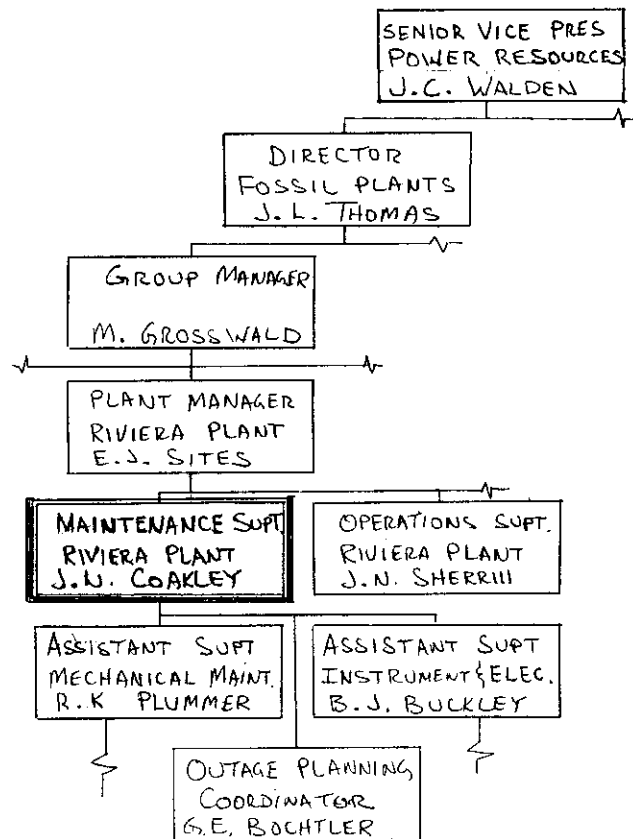
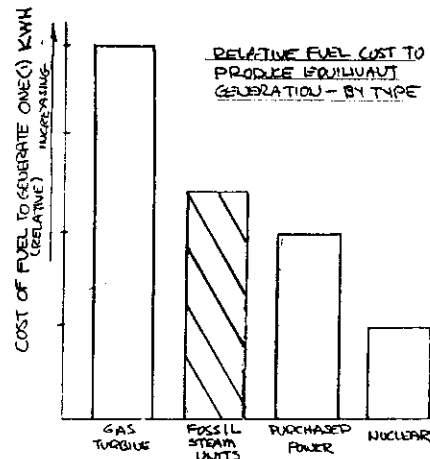
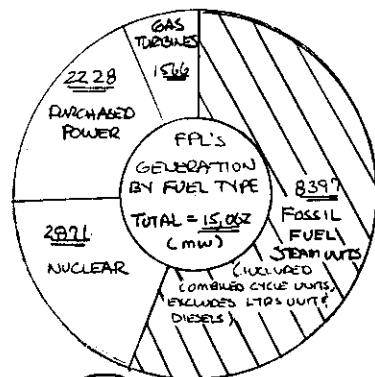




### THEME:

" PERFECT EXECUTION OF FOSSIL  
PLANT CYCLIC OPERATION  
AT RIVIERA POWER PLANT

PREPARED BY JIM COAKLEY  
RIVIERA POWER PLANT

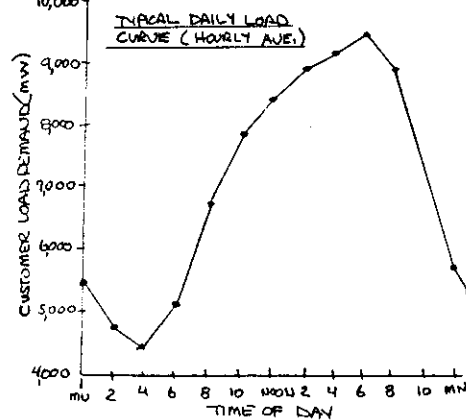
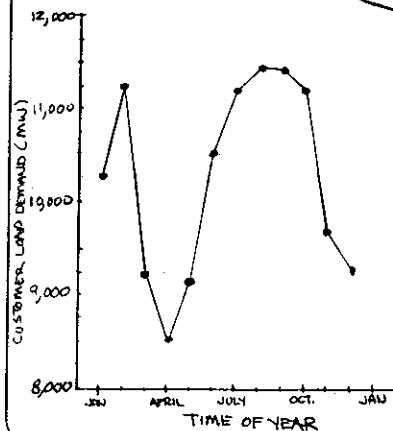


**"SUPPLY"**  
 (FPL'S ELECTRICAL GENERATION)

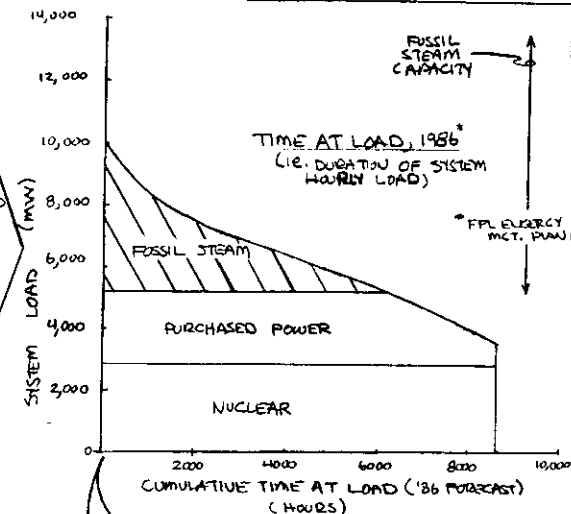
**THE 'MISSION':**

"SUPPLY POWER TO MEET CUSTOMER DEMAND AT LOWEST 'RELIABLE' COST"

