

CASE: AIR LEAKAGE TO A POWER PLANT CONDENSER

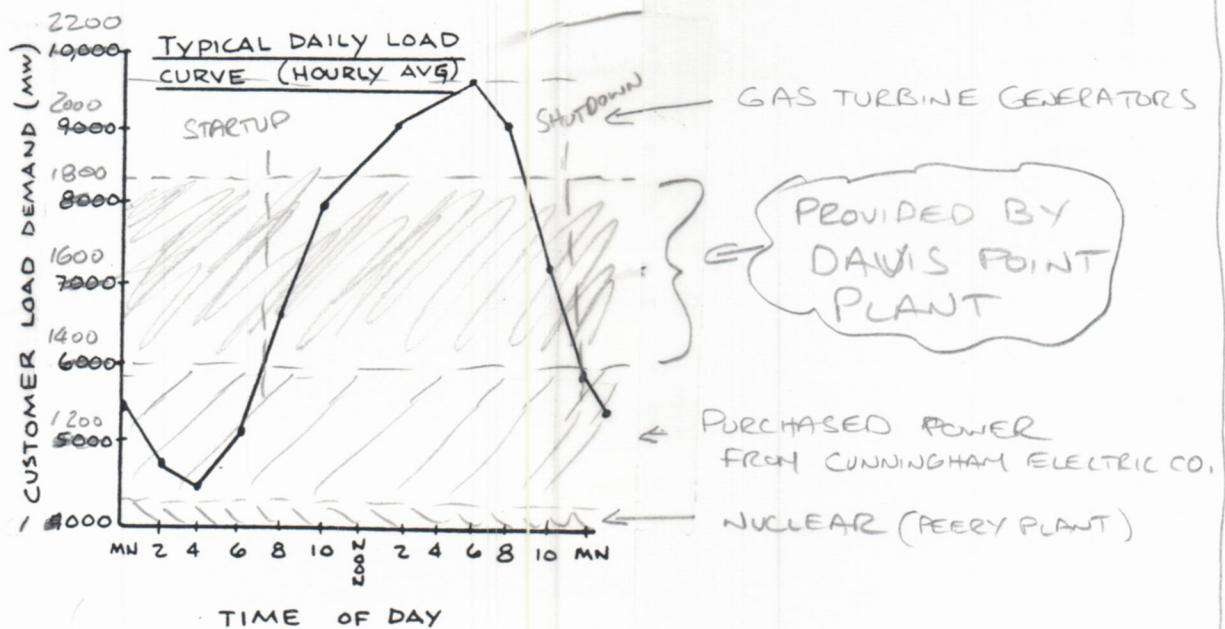
IDENTIFY AN IMPROVEMENT OPPORTUNITY

BACKGROUND

THE DAVIS POINT THERMAL POWER PLANT SUPPLIES UP TO 440 MEGAWATTS OF ELECTRIC POWER TO THE SINGLETON ELECTRIC + LIGHT COMPANY'S TRANSMISSION SYSTEM. (SEL)

SINCE THE STARTUP OF THE COMPANY'S PEERY NUCLEAR UNIT, THE DAVIS POINT PLANT HAS BEEN OPERATED IN A "CYCLING" MODE - AS THE COMPANY'S DAILY DEMAND FOR ELECTRICITY VARIES, DAVIS POINT WILL STARTUP, OPERATE AND THEN SHUT DOWN;

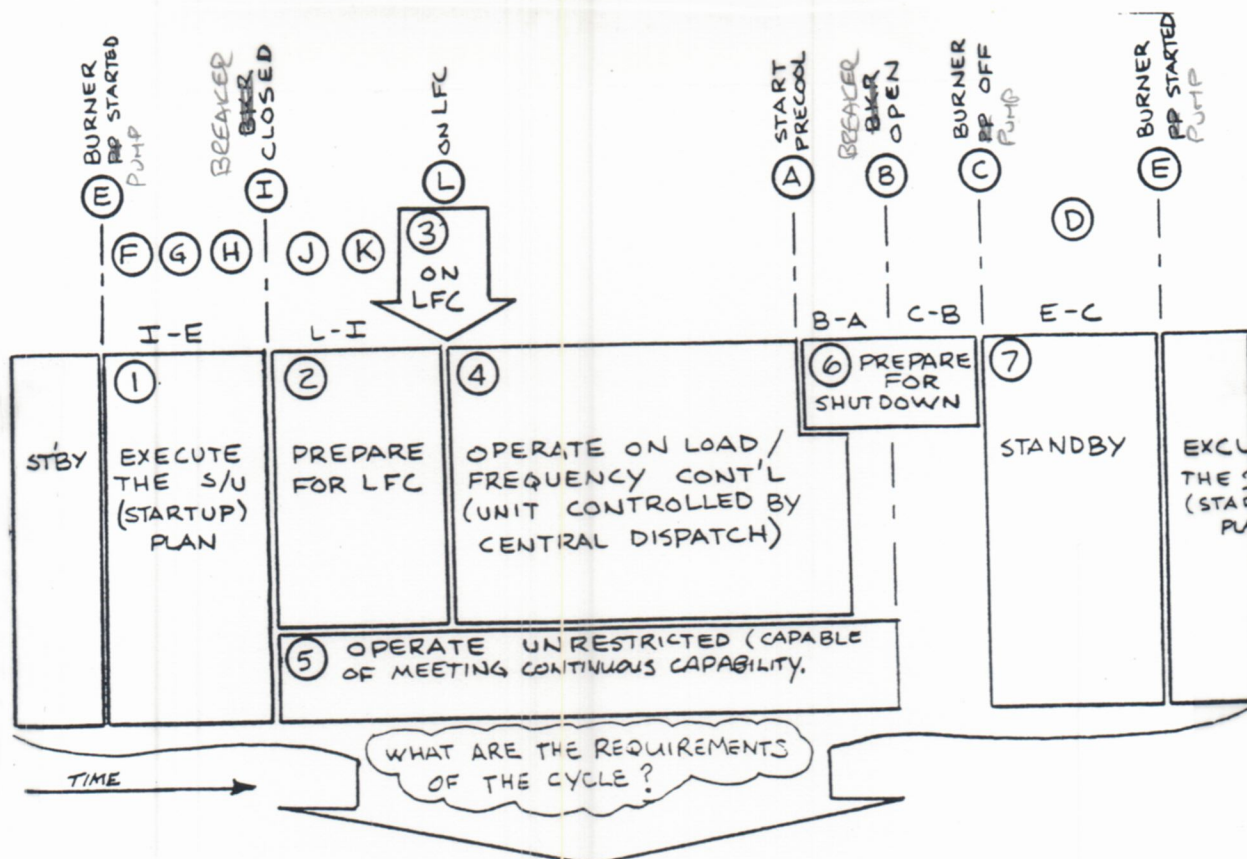
"DEMAND" (CUSTOMERS' REQUIREMENT FOR ELECTRICAL ENERGY) REFERRED TO AS 'LOAD'



