE ROLL TRANSITIONS.

2. THE SHORT LOWER ROLL PROCESSES TESTED PRODUCE ACCEPTABLE RESULTS AND CAN BE USED A STAND ALONE PROCESS.

3. THE ACCEPTABLE BEHAVIOR OF THE SHORT LOWER JOINT SHOWS THE FULL CONTACT AREA OF THE BASE JOINT PROCESS IS NOT REQUIRED FOR ACCEPTABLE PERFORMANCE.

4. THE SHORT OR BASE PROCESS IS ACCEPTABLE TO APPLY OVER TUBING WHICH HAS EDDY CURRENT INDICATIONS AS LOW AS[ ]^{a,c,e} INCHES FROM THE TUBE END.

CORROSION CONSIDERATIONS

PREVIOUS CORROSION DATA APPLIES

HYDRAULIC EXPANSION INSTALLATION PARAMETERS ARE UNCHANGED.

ROLL EXPANSION IS CONTAINED WITHIN THE HYDRAULIC EXPANSION REGION.

SHORT REROLL IS APPLIED AT REDUCED TORQUE, MAINTAINING CONSISTENT COLD WORKING AND STRAIN OF SLEEVE.

THERMALLY TREATED ALLOY 690 HAS SUPERIOR CORROSION RESISTANCE, PARTICULARLY WITH REGARDS TO PWSCC.

LONG TERM TEST PROGRAM

FATIGUE TESTING WITH THERMAL CYCLING

HEAT TO [ ]^{b,e}

EXTERNAL LOAD CYCLED [ ]^{a,b,e} LBS COMPRESSIVE
(RESULTS IN ACTUAL JOINT LOADING OF [ ]^{a,b,e} LBS
TENSION TO [ ] COMPRESSION. LOAD IS
CYCLED AT [ ]^{b,e} HERTZ

[ ]^{b,e} FATIGUE CYCLES

THERMAL CYCLING

[ ]^{b,e} CYCLES (ROOM TEMPERATURE TO [ ]^{b,e}

ELEVATED TEMPERATURE PUSH OUT AND PULL OUT

PUSH OUT AND PULL OUT MEASURED AT [ ]^{b,e}

CONCLUSIONS

1. THE BASE LOWER SLEEVE JOINT PROCESS IS STILL VALID WITH TUBES HAVING LOW ROLL TRANSITIONS AND CLEAN CREVICES.

2. POST SLEEVE INSTALLATION EDDY CURRENT INDICATES THAT TUBES AT KEWAUNEE HAVE CLEAN CREVICES.

3. THE BASE LOWER SLEEVE JOINT PROCESS IS EFFECTIVE WITH TUBES HAVING LOW ROLL TRANSITIONS WHICH DISPLAY INDICATIONS, AND CLEAN CREVICES.

4. A MODIFIED LOWER SLEEVE JOINT PROCESS (HAVING A SHORTER ROLL ZONE) IS EFFECTIVE IN TUBES WITH SHORT TUBE ROLLS ON A STAND ALONE BASIS.

SAFETY EVALUATION

The use of the modified lower sleeve joint does not have an adverse effect on the safe operation of the steam generator from the previously reviewed joint design.

* The same design and acceptance criteria are used for structural integrity and leak tightness.

* The flow margin for normal operation and postulated accident conditions is not adversely effected.

* Residual stresses in the sleeve transitions are the same of lower than the original design.

* Inservice inspection capability and acceptance criteria are not adversely effected.

* Technical Specification changes are not required.

SAFETY EVALUATION

The use of the revised lower sleeve joint is not an unreviewed safety question per the criteria of 10CFR50.59

* The modification does not reduce the margin to safety.

* The modification does not increase the potential of a previously analyzed accident.

* The analysis of a tube rupture accident bounds all possible hypothetical failures of a sleeve.