**"DEMAND"** (CUSTOMERS' REQUIREMENT FOR ELECTRICAL ENERGY) REFERRED TO AS 'LOAD'

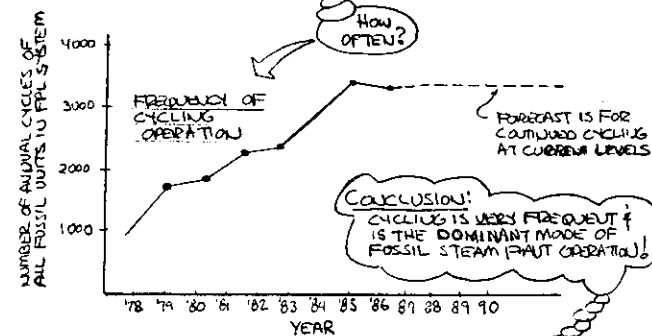


HOW DOES LOAD & COST OF GENERATION EFFECT UNIT OPERATION?



**CONCLUSION:**  
 FOSSIL UNITS MUST CYCLE OFF LINE WHEN THEIR GENERATION IS NOT REQUIRED TO MEET CUSTOMER LOAD DEMAND

How often?



**CONCLUSION:**  
 CYCLING IS VERY FREQUENT & IS THE DOMINANT MODE OF FOSSIL STEAM (PART OPERATION)

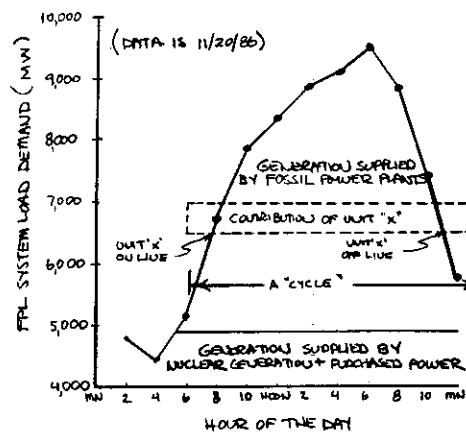
GO TO PG. 2

WHAT DOES AN INDIVIDUAL UNIT LOOK LIKE

REASON FOR SELECTING THE THEME (cont'd)

FROM PG. 1:  
"WHY FOSSIL  
POWER PLANT  
UNITS CYCLE  
OUT OF LINE"

UNDERSTANDING THE 'MISSION'  
OF A FOSSIL FUEL POWER PLANT UNIT



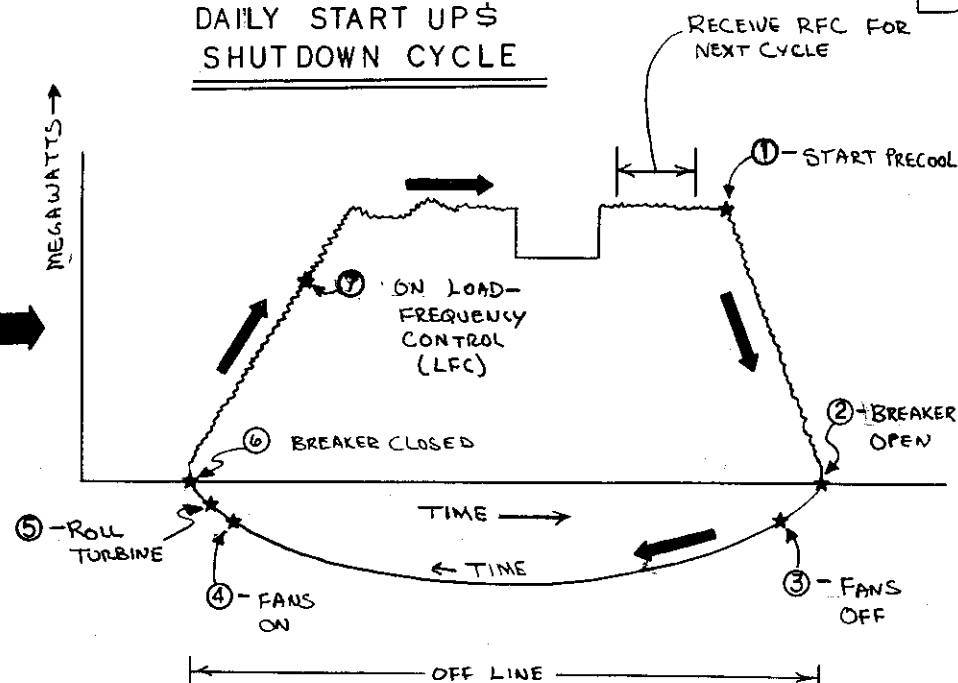
THE 'MISSION' OF EACH FOSSIL FUELED UNIT IS TO PROVIDE THE GENERATION NECESSARY TO FILL THE DAILY LOAD SHAPE AT THE DIRECTION OF SYSTEM OPERATIONS.

