

GINNA STATION
B-STEAM GENERATOR
NRC MEETING
MARCH 23, 1982

AGENDA

- INTRODUCTION
- INSPECTION AND EXAMINATION RESULTS
- DAMAGE MECHANISM EVALUATION
- RECOVERY PROGRAM
- TECHNICAL BASIS FOR REPAIRS
- PLANT SCHEDULE
- CONCLUSION

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OBJECTIVES

- DETERMINE FULL EXTENT OF DEFECTS AND LOOSE PARTS
- DETERMINE FAILURE MECHANISM(S)
- RESTORE STEAM GENERATOR TO A CONDITION WHICH IS SAFE TO OPERATE MAINTAINING RADIATION EXPOSURES AS LOW AS REASONABLY ACHIEVABLE
- OBTAIN NRC CONCURRENCE FOR RETURN TO POWER

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PURPOSE OF MEETING

- TO REVIEW RESULTS OF INSPECTIONS TO DATE
- TO OBTAIN CONCURRENCE WITH STEAM GENERATOR PROGRAM CONCEPTS
- TO OBTAIN APPROVAL FOR REMOVAL OF STEAM GENERATOR TUBE SECTIONS

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NSARB/NRC REVIEWS

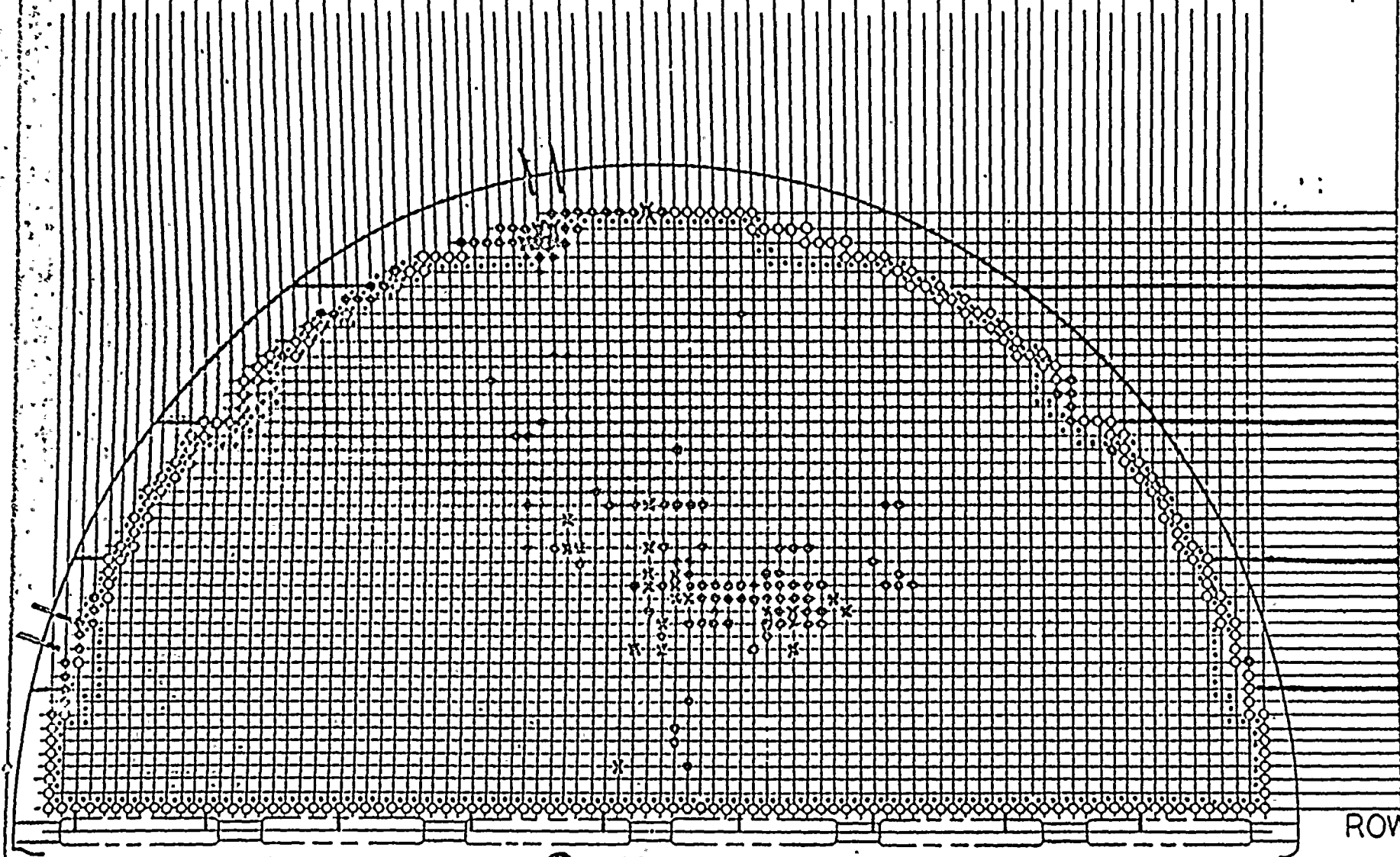
- o concurrence with program concepts
 - NSARB - 2/26
 - NRC - 3/1
- o approval of removal of metallurgical samples
 - NSARB - 2/26
 - NRC - 3/1
- o approval of repair program
 - NSARB - 3/16
 - NRC - 3/23
- o approval of return to power
 - NSARB - mid April
 - NRC - late April

RG&E Steam Generator

91 89 87 85 83 81 79 77 75 73 71 69 67 65 63 61 59 57 55 53 51 49 47 45 43 41 39 37 35 33 31 29 27 25 23 21 19 17 15 13 11 9 7 5 3 1

COLUMN

92 90 88 86 84 82 80 78 76 74 72 70 68 66 64 62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2



MANWAY



PLUGGED TUBES



SLEEVED TUBES

NOZZLE

ROW

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INSPECTION UPDATE
NO. 4 WEDGE AREA

- o R45C54
-missing and severed at first support plate
- o R44C54
-severed at top of tubesheet
- o R44C55
-severed at top of tubesheet
-partially severed at first support plate
- o R43C55
-severed at top of tubesheet
- o R44C56
-missing and severed at first support plate
- o R44C57
-missing and severed at first support plate