DAVIS POINT PLANT MISSION: TO PROVIDE THE ELECTRIC POWER GENERATION NECESSARY TO FILL THE DAILY LOAD REQUIREMENTS AT THE DIRECTION OF SEL'S SYSTEMS OPERATION

IDENTIFY AN IMPROVEMENT OPPORTUNITY

TO PERFORM THIS MISSION, DAVIS POINT PLANT A SEVEN PHASE STARTUP, OPERATE, SHUTDOWN & STANDBY PROCESS AS NEEDED (USUALLY DAILY):



CUSTOMER DRIVEN REQUIREMENTS OF THE CYCLE

SHORT TERM RELIABILITY

CUSTOMER: SYSTEM OPERATIONS

LOG'N IN CYCLE	INDICATOR	S-UPPER	S-LOWER
I	P1-UNIT WILL BE ON LINE WITHIN WINDOW FROM LFC	2HR	NONE
L	P2-UNIT WILL BE ON LFC WHEN REQUESTED	+5MIN.	-15MIN.
A-C	P3-UNIT WILL STAY ON CONTROL UNTIL REQUESTED TO COME OFF.	NONE	100%(TARGET)
B-I	P4-UNIT WILL BE AVAILABLE FOR CONTINUOUS CAPABILITY	NONE	100%(TARGET)
B	P5-UNIT WILL COME OFF WHEN REQUESTED	3HR	NONE

LONG TERM RELIABILITY

CUSTOMER: POLICY DEPARTMENT COMMITTEE
MID TERM OBJ. NO. 2*

LOG'N IN CYCLE	INDICATOR	S-UPPER	S-LOWER
I-L	L1-BOILER FSH TEMP S/U RATE	250F/HR	NONE
A-C	L2-BOILER FSH TEMP S/D RATE	250F/HR	NONE
I-L	L3-TURBINE 1ST STAGE METAL TEMP S/U RATE	215F/HR	NONE
A-C	L4-TURBINE 1ST STAGE METAL TEMP S/D RATE	215F/HR	NONE
I-L	L5-TURBINE IP BLADE RING METAL TEMP S/U RATE	215F/HR	NONE
L-A	L6-CONDENSER AIR IN-LEAKAGE	8 SCFM	NONE

* "INCREASE LONG TERM UNIT RELIABILITY WHILE RECOGNIZING THE NEED TO REDUCE PLANNED OVERHAUL RESOURCES REQUIREMENTS IN THE 1990'S"

HOW ARE WE DOING?

IDENTIFY AN IMPROVEMENT OPPORTUNITY

SUMMARY OF INDICATOR PERFORMANCE :

DAVIS BENT RANT

LOC'N IN CYCLE	INDICATOR	S-UPPER	S-LOWER	$\bar{x}$	S	S2	R	Units	n	Cp	POTENTIAL IMPACT ON RELIABILITY AT CURRENT VALUES OF DATA
I	P1-UNIT WILL BE ON LINE WITHIN WINDOW FROM LFC	2HR	NONE	99.50	1.90	3.50	6.46	Per Cent*	12		LOW
L	P2-UNIT WILL BE ON LFC WHEN REQUESTED	+5MIN.	-15MIN.	97.20	9.60	92.40	33.3	Per Cent*	12		LOW
A-L	P3-UNIT WILL STAY ON CONTROL UNTIL REQUESTED TO COME OFF.	NONE	100%(TARGET)	99.70	0.80	0.70	2.8	Per Cent**	12		LOW
B-I	P4-UNIT WILL BE AVAILABLE FOR CONTINUOUS CAPABILITY	NONE	100%(TARGET)	96.50	6.60	44.20	21.7	Per Cent**	12		MED-HI
B	P5-UNIT WILL COME OFF WHEN REQUESTED	3HR	NONE	97.50	4.20	17.50	9.68	Per Cent*	12		LOW
L-I	L1-BOILER FSH TEMP S/U RATE	250F/HR	NONE	158.30	33.11	1096.34	138.32	Deg F	25		LOW
C-A	L2-BOILER FSH TEMP S/D RATE	250F/HR	NONE	56.32	20.22	408.69	83.91	Deg F	21		LOW
L-I	L3-TURBINE 1ST STAGE METAL TEMP S/U RATE	215F/HR	NONE	58.73	25.80	665.44	102.11	Deg F	25		LOW
C-A	L4-TURBINE 1ST STAGE METAL TEMP S/D RATE	215F/HR	NONE	69.52	24.62	605.93	100.09	Deg F	22		LOW
L-I	L5-TURBINE IP BLADE RING METAL TEMP S/U RATE	215F/HR	NONE	87.41	30.30	917.81	123.17	Deg F	24		LOW
A-L	L6-CONDENSER AIR IN-LEAKAGE	8 SCFM	NONE	34.80	15.90	251.30	65.3	SCFM	26	0.40	HI