POWER RESOURCES  
MID-TERM OBJECTIVE #2:  
"INCREASE LONG TERM UNIT RELIABILITY WHILE RECOGNIZING THE NEED TO REDUCE PLANNED OVERHAUL RESOURCES REQUIREMENTS IN THE 1990'S"

THEME

PERFECT EXECUTION OF FOSSIL PLANT CYCLIC OPERATION AT RIVIERA POWER PLANT

DAILY START UP'S  
SHUTDOWN CYCLE



QUESTION #1

HOW WELL ARE WE MEETING OUR CUSTOMER'S REQUIREMENTS

QUESTION #2

ARE WE OPERATING WITHIN ENGINEERING LIMITS OF THE BOILER AND TURBINE?

TO  
3

# CURRENT SITUATION

## REQUIREMENTS OF THE CYCLE

### CUSTOMER REQUIREMENTS (SYSTEM OPERATIONS)

- UNIT WILL BE AVAILABLE FOR COMPUTER CONTROL AT THE REQUESTED TIME. (LIMITS 5 MIN EARLY 5 MIN LATE)
- UNIT WILL STAY ON CONTROL CONTINUOUSLY UNTIL REQUEST FROM DISPATCHER TO TAKE OFF.
- UNIT WILL STAY ON LINE DURING REQUESTED PERIODS AND BE AVAILABLE FOR UNIT CONTINUOUS CAPABILITY.

- UNIT WILL BURN THE FUEL DESIGNATED BY SYSTEM
- UNIT WILL COME OFF LINE WHEN REQUESTED.

### ENGINEERING LIMITATIONS (RELIABILITY/AVAILAB)

- BOILER MAIN STEAM TEMPERATURE MAXIMUM AND RAMP RATE.
- TURBINE METAL TEMPERATURE RAMP RATES

### ECONOMIC CONSIDERATIONS (EFFICIENCY) ★

- AUXILIARY ENERGY CONSUMPTION.
- DURATION UNIT IS ON LINE AND OFF CONTROL (BREAKER CLOSED TO LFC)

| CYCLE STAGE | VARIABLE                  | X      | LIMIT | S    | Cp   | COEF OF VAR. | WITHIN ENG LIMITS? | WITHIN COST LIMITS? | SERIOUS? | URGENT? | GROWING? |
|-------------|---------------------------|--------|-------|------|------|--------------|--------------------|---------------------|----------|---------|----------|
| ① TO ②      | PRECOOL TO BKR OPEN       | 54.9°F | 100°F | 18.1 | N/A  | -33          | Y                  | N/A                 |          |         |          |
|             | MAIN STEAM RAMP RATE      |        |       |      |      |              |                    |                     |          |         |          |
|             | 1STG METAL TEMP RAMP RATE | 95.9   | 120°F | 31.1 | 1.29 | -33          | Y                  | N/A                 |          |         |          |
| ④ TO ⑤      | FANS STARTED TO ROIL TURB |        |       |      |      |              |                    |                     |          |         |          |
|             | TIME (DURATION - MIN)     | 43     | ★     | 20.9 | N/A  | -49          | Y                  | N/A                 |          |         |          |
| ⑤ TO ⑥      | ROIL TURBINE TO BKR CLOSE |        |       |      |      |              |                    |                     |          |         |          |
|             | TURBINE ROIL TIME (MIN)   | 14.7   | >10   | 4.7  | N/A  | -29          | N                  | N/A                 | N        | N       | N        |
| ⑥ TO ⑦      | BKR CLOSED TO LFC         |        |       |      |      |              |                    |                     |          |         |          |
|             | 1STG METAL TEMP (°F)      | 106.5  | 120   | 41.4 | N/A  | -38          | N                  | N/A                 | N        | N       | N        |
|             | TIME                      | 97.3   | ★     | 9.6  | N/A  | -09          | N/A                | N/A                 |          |         |          |
| ⑦ TO ⑧      | ON LFC - BREAKER OPEN     |        |       |      |      |              |                    |                     |          |         |          |
|             | OFF CONTROL EVENT #/CYC   | 37     | 0     | 193  | N/A  | 2.5          | N/A                | N                   | Y        | Y       | Y        |
|             | OFF CONTROL TIME HRS/CYC  | 2.44   | 0     | 5.52 | N/A  | 2.3          | N/A                | N                   | Y        | Y       | Y        |

### FINDING

PRV-3 PRV-4  
RIVIERA PLANT UNIT 3 & UNIT 4  
ARE COMING OFF COMPUTER CONTROL  
AN AVERAGE OF 2.44 HOURS / CYCLE

### CONCLUSION

WE ARE NOT SATISFYING OUR CUSTOMER'S  
REQUIREMENT TO STAY ON LOAD FREQ CONTROL

TO PAGE 4

# CURRENT SITUATION

FROM PAGE 3

3

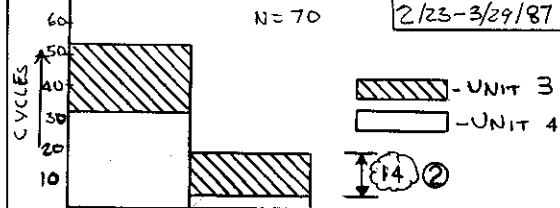
## CONCERN

IS OFF CONTROL MORE PREVALENT WITH ONE UNIT THAN THE OTHER?