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METALLURGICAL EXAMINATION

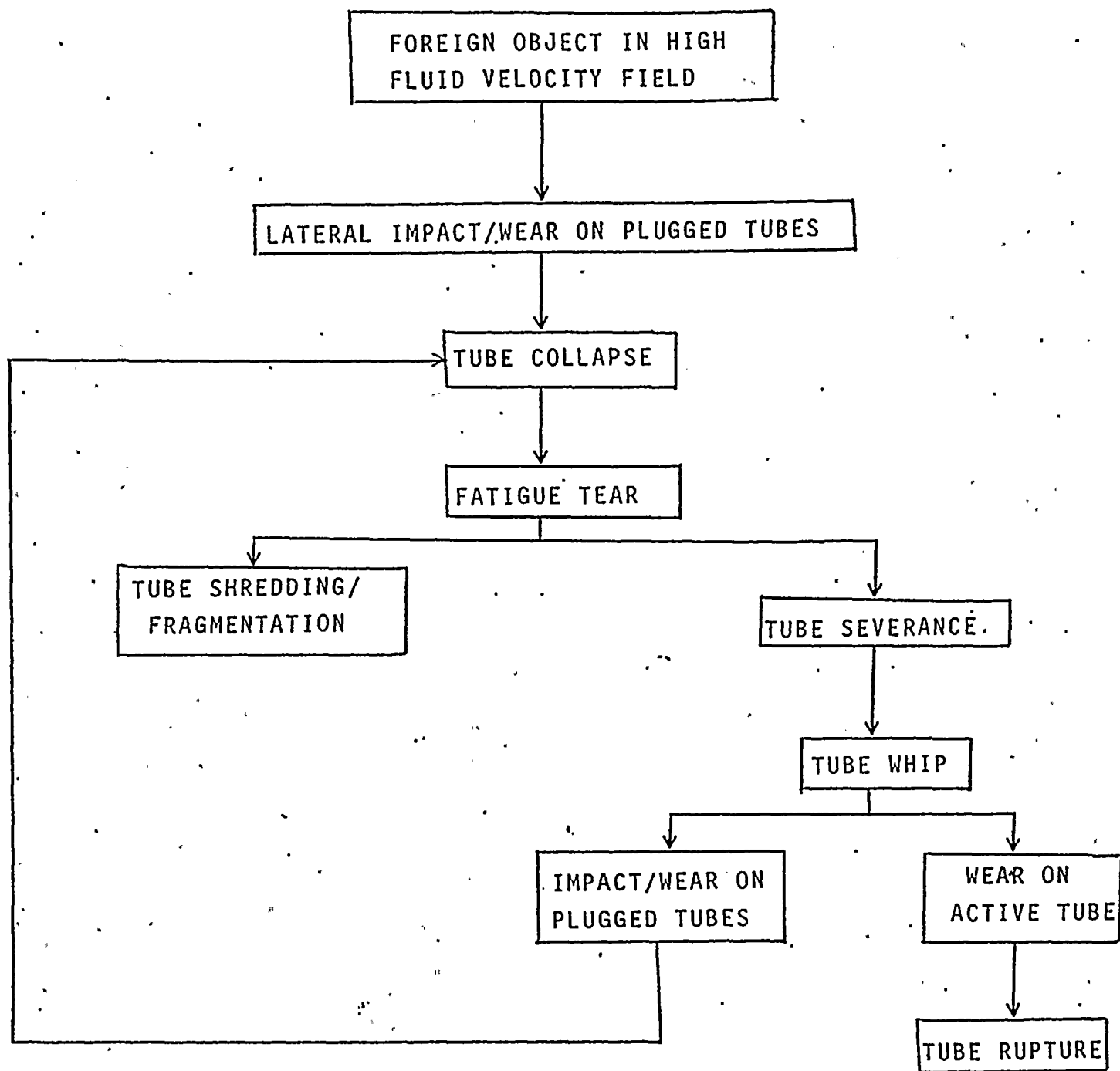
- o site photography
- o Westinghouse R&D laboratories
- o model for wear orientation comparisons
- o photography at 90° increments
- o radiography at 45° increments
- o transverse cross sections of column 55 tubes
 - R42C55 - 2.5" and 4" from upper end
 - R43C55 - 2.5" and 4" from upper end
 - R44C55 - 2.5", 4" and 8" from upper end
 - SEM and standard photomicrographs

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LABORATORY EXAMINATION REMOVED TUBING

- WEAR SURFACES
- PRIMARILY RUBBING WEAR CIRCUMFERENTIAL DIRECTION
- NO EVIDENCE OF CORROSION INVOLVEMENT
- EVIDENCE OF SURFACE COLD WORKING
- FATIGUE STRIATION ON FRACTURE SURFACE
- TENSILE OVERLOAD BURST TUBE FAILURE SURFACE.

R. E. GINNA S/G B - POSTULATED TUBE RUPTURE MECHANISM.



MECHANISM EVALUATION PROGRAM

- 0 INVESTIGATION OF VARIOUS INFLUENCES
 - MECHANICAL LATERAL LOADS
 - GROSS FLUID LOADS
 - AXIAL LOADS
 - LOCAL FLUID LOADS
- 0 HISTORICAL INFORMATION REVIEW
- 0 INITIAL PERIMETER TUBE INVESTIGATION
- 0 LABORATORY EXAMINATION OF REMOVED TUBE SECTIONS
- 0 MODEL TESTING
- 0 LABORATORY COLLAPSE AND FATIGUE TESTING
- 0 FIELD TESTING AND EXAMINATION

LATERAL LOADS

- 0 EXTERNAL PRESSURE
- 0 TUBE OVALITY
- 0 VARYING LEVELS OF CONCENTRATED LOADS
- 0 VARYING LEVELS OF TUBE WALL THICKNESS
- 0 AXIAL LOAD AFFECT