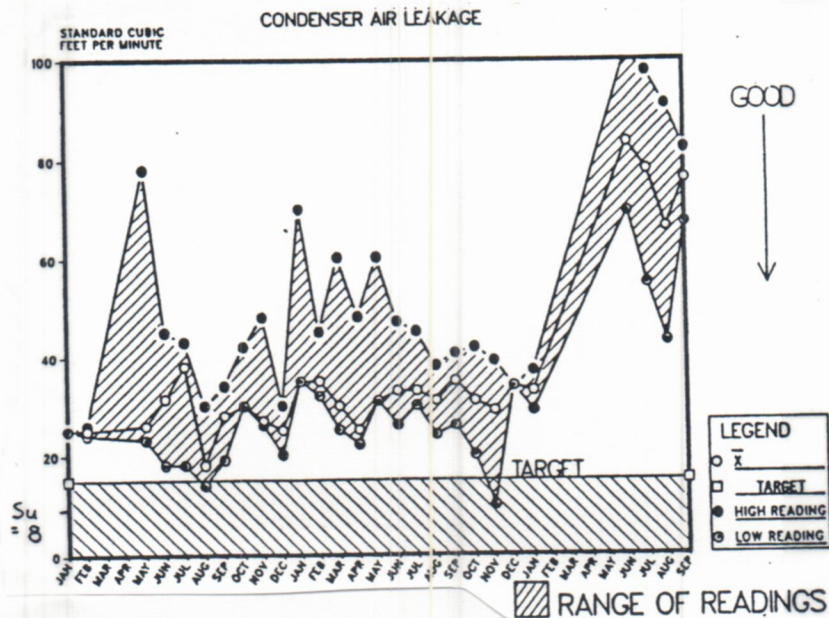
* per cent of data meeting spec
** per cent of target reached

THE CONDENSER AIR IN-LEAKAGE ON BOTH UNITS HAS A HIGH POTENTIAL IMPACT ON RELIABILITY DUE TO EXCESSIVELY HIGH LEAKAGE RATES... WHAT DOES IT LOOK LIKE?

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I IDENTIFY AN IMPROVEMENT OPPORTUNITY



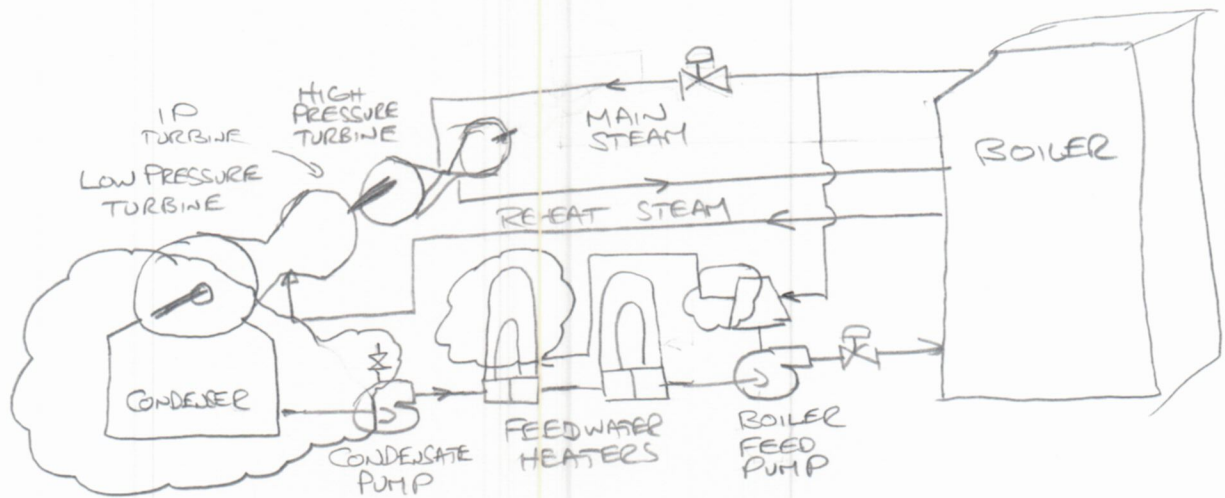
Air Leakage has been higher than the target and, recently, has been increasing

OPPORTUNITY STATEMENT

An opportunity exists to reduce the Condenser Air Leakage at Davis Point Thermal Plant. The process is important to work on since Air Leakage affects plant efficiency and long-term reliability (corrosion due to dissolved oxygen in the Condensate, Feedwater and Boiler systems).