## INVESTIGATION

STRATIFICATION OF SAMPLE INTO SUCCESSFUL/UNSUCCESSFUL CYCLES BY UNIT. SAMPLE PERIOD 2/23-3/29/87

N=70



SUCCESSFUL "ON CONTROL" 100% OF REQUESTED TIME

① UNSUCCESSFUL OFF CONTROL FOR AT LEAST ONE MINUTE DURING THE CYCLE

## FINDINGS

- ① THERE WERE 18/70 (26%) CYCLES THAT PRV-3 DID NOT STAY ON CONTROL 100% OF TIME.
- ② PRV-3 ACCOUNTS FOR 75% (14/18) OF UNSUCCESSFUL CYCLES

## CONCLUSION

PRV-3 IS THE PREDOMINANT UNIT PREVENTING THE PLANT FROM SATISFYING THE CUSTOMER'S REQUIREMENT TO BE ON LOAD CONTROL.

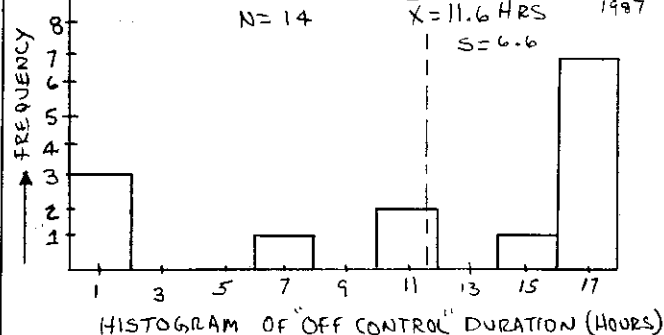
## CONCERN

WHAT IS THE DISPERSION OF THE DURATION OF "OFF CONTROL" EVENT  
DEFINITION: AN EVENT IS DEFINED AS ONE CYCLE WHICH HAS ONE OR MORE OCCURRENCES OF "OFF CONTROL"

## INVESTIGATION

N=14

DATA DATES 2/22-3/29 1987  
X=11.6 HRS  
S=6.6



HISTOGRAM OF "OFF CONTROL" DURATION (HOURS)

## FINDING

THERE IS WIDE VARIABILITY IN "OFF CONTROL" DURATIONS

## CONCLUSION

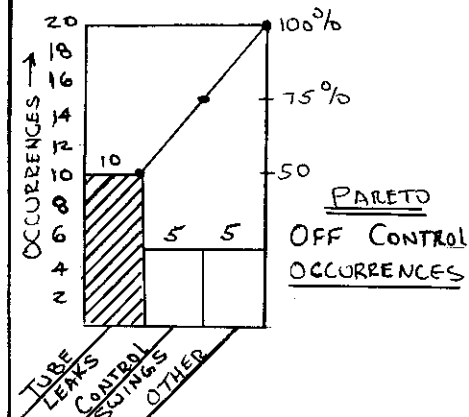
78% (11/14) OF EVENTS ARE 6 HOURS OR LONGER

4

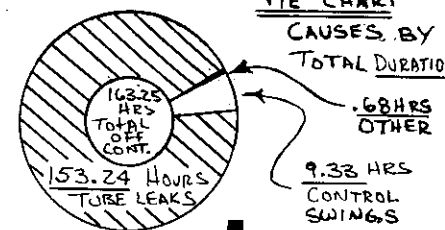
## CONCERN

WHAT ARE THE CAUSES FOR PRV-3 OFF CONTROL OCCURRENCES?

## INVESTIGATION



PIE CHART CAUSES BY TOTAL DURATION



## CONCLUSION

TUBE LEAKS ACCOUNT FOR 50% OF OFF CONTROL OCCURRENCES AND 93% OF OFF CONTROL TIME

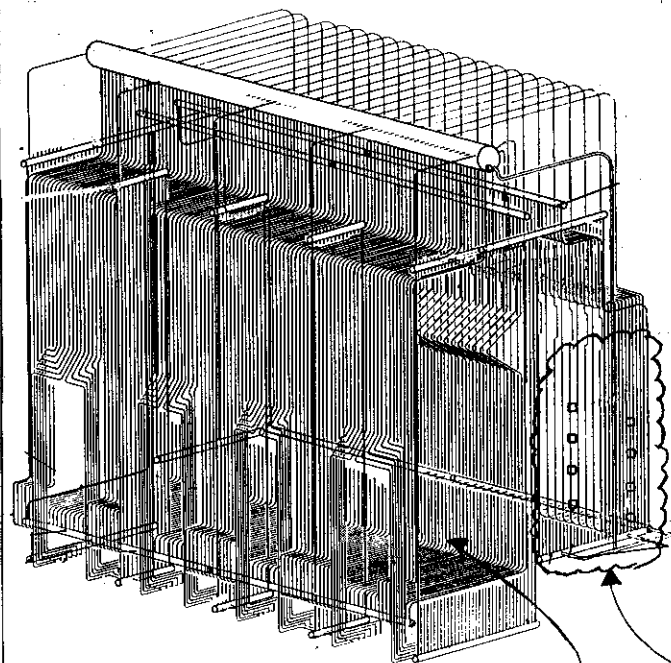
TO PAGE 5

5

FROM  
PAGE 4

WHERE ARE THE LEAKS  
OCCURRING?