GROSS FLUID LOADS

0 FLUID ELASTIC INTERACTION ANALYSIS

FLOW VELOCITIES

TUBE CROSS SECTION

FLUID ELASTIC STABILITY

VORTEX SHEDDING

CROSS FLOW

0 EFFECT OF TUBE REMOVAL ON FLUID FLOW FIELD

AXIAL LOADS

0 STRUCTURAL EVALUATION

TUBE-TO-SHELL MISMATCH

TUBE-TO-TUBE MISMATCH

MISALIGNMENT

TUBESHEET-SUPPORT PLATE MISMATCH

TUBESHEET ROTATION

STRESS CONCENTRATION

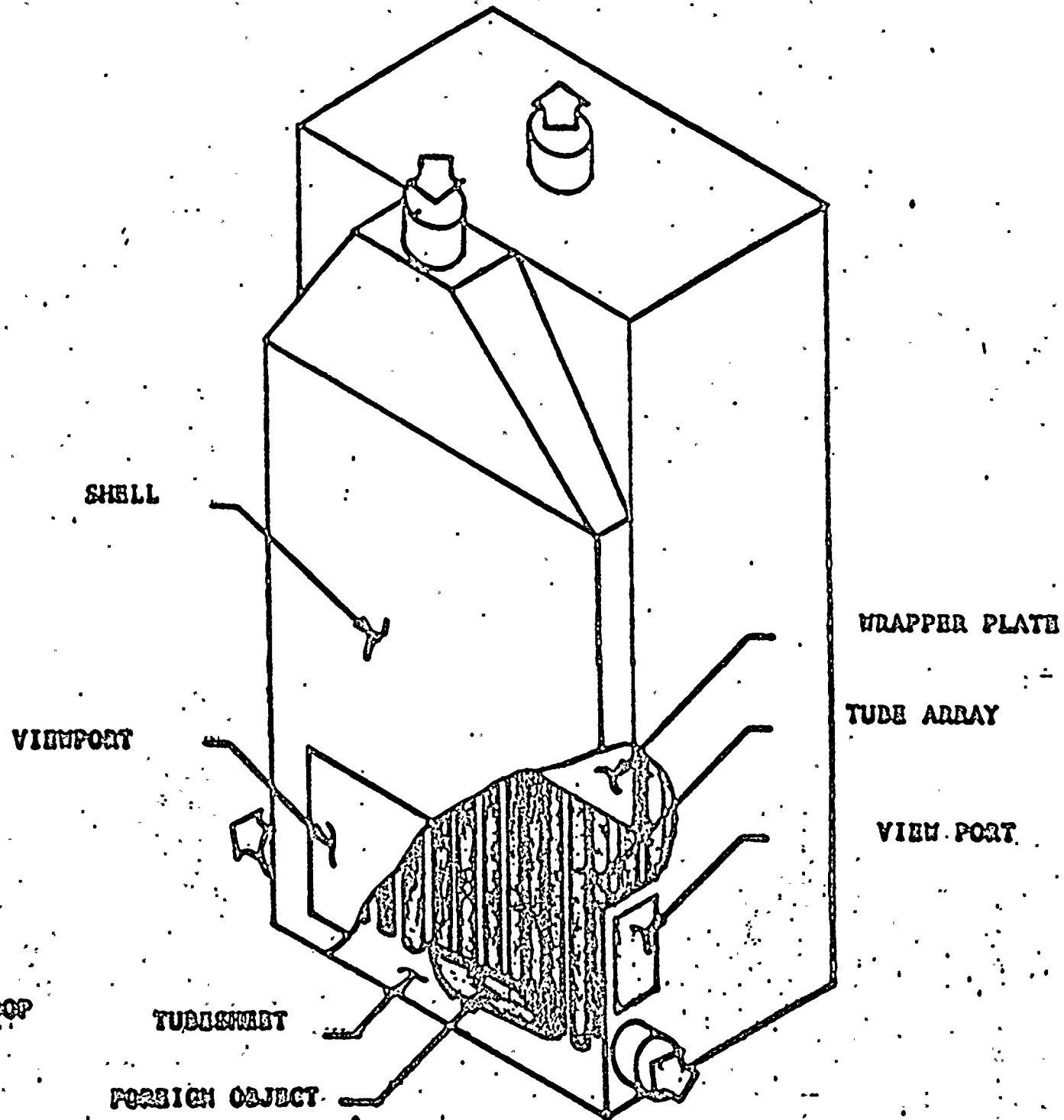
0 U-BEND WITH REMOVED SECTION

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LABORATORY EXAMINATION REMOVED TUBING

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BUNDLE INLET FLOW MODEL



COLD FLOW TEST LOOP
HEAT EXCHANGER TEST
FACILITY
TAMPA, FLORIDA
KLM-2/82

LABORATORY TESTING

0 COLLAPSE TESTING

EXTERNAL PRESSURE

LATERAL LOADS

AXIAL LOAD

0 FATIGUE TESTING

AMPLITUDES

GEOMETRY

BOUNDARY CONDITION

AXIAL LOAD

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CORRECTIVE ACTIONS

- o eddy current examination
- o video inspections
- o obtain metallurgical samples
- o remove structurally degraded tube sections
- o restore preventatively plugged tubes to service
- o remove foreign objects and tubing fragments
- o eddy current examine tubes adjacent to repairs
- o secondary side video inspection following repairs
- o primary and secondary hydrostatic tests
- o metal impact monitoring system


























































































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B-STEAM GENERATOR
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MARCH 23, 1982


REPAIR OPTIONS

- o EDM cutting process
- o mechanical cutters
- o hydraulic tube removal system
- o loose parts retrieval equipment
- o remove from tubesheet end
- o additional shell penetrations
- o proven repair techniques


GINNA STATION
B-STEAM GENERATOR


NO. 4 WEDGE AREA


COLUMN	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	
																		45
																		44
																		43
																		42
																		41
																		40
																		ROW

 Pulled April 1978 (1 tube)

 Structurally Degraded (19 tubes)

 Video Indication (1 tube)

 Eddy Current Signal (5 tubes)

































































 Preventatively Plugged (3 tubes)

GINNA STATION
B-STEAM GENERATOR
NO. 6 WEDGE AREA




COLUMN	92	91	90	89	88	87	86	
					○	○	○	19
					○	○	○	18
				⊗	○	○	○	17
				⊗	○	○	○	16
			⊗	⊗	○	○	○	15
			⊗	○	○	○	○	14
			⊗	○	○	○	○	13
		⊗	○	○	○	○	○	12
		⊗	○	○	○	○	○	11
		⊗	○	○	○	○	○	10
		⊗	○	○	○	○	○	9
	⊗	○	○	○	○	○	○	8
	○	○	○	○	○	○	○	7
								ROW

- ⊗ Structurally Degraded (5 tubes)
- ⊗ Video OD Indication (5 tubes)
- ⊗ Eddy Current Signal (1 tube)

GINNA STATION
B-STEAM GENERATOR
RC40C70 AREA

COLUMN	77	76	75	74	73	72	71	70	69	68	67	66	65	
														41
														40
														39
														38
														37
														36
														35
														34

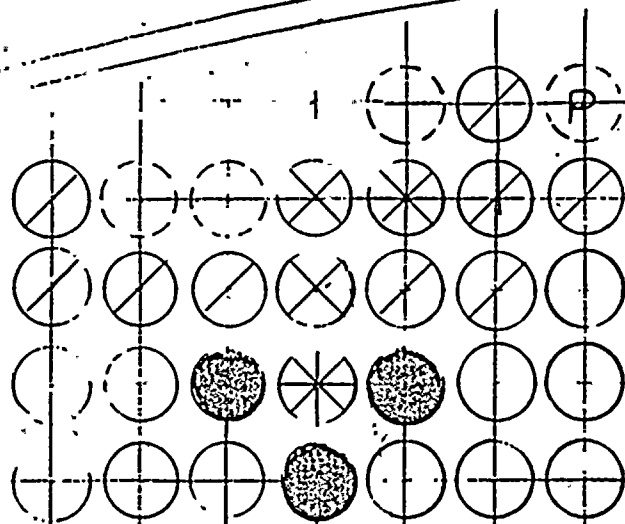
ROW

-  Structurally Degraded (no tubes)
-  Video OD Indication (5 tubes)
-  Eddy Current Signal (4 tubes)

3/19/82

SHELL

WRAPPER



45

44

43

42

41

58

57

56

55

54

53

52

GINNA STATION
B-STEAM GENERATOR
CATEGORIZATION OF DEFECTS

CATEGORY	NO. 6 WEDGE AREA	R40C70 AREA	NO. 4 WEDGE AREA	NO. 2 WEDGE AREA
1. Structurally Degraded	R8C92 R11C91 R12C91 R14C90 R15C90		R42C55M R43C59 R44C55M R43C53 R43C60 R44C56 R43C54M R43C61 R44C57 R43C55M R44C52 R44C58 R43C56M R44C53M R45C53 R43C57 R44C54 R45C54 R43C58	
2. Video OD Indication	R9C91 R10C91 R13C90 R16C89 R17C89	R38C71 R38C72 R39C68 R39C69 R39C70	R45C51	
3. Eddy Current Signal	R15C89	R35C75 R40C67 R40C68 R41C66	R45C46 R45C47M R45C48 R45C49 R45C50	R12C2 R28C12 R30C15 R31C15 R32C15 R32C16 R33C15
4. Preventatively Plugged			R41C55 R42C54 R42C56	
TOTALS	11	9	28	7

M Metallurgical Samples
R45C52 pulled April 1978.

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March 23, 1982

GINNA STATION

B-STEAM GENERATOR

NO. 2 WEDGE AREA

Column	17	16	15	14	13	12	11		
	○	○						34	
	○	○	⊗					33	
	○	⊗	⊗					32	
	○	○	⊗	○				31	
	○	○	⊗	○	○	○		30	
	○	○	○	○	○	○	○	29	
	○	○	○	○	○	⊗	○	28	
	○	○	○	○	○	○	○	27	ROW

⊗ Structurally Degraded (no tubes)