CLARIFY AND STABILIZE THE PROCESS

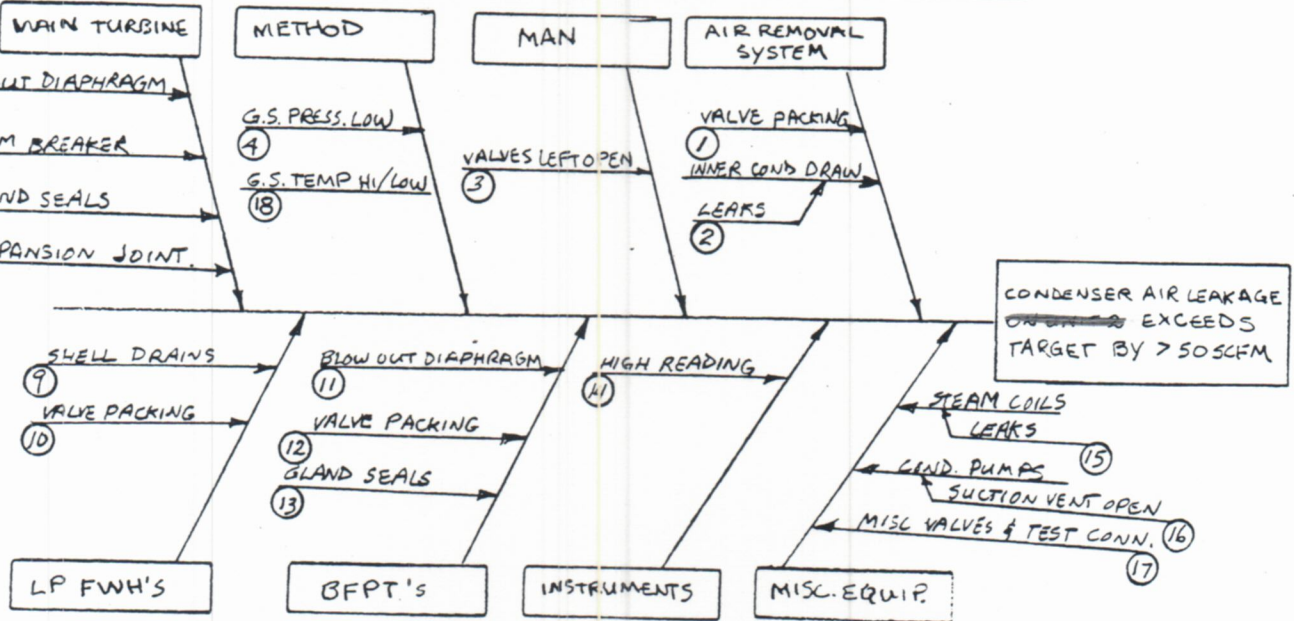
THE DAVIS POINT PLANT POWER CONVERSION SYSTEM APPEARS SCHEMATICALLY AS :



AIR INLEAKAGE CAN ONLY OCCUR IN AREAS WHERE THE SYSTEM IS UNDER A VACUUM - CIRCLED AREAS

CAUSE AND EFFECT ANALYSIS

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POTENTIAL CAUSE

REASON(S) TO DISPROVE CAUSE

1	NO LEAK VERIFIED WITH FREON DETECTION TECHNIQUE
2	SAME AS 1
3	VISUALLY VERIFIED - PROCEDURE OI-405
4	PRESSURE VERIFIED TO BE CORRECT
5	LEAK CHECKED BY FLOODING WITH WATER
6	SAME AS 1
7	CANNOT DISPROVE
8	SAME AS 1
9	SAME AS 3
10	SAME AS 1
11	SAME AS 5
12	SAME AS 1
13	CANNOT DISPROVE
14	CALIBRATION CHECKED OK
15	VALVES VERIFIED CLOSED TO CONDENSER
16	SAME AS 1
17	CANNOT DISPROVE
18	TEMP. VERIFIED TO BE CORRECT

POSSIBLE CAUSES

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CAUSE AND EFFECT ANALYSIS

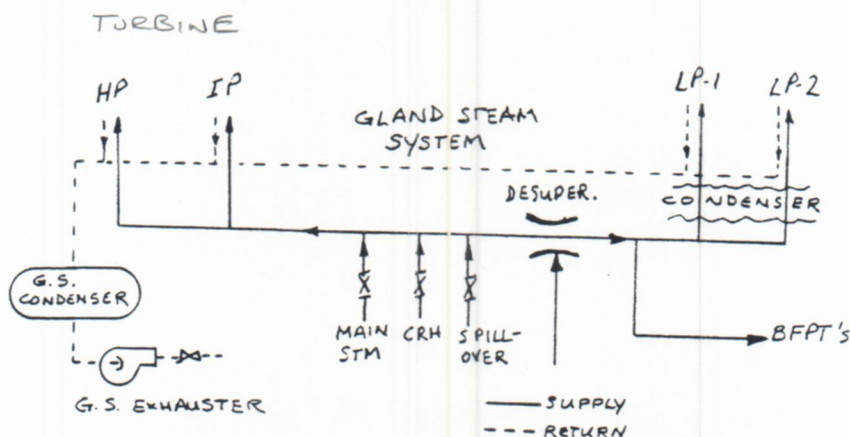
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THE THREE POTENTIAL CAUSES OF HIGH AIR INLEAKAGE IDENTIFIED ARE:

- MAIN TURBINE GLAND SEALS
- BFPT GLAND SEALS
- MISC VALVES & TEST CONNECTIONS

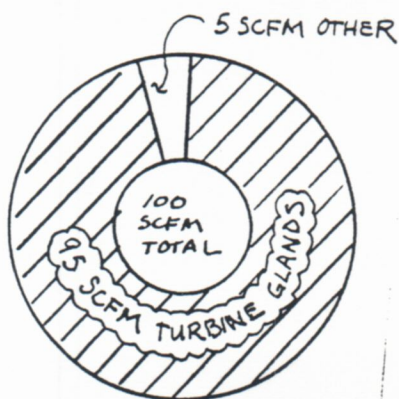
QUESTION: HOW CAN THE MAIN AREA OF AIR INLEAKAGE BE IDENTIFIED?

CONSIDER THE GLAND STEAM SYSTEM:



IF THE GLAND STEAM SUPPLY PRESSURE WAS RAISED VERY HIGH AND THE EXHAUSTER TURNED OFF, STEAM WOULD BE FORCED OUT THE SEALS, TEMPORARILY STOPPING ANY AIR INLEAKAGE THRU THE SEALS. THUS THE CONTRIBUTION OF THE SEALS TO AIR INLEAKAGE COULD BE MEASURED. (HP & IP SEALS CAN BE IGNORED SINCE THERE IS NO PATH TO CONDENSER)

RESULTS:



CONCLUSION:

95% OF AIR INLEAKAGE IS THRU TURBINE GLANDS

QUESTION:

WHICH TURBINE GLANDS ARE THE WORST?

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DETAILS OF CON.