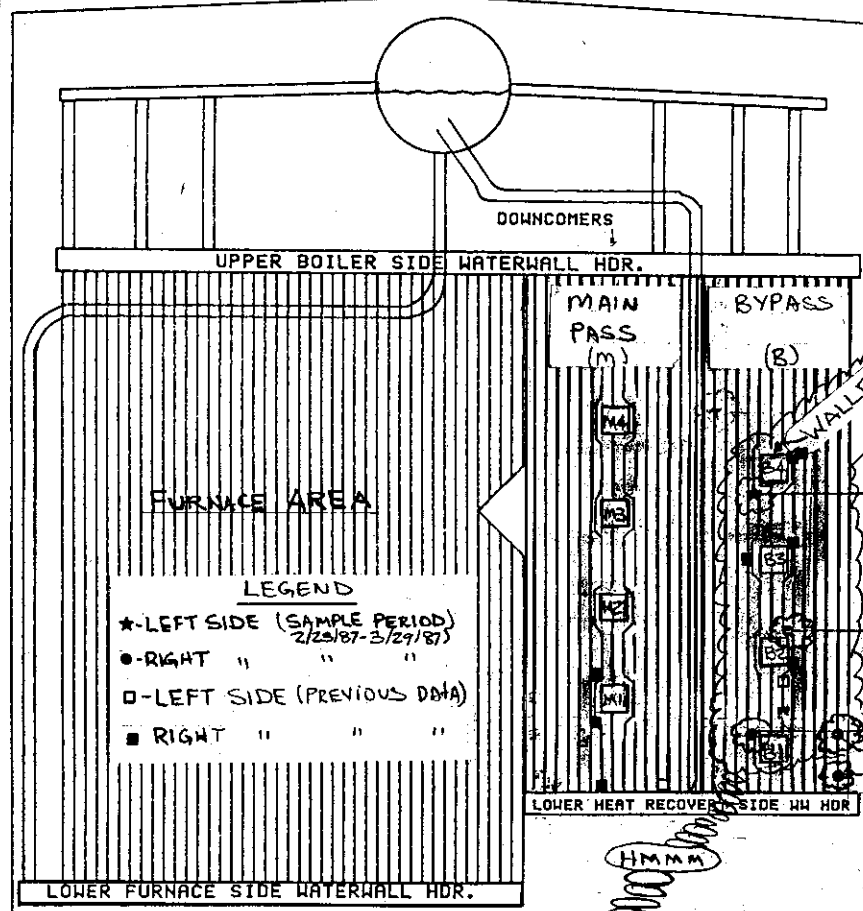
RIVIERA UNIT 3  
3 DIMENSION VIEW OF  
BOILER WATER TUBES



FURNACE AREA - NO LEAKS!!  
WATER CIRCULATION SYSTEM

# CURRENT SITUATION

## RIGHT SIDE VIEW OF BOILER-WATER CIRCUITS



| REPORT No. | FAILURES | DATE |
|------------|----------|------|
| 54         | 3/25/87  |      |
| 51         | 3/22/87  |      |
| 50         | 3/2/87   |      |
| 50         | 3/26/87  |      |
| 55         | 3/26/87  |      |

THERE APPEARS TO BE A CONCENTRATION  
OF LEAKS NEAR WALLBOXES

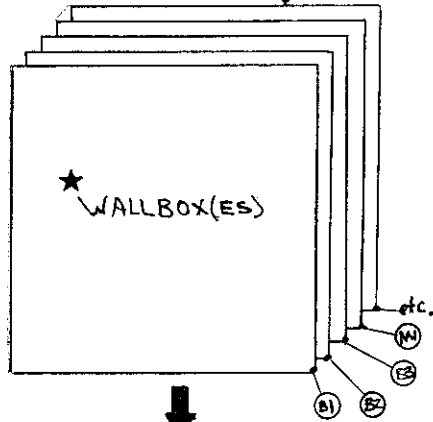
WHAT WOULD THE CONCENTRATION  
BE IF ALL WALL BOXES WERE OVERLAPED?