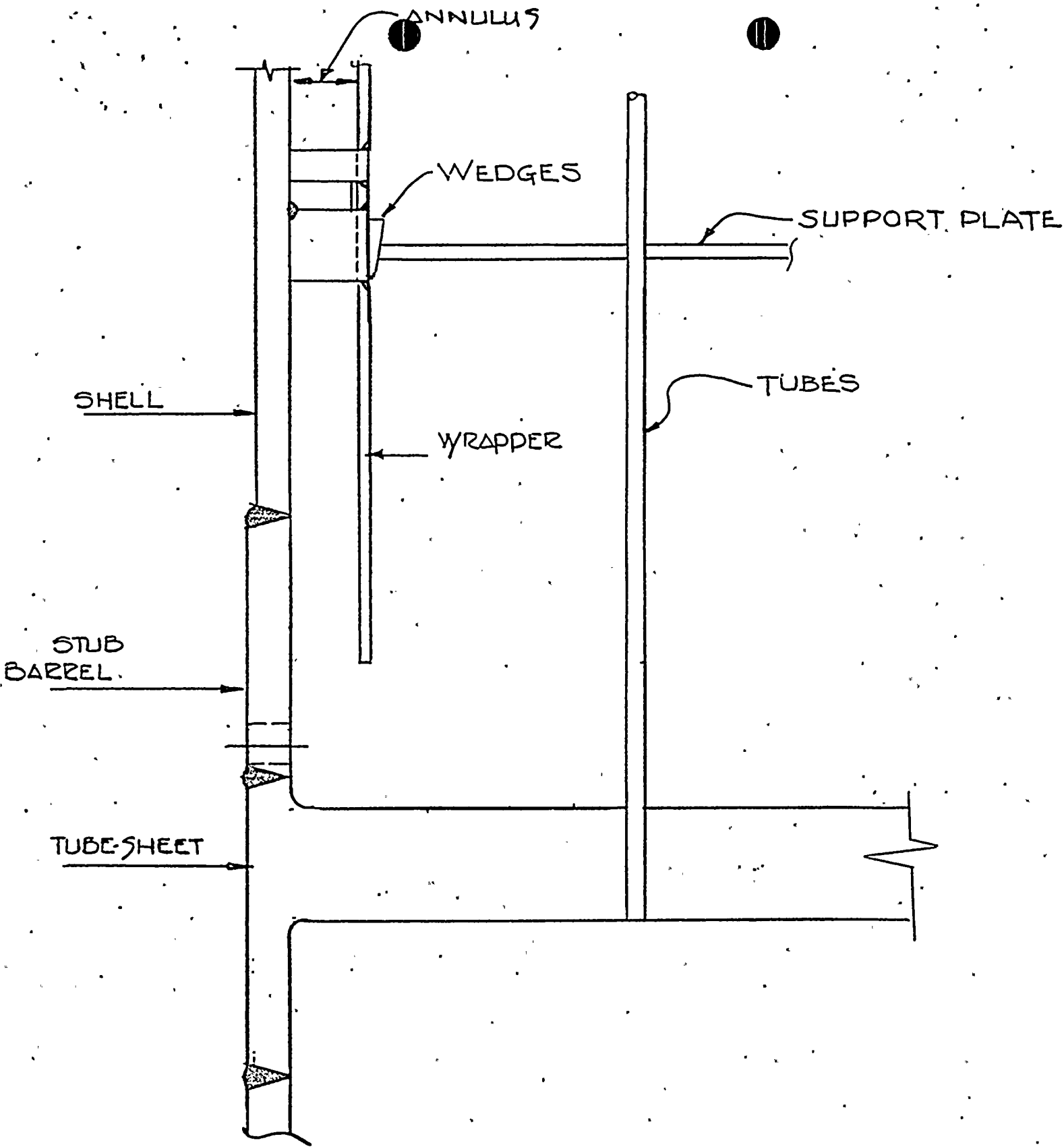
⊕ Video OD Indication (no tubes)

⊗ Eddy Current Signal (6 tubes)

R12 C2 not shown

○ Stay Bar

3/19/82



O	ORIGINAL	INITIAL DATE			
NUMBER	REVISION	DRAWN BY	CHECKED BY	RESP. ENG.	ENG. MAN'G'R.
ROCHESTER GAS & ELECTRIC CORP. ROCHESTER, NEW YORK		GINNA STA. "B" STM GEN. 3" SHELL PEN.		SCALE NO.	

CONDITIONS:

- TUBE REMOVAL
- SURFACE IRREGULARITY WITHOUT COLLAPSE
- SEVERED TUBES AT FIRST TSP

HYDRAULICS CONSIDERATIONS:

- TUBE FATIGUE DUE TO FLUID INTERACTIONS
 - FLUID-ELASTIC STABILITY
 - VORTEX SHEDDING
 - TURBULENCE
 - LOCAL FLUID EFFECTS - EDDYS, CRACK STABILITY
- FLOW VELOCITY AND QUALITY CHANGES

STRUCTURAL CONSIDERATIONS:

- FATIGUE MARGIN UNDER OPERATING TRANSIENTS
- COLLAPSE INTEGRITY
- STABILITY OF TUBES SEVERED BELOW TSP

TUBE GEOMETRY

.275 IN. OD .05 IN. AVG. WALL
LINEAR DIMENSIONS = IN.
VELOCITY = FPS.