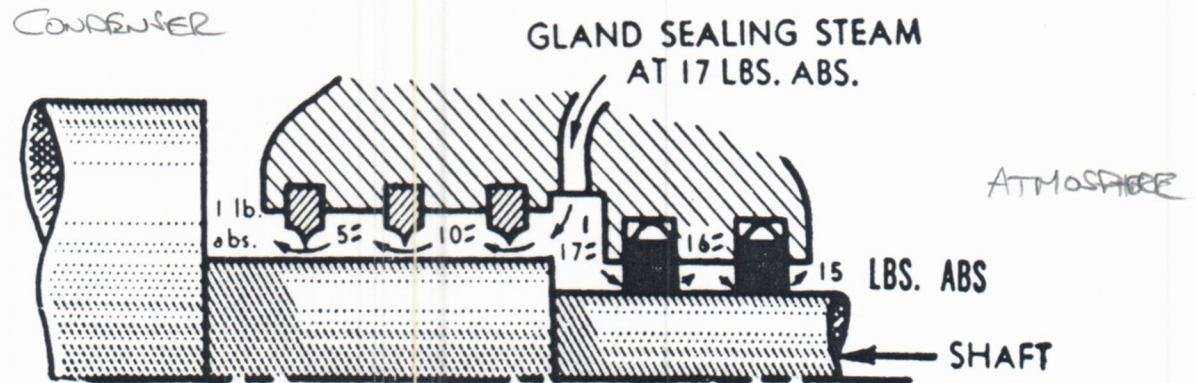


FIG. 3-11. Turbine Gland with Low Pressure in Turbine.

shows diagrammatically a turbine gland seal in its simplest form.

Steam at about 2 p.s.i., gauge, (17 p.s.i.a.) is led into a space between two sets of gland packing. As its pressure is greater than the atmosphere and the pressure inside of the turbine, the gland steam flows both into the casing and out into the engine-room thus positively excluding all air from the turbine.

Since even high pressure turbines are under a vacuum at various times (i.e. when standing by, backing down, etc.) all turbine glands are fitted with gland sealing steam. However, when operating at high speeds, the turbine internal pressures at both the high and the low pressure ends of the high pressure turbine are usually considerably above atmospheric pressure, while at

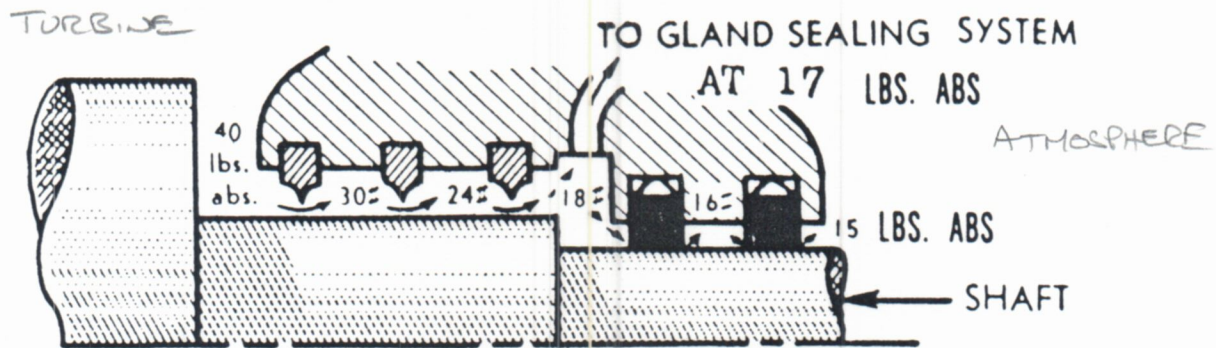


FIG. 3-12. Turbine Gland with High Pressure in Turbine.

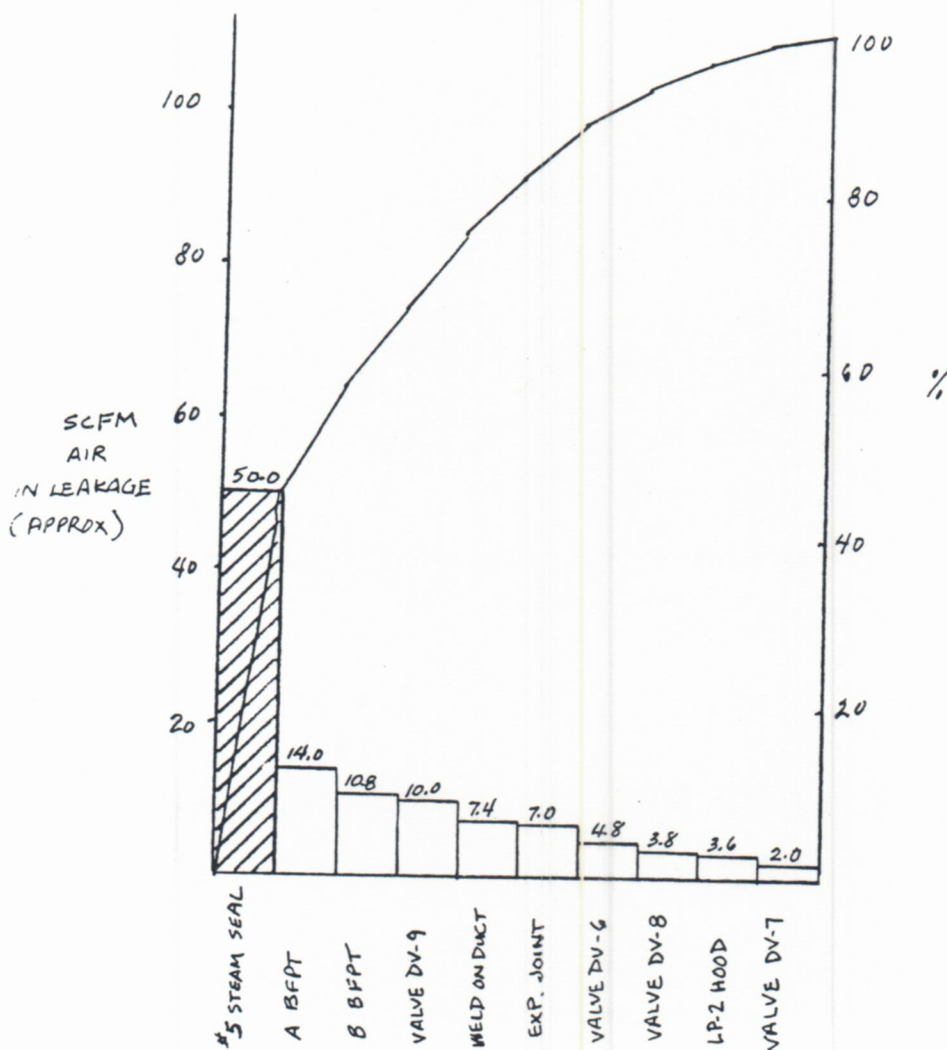
both ends of the low pressure turbine the pressure is below atmospheric. Suppose now that in *Fig. 3-11* the pressure inside the turbine, instead of being 1 p.s.i.a., is 40 p.s.i.a. and, after having passed through the labyrinth packing into the chamber where the gland steam is admitted, its pressure has been reduced to 18 p.s.i.a. The steam will then flow in two directions as shown in *Fig. 3-12*. Part of it will continue to flow out of the turbine gland through the carbon packing, but most of it, being at a higher pressure than the gland sealing steam, will flow into the gland sealing connection reversing the direction of the gland steam. It is usual for the gland sealing line to be closed at such times in which case a gland leak-off connection is provided to lead the excess steam to a lower stage or to the condenser.