SEE  
PAGE

6

FROM PAGE 5

IMAGINE, IF YOU STACKED (OVERLAYED) ALL WALLBOX AREAS ON TOP OF EACH OTHER LIKE THIS

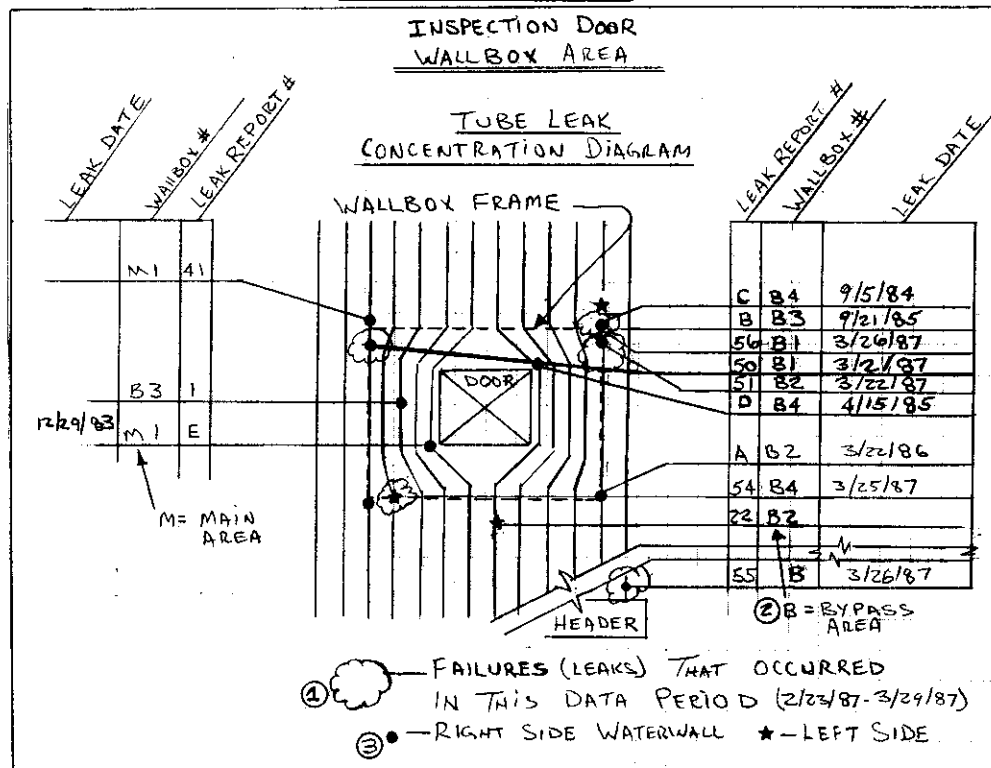


AND THEN OBSERVED THE CONCENTRATION OF ALL LEAKS

WHAT WOULD THE CONCENTRATION LOOK LIKE?

★ NOTE - A WALLBOX IS A "FRAME" AROUND A DOOR THAT IS USED FOR PERSONNEL ACCESS TO THE BOILER FOR INSPECTIONS AND MAINTENANCE

## CURRENT SITUATION



## FINDINGS

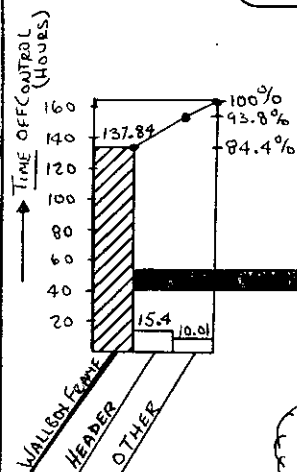
- ① - 4/5 (80%) OF ALL LEAKS THAT OCCURRED IN SAMPLE DATA PERIOD OCCURRED IN WALL BOX AREA (REF. PAGE 5)
- ② - 5/5 (100%) OF ALL LEAKS IN SAMPLE DATA PERIOD OCCURRED IN THE BYPASS HEAT RECOVERY AREA
- ③ - 4/5 (80%) OF ALL LEAKS THAT OCCURRED IN SAMPLE PERIOD OCCURRED ON THE RIGHT SIDE HEAT RECOVERY AREA SIDE WATERWALL
- ④ - 4/5 (80%) OF ALL LEAKS THAT OCCURRED IN SAMPLE PERIOD OCCURRED ON OR NEAR THE WALLBOX FRAME

## PROBLEM STATEMENT

HIGH CONCENTRATION OF TUBE LEAKS IN THE HEAT RECOVERY BYPASS AREA NEAR THE FRAME OF THE WALLBOXES

TO PAGE 7

## SETTING THE TARGET



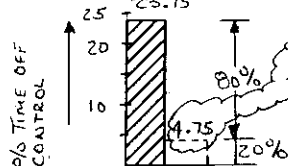
WHAT IS THE MAGNITUDE OF TUBE LEAKS NEAR THE WALLBOX FRAME EXPRESSED IN % OF TOTAL TIME REQUESTED TO BE ON CONTROL?

TIME OFF CONTROL DUE TO LEAKS AT WALLBOX  
TOTAL TIME REQUESTED TO BE ON CONTROL

$$\times 100\% = \frac{\% \text{ TIME OFF CONTROL DUE TO TUBE LEAKS NEAR THE WALLBOX FRAME}}{\%}$$

TOTAL TIME REQUESTED = (35 CYCLES) (16.58 HRS/CYCLE) = 580.3 HRS  
L =  $\bar{x}$  FOR 18 "NORMAL" CYCLES

CURRENT  
 $\frac{137.84 \text{ HRS}}{580.3 \text{ HRS}} \times 100\% = 23.75\% = \% \text{ TIME OFF CONTROL DUE TO TUBE LEAKS NEAR WALLBOX}$