SECONDARY FLUID
CROSS FLOW REGION

FLUID VELOCITY

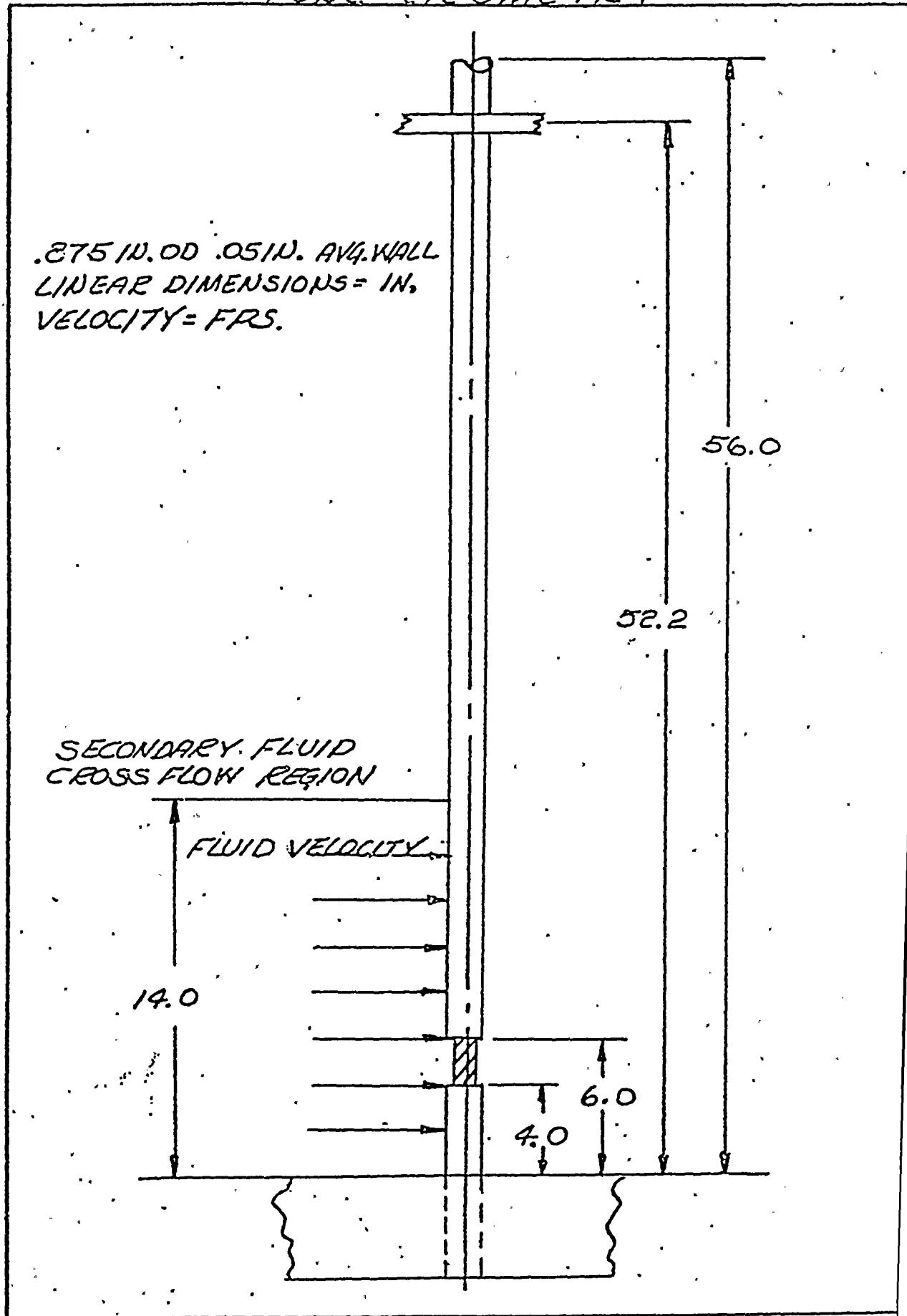
14.0

56.0

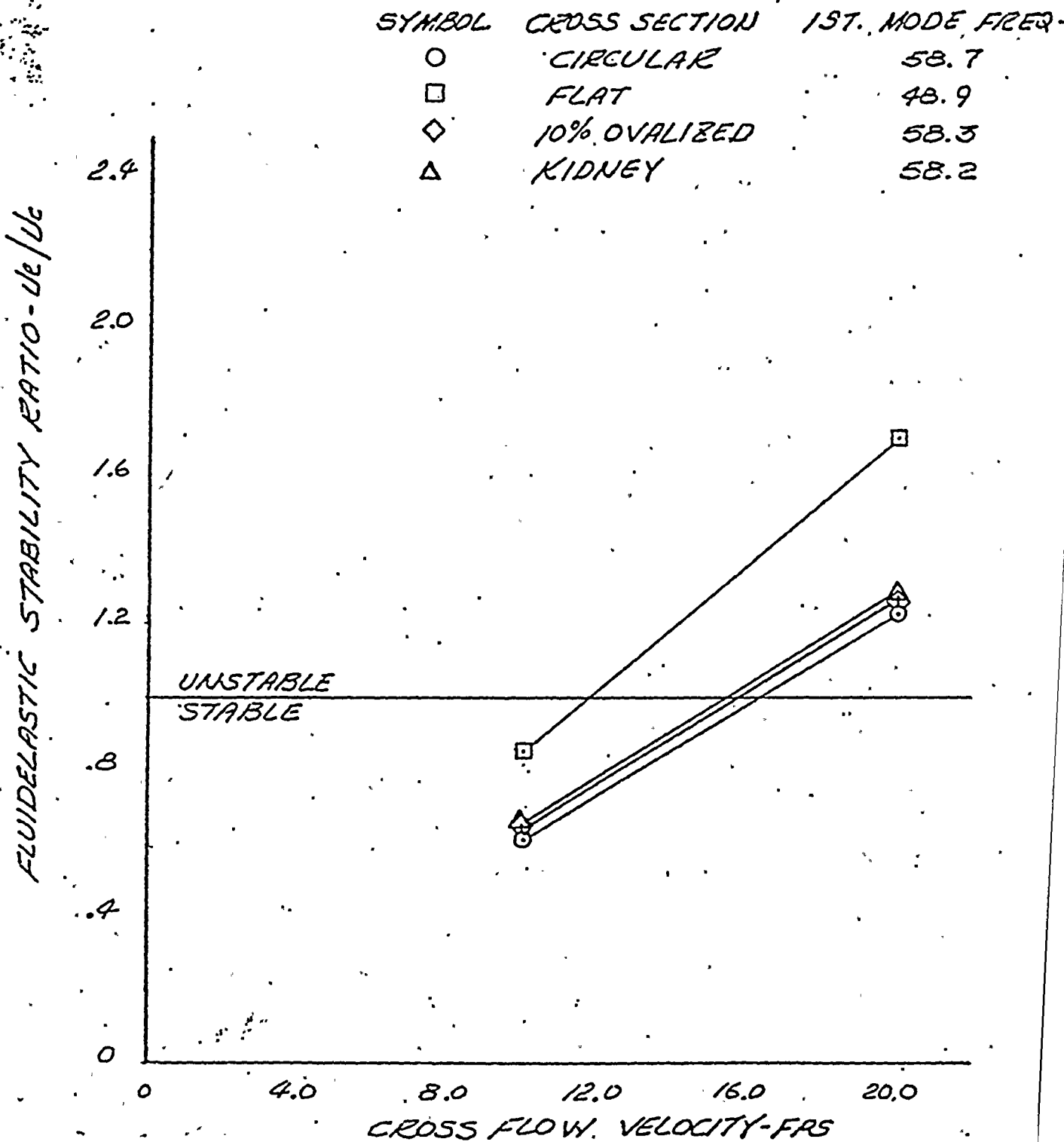
52.2

6.0

4.0



FIXED-FIXED BOUNDARY CONDITIONS
DAMPING RATIO = 0.01

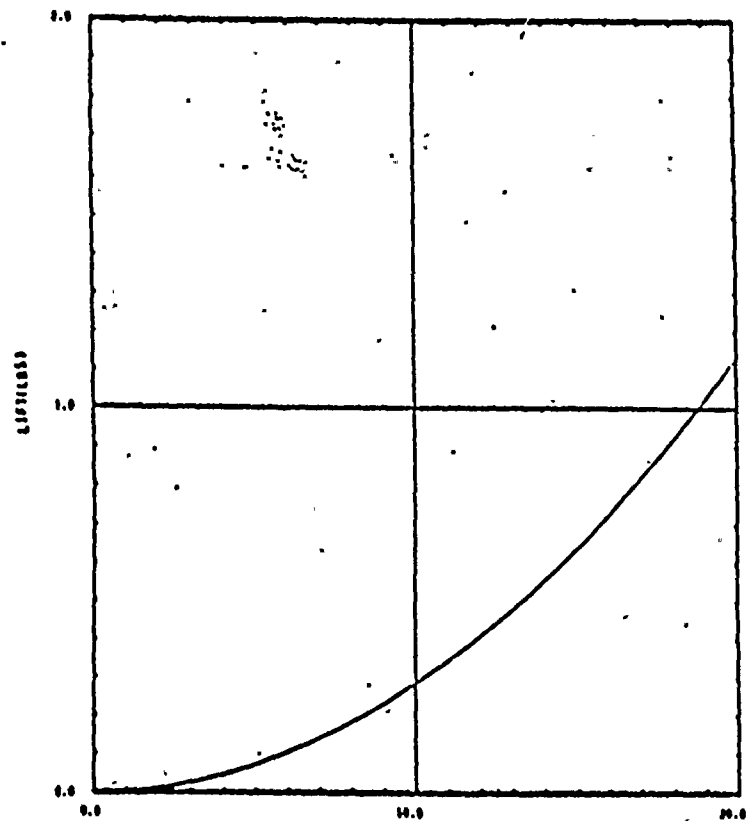


SUMMARY OF VORTEX SHEDDING AND TURBULENCE
ANALYSES

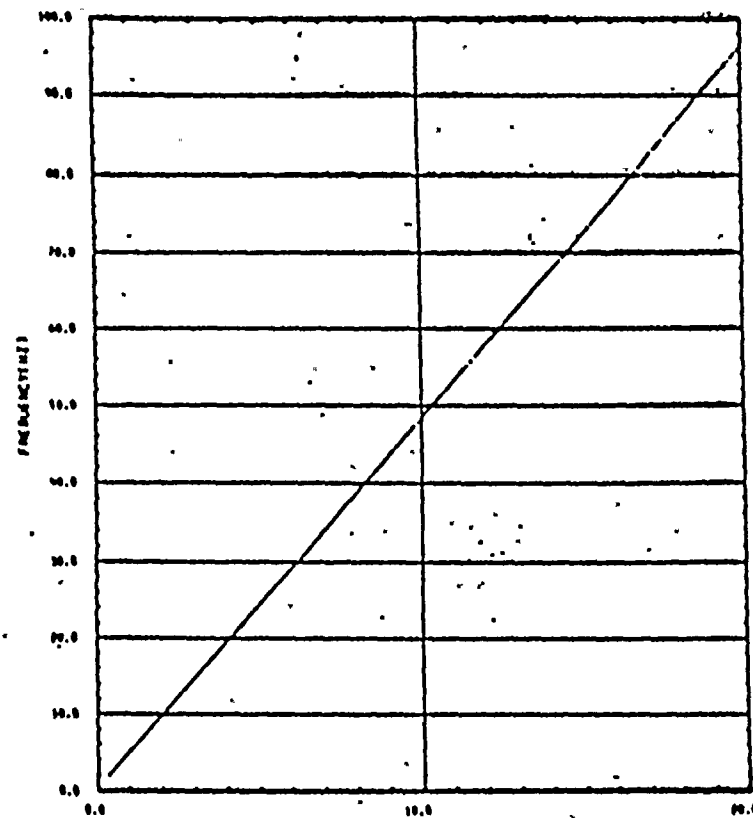
- FIXED-FIXED BOUNDARIES
- CROSS-FLOW VELOCITY, 10.0 FPS
- DAMPING RATIO, 0.01

CROSS SECTION OF DISTORTED ZONE	VIBRATION AMPLITUDES, MILS	
	VORTEX SHEDDING	TURBULENCE
CYLINDER (NOMINAL)	0.77	0.81
10% OVALITY	0.79	0.83
KIDNEY	0.79	0.83
FLAT	2.13	1.53

VIBRATION AMPLITUDE DUE TO VORTEX SHEDDING AND CROSS-FLOW TURBULENCE
ARE RELATIVELY UNAFFECTED BY SMALL DISTORTIONS AND SURFACE IRREGULARITY