ANALYSIS

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TO FIND WHICH TURBINE GLANDS WERE THE WORST, A CONTRACTOR WAS EMPLOYED USING A SENSITIVE HELIUM DETECTION TECHNIQUE WHICH ENABLED APPROXIMATE MEASUREMENT OF EACH LEAK, AS WELL AS FINDING SOME LEAKS THAT WERE MISSED.

RESULTS:



CONCLUSION:

#5 STEAM SEAL HAS BY FAR THE MOST LEAKAGE.

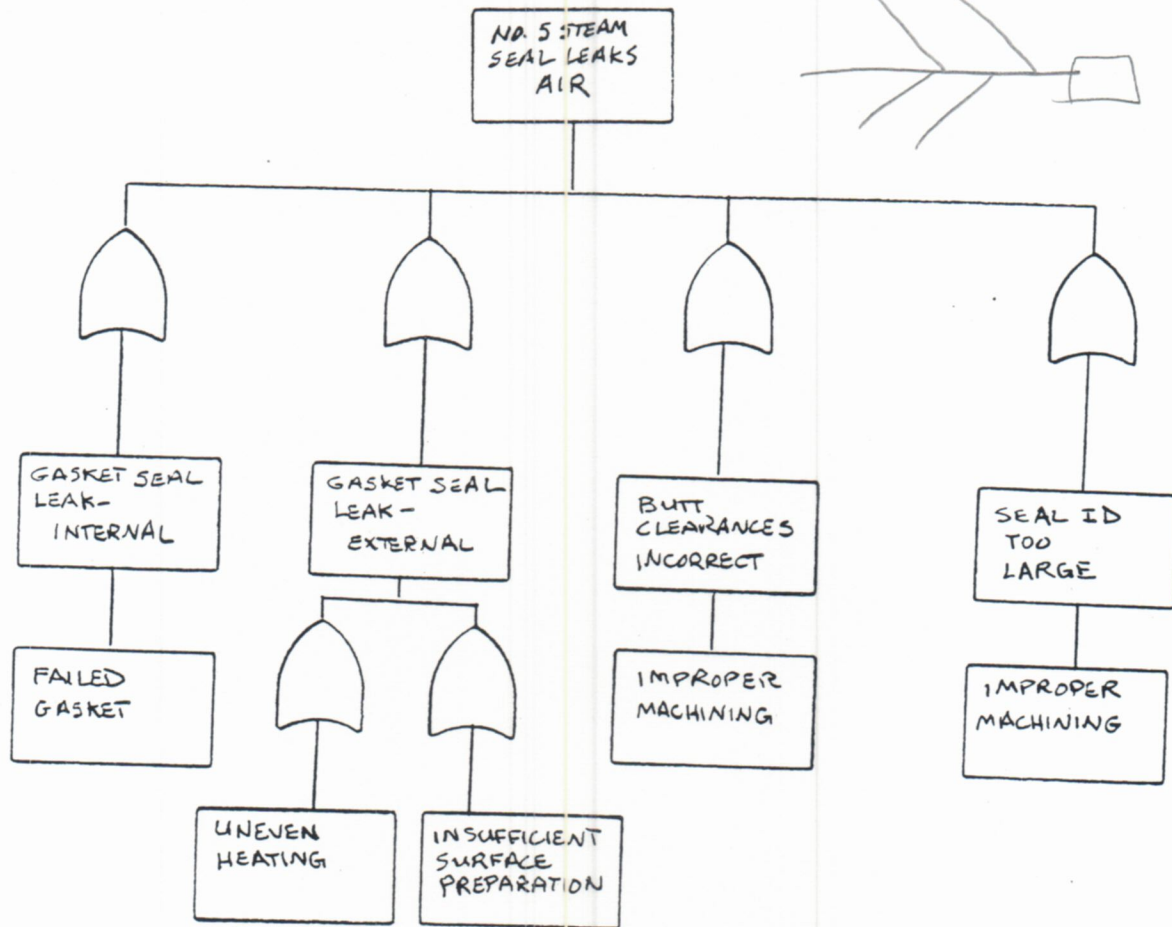
QUESTION:

WHY WAS THE #5 STEAM SEAL LEAKING IN AIR?