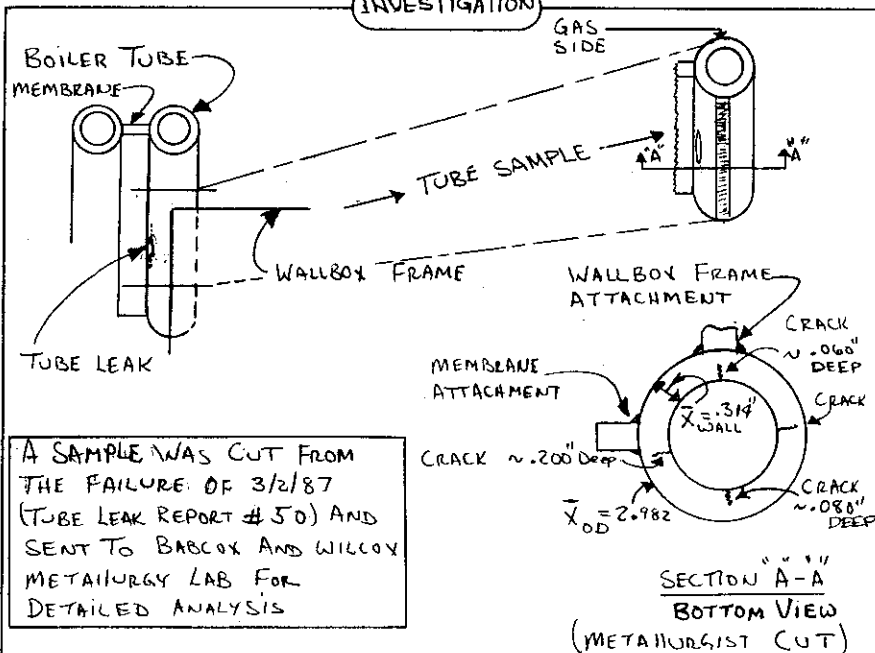


## ANALYSIS

## CONCERN

- WHAT IS THE FAILURE MECHANISM OF A TYPICAL TUBE LEAK NEAR THE FRAME OF THE WALL BOX?

## INVESTIGATION



ANALYSIS CONTINUED

FINDINGS

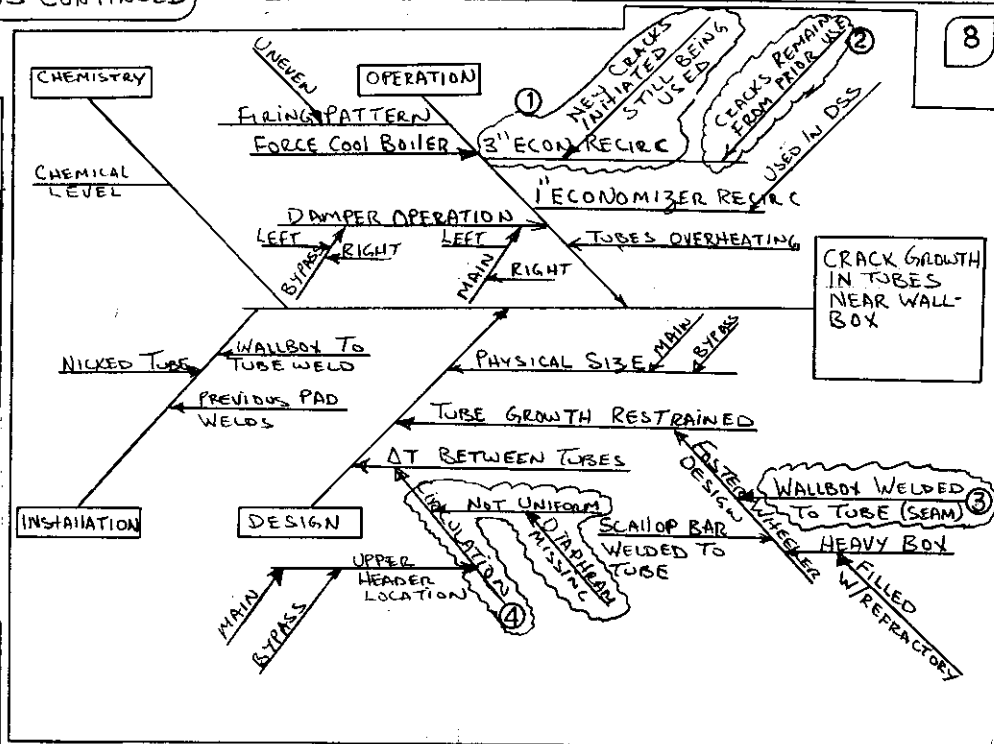
- CORROSION FATIGUE CRACKS WERE OBSERVED ON THE INSIDE DIAMETER SURFACE
- DIMENSIONAL CHECKS INDICATE NO EVIDENCE OF SWELLING OR WALL THINNING.
- THE CRACK FRONT IS RICH IN PHOSPHORUS



CONCLUSION

- THE ID SURFACE CRACKING IS ASSOCIATED WITH THE CORROSION FATIGUE MECHANISM. i.e. IT IS A COMBINATION OF SYSTEM STRESSES OR RESIDUAL STRESSES IN THE PRESENCE OF A CORROSIVE ENVIRONMENT.
- IT IS THE METALLURGIST'S OPINION THAT THE CORROSION COMPONENT IS A SMALL CONTRIBUTOR TO THE STRESS CRACK GROWTH. IT IS NOT THE CAUSE OF INITIATION OF THE CRACK, HOWEVER IT DOES ACCELERATE GROWTH.

BASED ON  
VISUAL SURFACE  
ANALYSIS AND  
CHEMICAL ANALYSIS  
OF CRACK CONTENTS



WHAT IS CAUSING THE STRESS TO BE GREATER ON THE RIGHT SIDE BYPASS AREA ??

POTENTIAL ROOT CAUSES

- ① ECONOMIZER RECIRC VALVE OPENED DURING STARTUP
- ② CRACKS REMAIN FROM PRIOR DAMAGE (ECONOMIZER RECIRC)
- ③ WALLBOX WELDED TO TUBE
- ④ INCORRECT CIRCULATION (NOT UNIFORM)