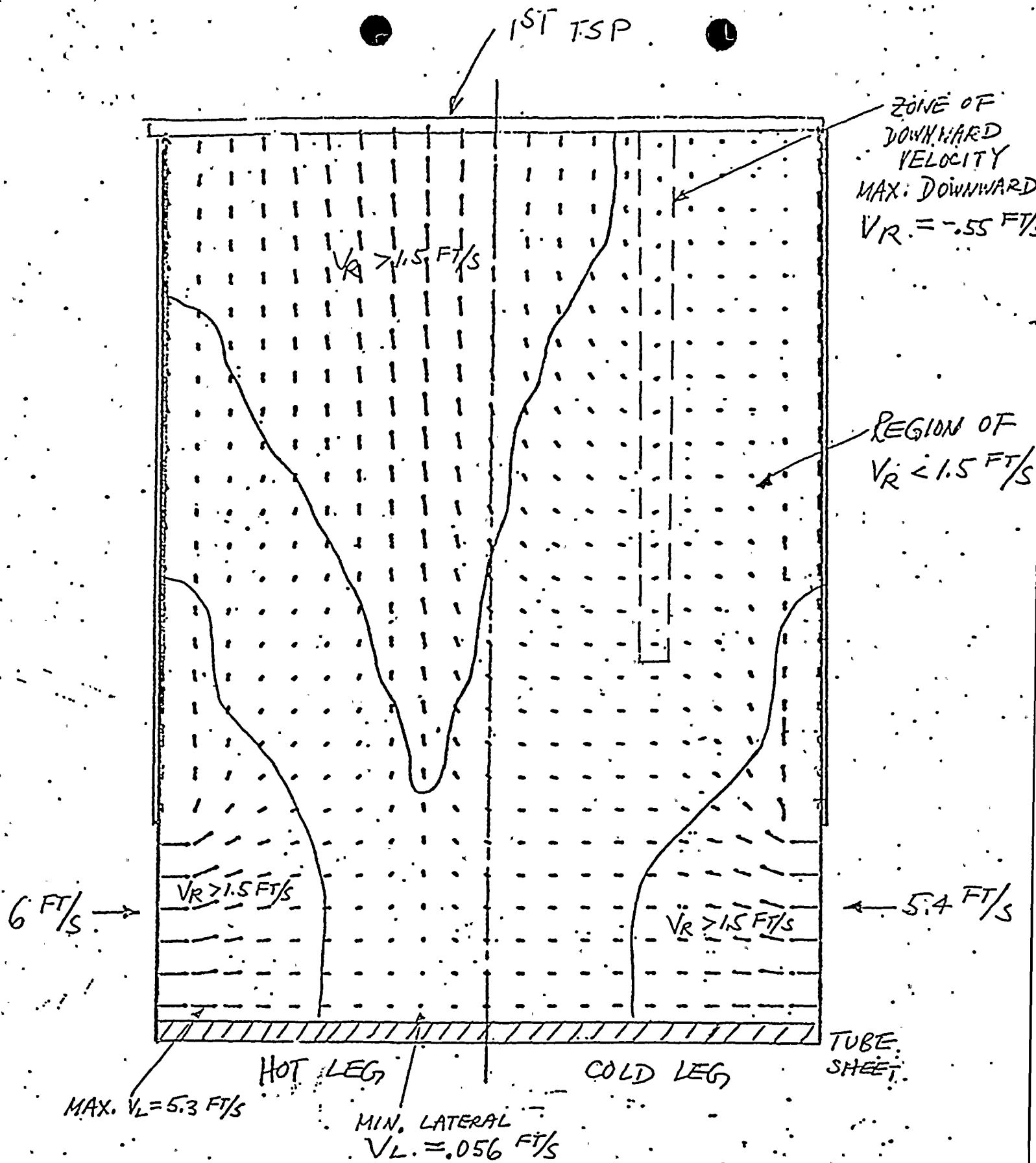


VELOCITY (FPS)
LIFT VS. VELOCITY

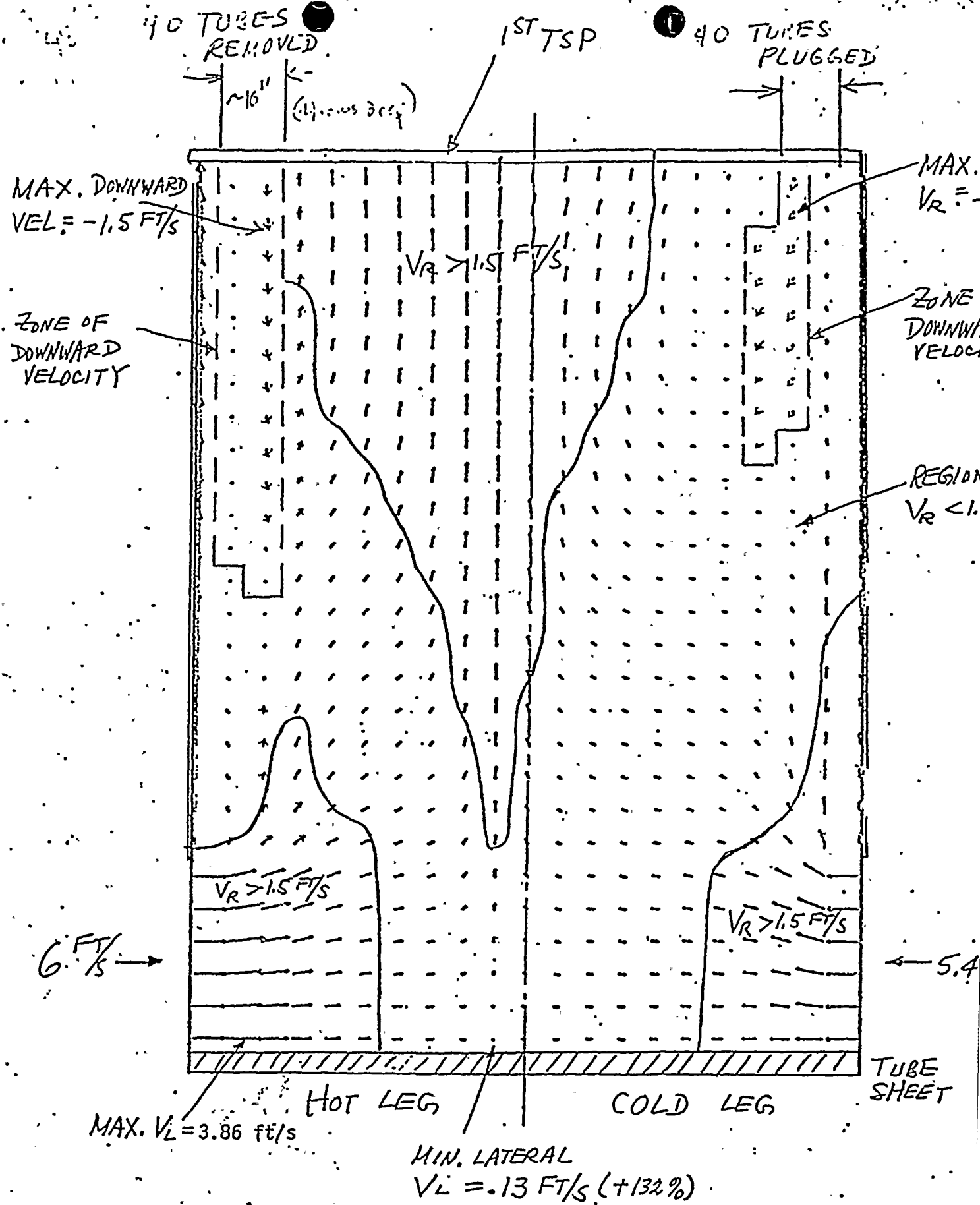


VELOCITY (FPS)
FREQUENCY VS. VELOCITY

OSCILLATING LIFT AND VORTEX - SHEDDING FREQUENCY FOR $D = 0.5$ INCH, $H = 2.0$ INCH



VELOCITY PATTERN OF NOMINAL CASE



VELOCITY PATTERN OF ⁴⁰ TUBES REMOVED AT HOT SIDE AND PLUGGED AT COLD SIDE

EFFECT OF HOT LEG TUBE REMOVAL ON CROSS-FLOW VELOCITY

(2-D MATHEMATICAL STUDY)

INPUT CROSS-FLOW VELOCITIES: 6.0 ft/sec. hot leg
5.4 ft/sec. cold leg

CASE	AVERAGE VELOCITY IN TUBE REMOVAL REGION	MAX. GAP VELOCITY IN FIRST TUBE ROW DOWNSTREAM
NOMINAL	5.30	19.40
10 TUBES REMOVED	3.69	13.50
40 TUBES REMOVED	3.86	14.14

0 TUBE REMOVAL DOES NOT ADVERSELY AFFECT FLOW VELOCITIES



FATIGUE EVALUATION OF SURFACE DAMAGED PLUGGED TUBE
(ASSUME FULL AXIAL RESTRAINT AT FIRST TSP)

- 0 ENVELOPING TRANSIENT - PLANT LOADING/UNLOADING, 14,500 CYCLES