ANALYSIS

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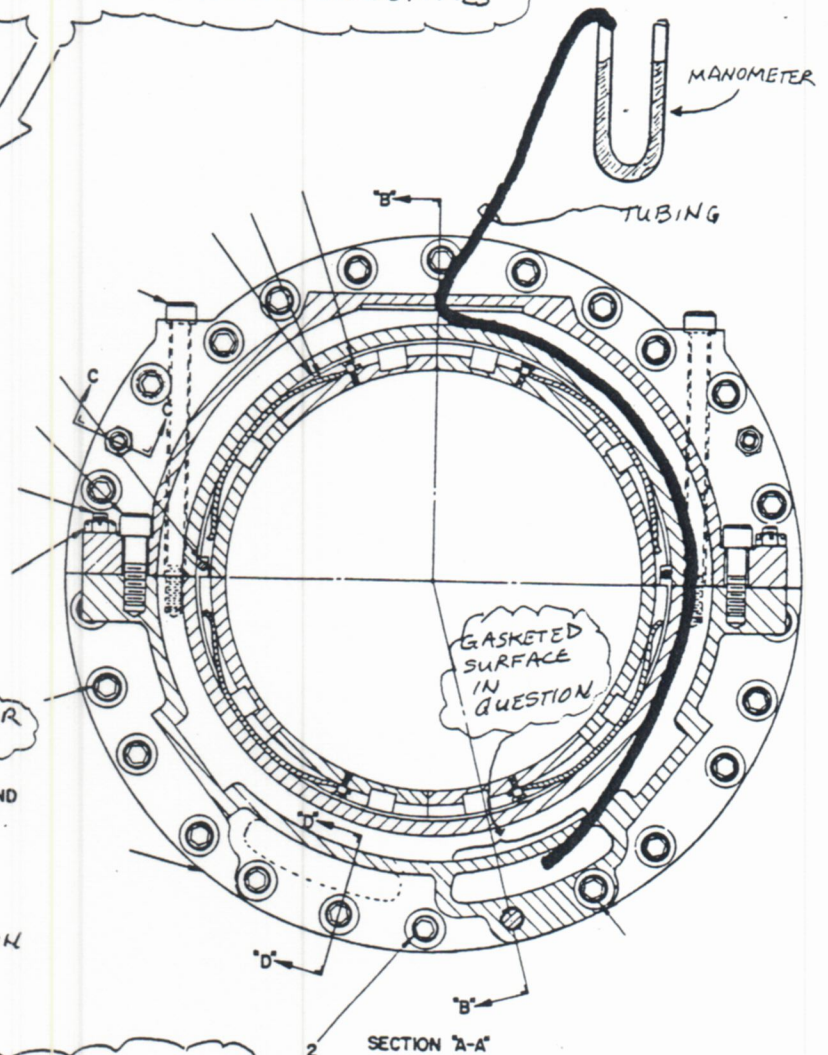
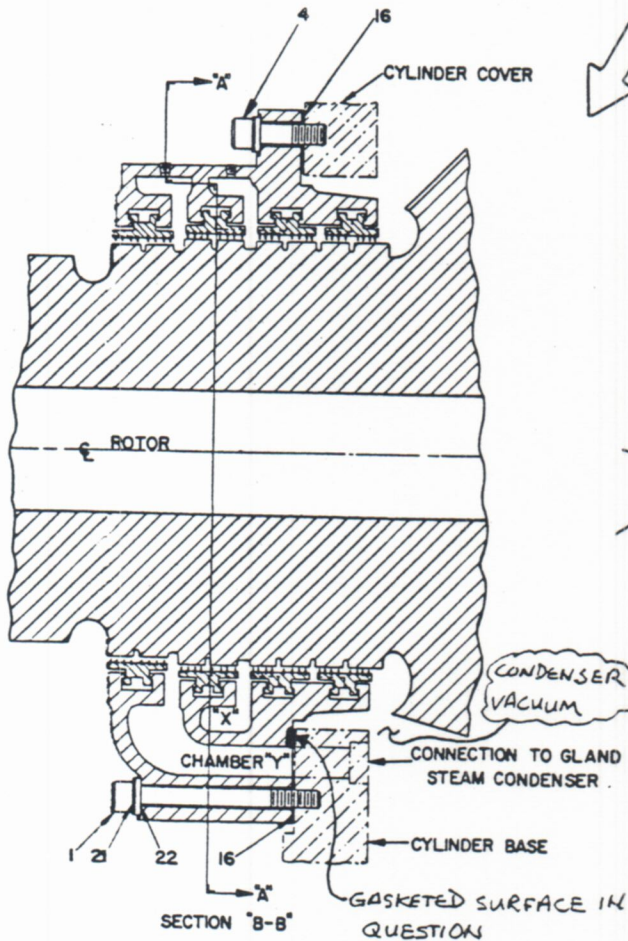


THE GASKET SEAL LEAKS - EXTERNAL COULD BE REMOVED FROM THE FAULT TREE BECAUSE THEY WERE STOPPED BY THE APPLICATION OF SEALANT. THE GASKET SEAL LEAKS - INTERNAL, THE BUTT CLEARANCES, AND THE SEAL ID ARE NORMALLY ONLY ABLE TO BE CHECKED DURING AN OVERHAUL. HOWEVER, AN IDEA FOR CHECKING FOR GASKET LEAKS - INTERNAL WAS TRIED.

ANALYSIS

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THROUGH BRAINSTORMING AN HYPOTHESIS WAS DEVELOPED THAT IF THE GASKET BETWEEN THE Y-CHAMBER AND THE FINAL TURBINE STAGE FAILED, CONDENSER VACUUM WOULD BE APPLIED TO THE STEAM SEAL BRUING IN LARGE QUANTITIES OF AIR.