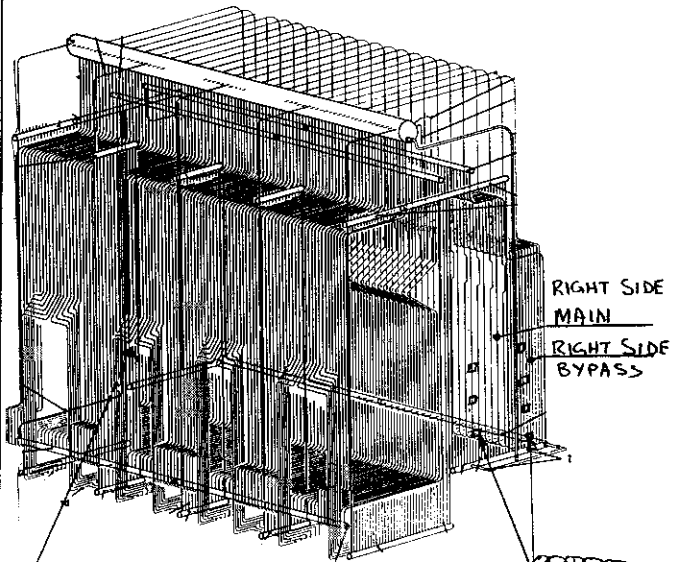
# ANALYSIS

FROM PAGE

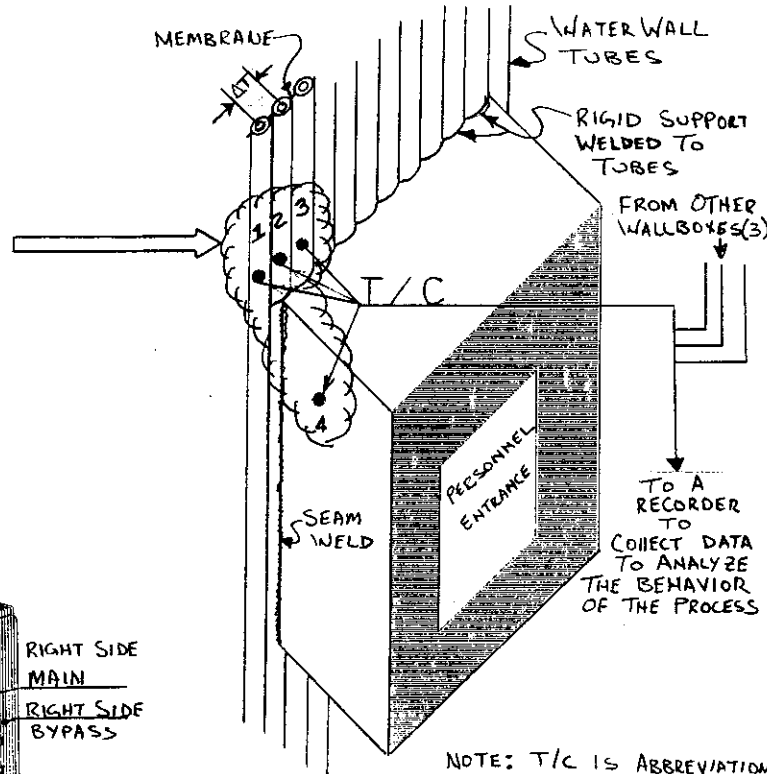
8

TO VERIFY ROOT CAUSE TEMPERATURE SENSING INSTRUMENTATION IS REQUIRED TO COLLECT DATA

INSTALL THERMOCOUPLES NEAR HIGH STRESS AREA IDENTIFIED BY TUBE SAMPLE ANALYSIS



## TYPICAL WALLBOX SHOWING TEST INSTRUMENTATION INSTALLED



NOTE: T/C IS ABBREVIATION FOR THERMOCOUPLE - A DEVICE FOR MEASURING TEMPERATURE

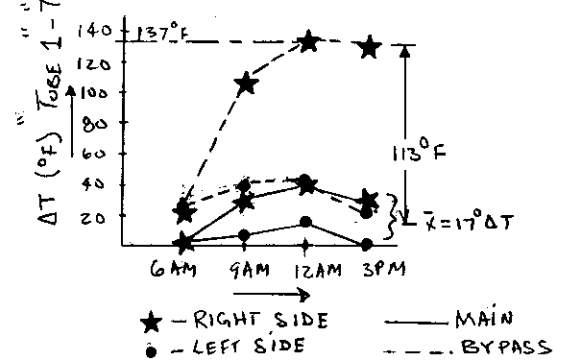
A TOTAL OF FOUR WALLBOXES WERE INSTRUMENTED TO OBTAIN DATA TO CORRELATE EACH AREA (TEMP. VS FAILURES)

9

## INVESTIGATION

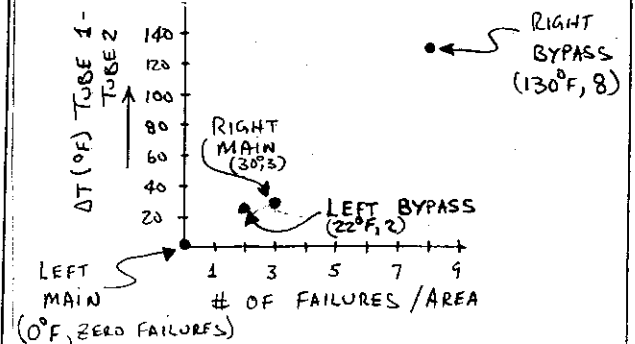
DATA DATE: 7/10/87

ADJACENT TUBE TEMP DIFFERENTIALS TREND IN EACH WALL BOX AREA



DATA DATE: 7/10/87

SCATTER DIAGRAM WATERWALL TUBE  $\Delta T$  AT FULL LOAD IN EACH AREA



TO PAGE