- 0 ASSOCIATED LOADS
 - TEMPERATURE VARIATIONS.
 - PRIMARY T_{HOT} : 547F (HOT STANDBY) TO 602F (100% POWER)
 - SECONDARY T_{ST} : 547F (HOT STANDBY) TO 518F (100% POWER)
 - EXTERNAL PRESSURE RANGE: 795-1020 PSI
 - AXIAL TUBE LOAD RANGES
 - TUBE-TO-SHELL THERMAL MISMATCH: ± 780 lbs.
ASSUMPTION - TUBE IN CONTINUOUS THERMAL EQUILIBRIUM WITH SECONDARY FLUID; STUB-BARREL WITH INFINITE THERMAL INERTIA
 - PLUGGED-TO-ACTIVE TUBE THERMAL MISMATCH: 0 TO + 1200 L
ASSUMPTION - SINGLE PLUGGED TUBE WITHIN A CLUSTER OF ACTIVE TUBES
- 0 AXIAL BENDING LOADS
 - AS-BUILT MISALIGNMENT, 0.25 INCH
 - TS-TO-TSP THERMAL GROWTH MISMATCH, 0.05 INCH
 - TS ROTATION DUE TO PRIM-TO-SEC Δp , 0.08 INCH

FATIGUE USAGE CALCULATIONS

- MAXIMUM STRESS INTENSITY RANGE

$$S_{ALT} = 56.25 \text{ KSI}$$

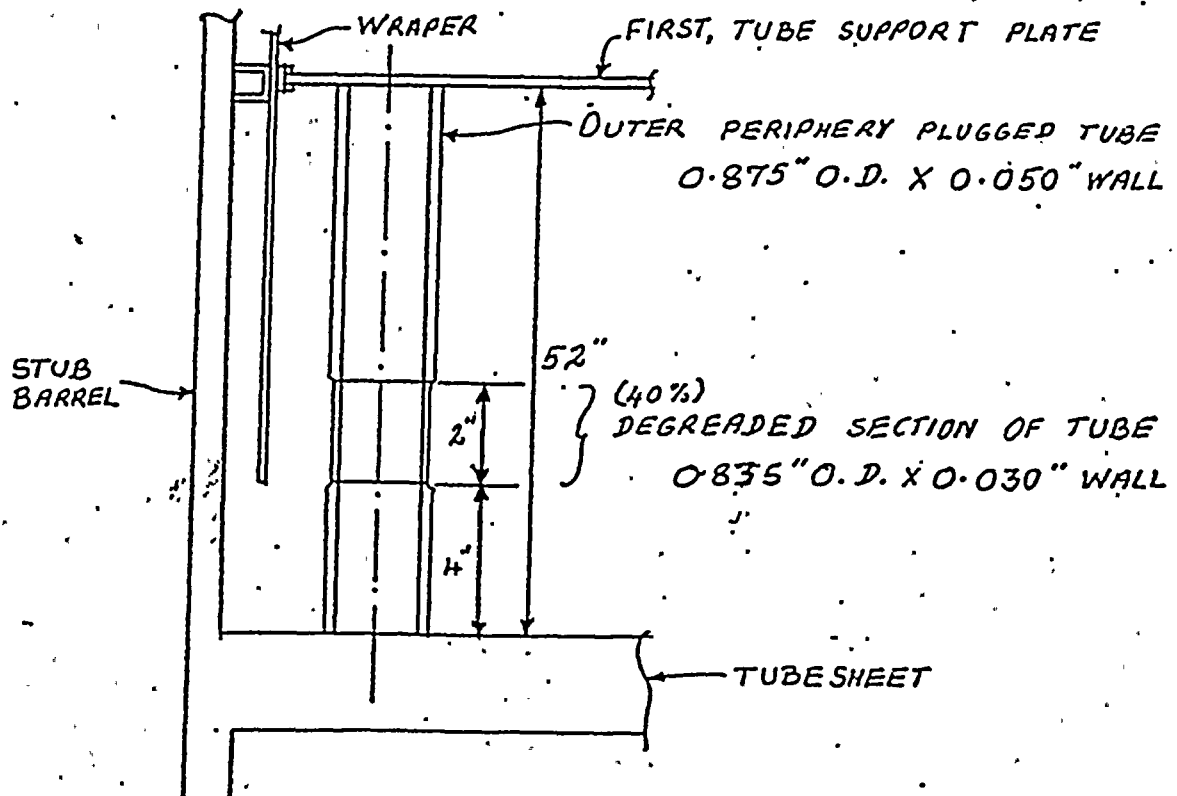
(ADJUSTED TO $E = 26 \times 10^3$ KSI FOR ASME FATIGUE CURVE)