TO PROVE THE HYPOTHESIS, A PIECE OF TUBING, CONNECTED TO A MANOMETER, WAS "SNAKED" INTO THE STEAM SEAL. WHEN IT REACHED THE GASKETED SURFACE IN QUESTION, ALL THE WATER WAS SUCKED OUT OF THE MANOMETER, INDICATING A VERY HIGH VACUUM AND THE PROBABILITY OF A FAILED GASKET

AN OVERHAUL WAS SCHEDULED TO INSPECT AND REPAIR THE SEALS

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ANALYSIS

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DURING THE NOV.-DEC. 1987 OVERHAUL,
THE SEALS WERE INSPECTED AND
THE FOLLOWING WERE FOUND:

- ALL GASKETS BETWEEN X, Y CHAMBERS AND
LAST TURBINE STAGE WERE FAILED (BLOWN OUT).
- THE SEAL ID'S WERE TOO LARGE RESULTING IN
EXCESSIVE CLEARANCES TO SHAFT.
- (● NO. 8 GLAND SEALS HAD EXCESSIVE BUTT CLEARANCES.)



SELECT IMPROVEMENTS COUNTERMEASURES

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PROBLEM	ROOT CAUSE	COUNTER-MEASURE	PRACTICAL METHOD	EFFECT-IVENESS	FEAS.	OVERALL	ACTION?
NO. 5 STEAM SEAL LEAKS AIR	GASKET FAILED (WRONG MAT'L)	CHANGE GASKET MATERIAL	CHANGE FROM FIBER TO STEEL GASKET	5	5	25	YES
	SEAL ID TOO LARGE	CHECK SEALS AFTER MACHINING	REVISE PROCEDURE	2	5	10	YES

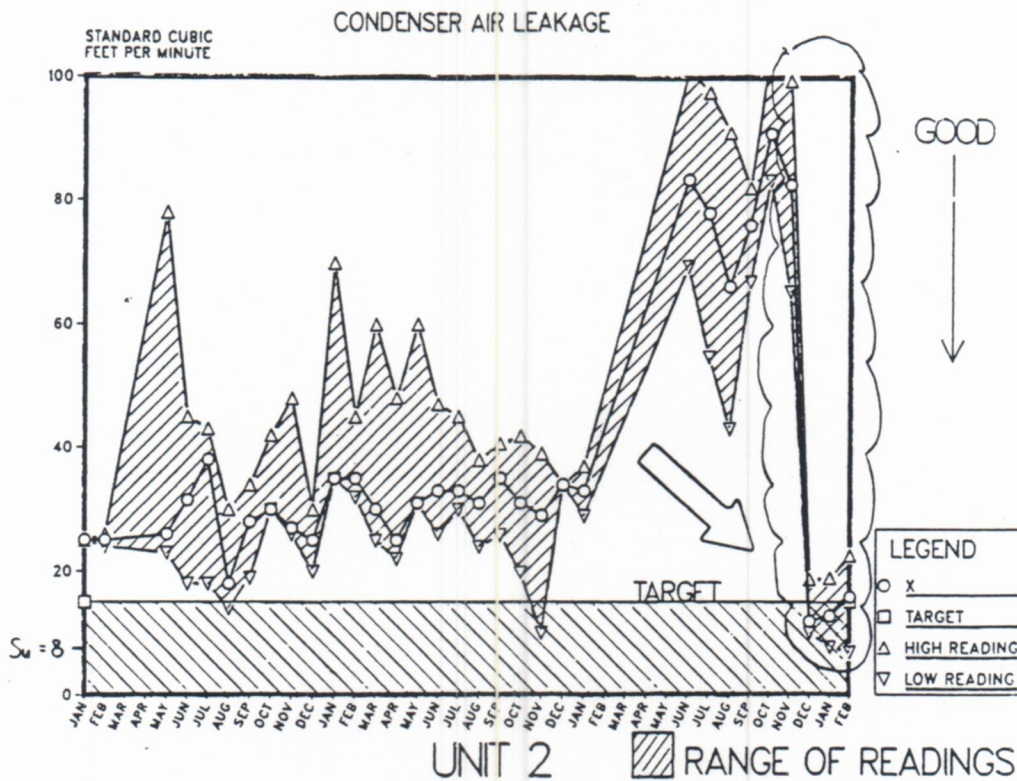
SCALE: 1=NONE 2=SOMEWHAT 3=MODERATE 4=VERY 5=EXTREME

NOTE: ABOVE COUNTERMEASURES WILL BE APPLIED TO ALL SEALS.



FDCA RESULTS

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WHEN THE UNIT WAS RETURNED TO SERVICE,
AIR LEAKAGE WAS DRAMATICALLY REDUCED
FROM AN AVG. OF 82.4 SCFM IN NOV. TO
11.8 IN DEC, 12.7 IN JAN, AND 15.8 IN FEB.

SCFM	NOV '87	DEC '87	JAN '88	FEB '88
$\bar{X}$	82.4	11.8	12.7	15.8 *
R	34.1	8.7	11.2	15.7

* TWO BFPT AIR
LEAKS IDENTIFIED

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DAVIS POINT

STANDARDIZATION IS CURRENTLY BEING
ADDRESSED BY THE MANATEE PLANT
AIR IN-LEAKAGE TASK TEAM IN TWO
MAIN AREAS:

- ENSURE THAT THE PROPER METAL GASKET IS
BEING USED IN FUTURE SEAL WORK.
- REVISE PROCEDURE TO ENSURE SEALS ARE
CHECKED AND ASSEMBLED PROPERLY
IN THE FUTURE.



DAVIS POINT

THE ~~MANATEE~~ PLANT AIR IN-LEAKAGE
TASK TEAM IS ALSO ADDRESSING FUTURE
PLANS IN THESE AREAS:

- ~~REPLICATION OF UNIT 1~~
- ADDRESS NEXT LARGEST SOURCE OF
AIR LEAKAGE
- CONTINUE TO IMPROVE UNTIL THE
AIR IN-LEAKAGE IS BETTER THAN
THE INDUSTRY STANDARD OF 8 SCFM.
- CHECK OTHER CRITICAL ITEMS SUPPLIED
FOR OVERHAUL