- ASSUMED STRESS CONCENTRATION FACTOR FOR SURFACE DAMAGE = 4.0 (MAX. PER ASME)

- NUMBER OF CYCLES $n = 59,000$ (THIS NUMBER REPRESENTS ALL TRANSIENTS LUMPED CONSERVATIVELY)
- MINIMUM ACTUAL USABLE CYCLES PER ASME CODE
 $N = 135,000$

- CALCULATED USAGE = $n/N = 0.4303$

TUBE GEOMETRY



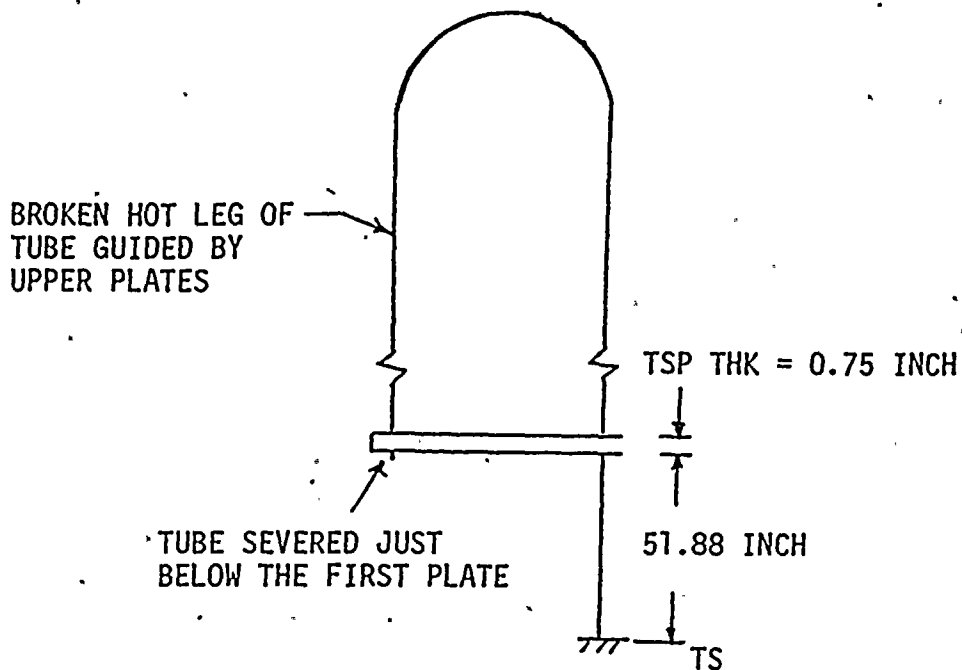
COLLAPSE INTEGRITY EVALUATIONS

BASED ON EXTENSIVE LABORATORY TESTING

- COLLAPSE PRESSURE FOR NOMINAL TUBING ~ 5000 PSI
- COLLAPSE STRENGTH IS RELATIVELY UNAFFECTED BY SHORT ($l \leq$ TUBE DIAMETER), THROUGH-WALL TIGHT CRACKS
- FOR TUBE COLLAPSE, DUE TO THE MAXIMUM $\Delta p \sim 1020$ PSI REQUIRED WALL DEGRADATION IS ~ 80%, IF UNIFORM, AND > 90% IF LOCAL

TUBE COLLAPSE RESULTS FROM PLASTIC INSTABILITY AND REPRESENTS AN INSTANTANEOUS FAILURE MODE. OF ALL THE LOADING CONDITIONS FOR RGE TUBING, THE MAXIMUM Δp (~ 1020 PSI) OCCURS DURING NORMAL OPERATION WHICH, THEREFORE, REPRESENTS A PROOF TEST.

STABILITY OF TUBES SEVERED BELOW TSP



- MAXIMUM TUBE BUNDLE STRETCH = 0.12 IN. DURING FLB,
 $\Delta p \approx 2560$ psi
- Prior-to-sec thermal growth mismatch

FOR PULL OUT* THRU 0.75 INCH THICK PLATE, REQUIRED $\Delta T = 1900$

MAX. EXPECTED ΔT $\left\{ \begin{array}{l} < 100F \text{ DURING OPERATION} \\ < 400F \text{ DURING A LOCA} \end{array} \right.$

- TUBE PULL-OUT DUE TO TUBE SWING OR ROTATION AT U-BEND NOT
POSSIBLE SINCE BROKEN LEG OF THE TUBE IS GUIDED THRU UPPER
PLATES

* REQUIRES PRIMARY SIDE DOWN TRANSIENT IF TUBES ARE AXIALLY
RESTRAINED AT THE PLATE, SECONDARY SIDE DOWN TRANSIENT, IF FREE

POST-REPAIR TUBE EVALUATION SUMMARY

- FLUID-ELASTIC STABILITY, VORTEX SHEDDING AND TURBULENCE RESPONSES OF A TUBE ARE PRACTICALLY UNAFFECTED BY SMALL DISTORTIONS AND SURFACE IRREGULARITIES.
- LOCAL FLUID FORCES ARE NEGLIGIBLY SMALL TO CAUSE CRACK PROPAGATION.
- REMOVAL OF TUBES HAS NO ADVERSE IMPACT ON TUBE STABILITY DUE TO FLUID INTERACTIONS.
- FOR SURFACE DAMAGED TUBES, ACCEPTABLE FATIGUE MARGIN EXISTS FOR SUBSEQUENT OPERATION.
- PLANT OPERATION BEING A PROOF COLLAPSE TEST, STRUCTURALLY STABLE TUBES ARE EXPECTED TO REMAIN STABLE DURING SUBSEQUENT OPERATIONS.
- TUBES SEVERED AT THE FIRST TSP ARE GEOMETRICALLY STABLE AND CANNOT PULL OUT OF THE PLATE DUE TO OPERATING AND FAULTED TRANSIENTS.

SCHEDULE

- START B S/G MODIFICATIONS - March 19, 1982
 - NUS MOCK-UP TEST - March 22, 1982
 - NRC MEETING - March 23, 1982
 - REMOVAL OF DAMAGED TUBES IN #4 AND #6 WEDGE AREAS -
March 31, 1982
 - MECHANICAL PLUG REMOVAL - April 2, 1982
 - COMPLETE WORK IN LOWER SECTION OF "B" STEAM GENERATOR -
April 5, 1982
 - COMPLETE "B" S/G MODIFICATIONS - April 11, 1982
 - RCP WORK COMPLETE - April 12, 1982
 - WATER LANCE "B" S/G - April 12, 1982
 - FINAL TV INSPECTION - April 13, 1982
 - SECONDARY HYDRO "B" S/G - April 14, 1982
 - CONTAINMENT AIR TEST (ILRT) - April 15, 1982
 - FINAL S/G REPORT - April 16, 1982
 - CREVICE CLEANING - April 20, 1982
 - NRC MEETING - Late April
-