Barnes, Anita G SAS

From: Barnes, Anita G SAS
Sent: Thursday, September 26, 2002 1:11 PM
To: Sautter, Brian W SAS
Cc: Ruffin, John S SAS
Subject: RE: Generator Characteristics and Transformer Test reports

Generators 5-8 - GEC ALSTHOM - Synchronous Generator-Motor

3 phase Star 13.8kv 60 HZ 120RPM .95 PF

Max. Temp Rise: 80 C Rotor 75C Stator Insulation Class F

	Generator	Motor
Rating Stator Amps	*137,000 HP/4560 Amps	*94500 KVA/3955 Amps
Excitation Voltage Current	140 volts/1470 Amps	129 Volts/1350 Amps
Rotation	Clockwise	Counter Clockwise

Francis Pump Turbine - Dominion Engineering Works, Montreal, Canada

Pump	Turbine
6200CFS	104,000 HP
148 ft Head	144 ft Head
120 RPM	120 RPM

*Note: The Generator is oversized for the Turbine. The name plate data for the Generator - Motor is for 157 ft Head. The normal rated head at Russell is 144 ft. This makes quite a bit of difference between the name plate data and the actual.

Approximate Actual Data for Units 5-8:

80,000 KVA .95 PF (75.6 MW) Routine Generation
87,000 KVA (82.6 MW) Max. Generation at 115%

Anita Gayle Barnes
Richard B. Russell Power Project

-----Original Message-----
From: Sautter, Brian W SAS
Sent: Wednesday, September 18, 2002 10:58 AM
To: Palmer, William J SAS; Barnes, Anita G SAS
Subject: Genator Characteristics and Transformer Test reports

We have had arequest from Santee Cooper to get the Generator Charcteristics for units 5-8. They would also like to get a copy of the manufactors test report for Transformer 3 and 4.

The reason they are requesting this information is that they are doing the Power flow and stabilization study for us. The study is part of the requirements placed on the VACAR group.

December 15, 1998

Area Engineer, Richard B. Russell Project

SUBJECT: Contract No. DACW 21-87-C-0008,
Manufacture Four Generator/Motors
Richard B. Russell Powerhouse and Dam, GA & SC
Warranty, Units 5-8
Letter # 220

Mr. Michael Albert
GEC Alsthom Electromechanical
P.O. Box 550
1500 Vandal Street
Sorel, Quebec, Canada J3P 5P5

Dear Mr. Albert:

As a follow-up to our September 30, 1998 meeting, the Government reviewed the acceptance date records for Units 5-8 Generator/Motors and found the following:

Unit 5 Acceptance - July 1992
Unit 6 Acceptance - July 1992
Unit 7 Acceptance - December 1992*
Unit 8 Acceptance - January 1993

*Although Government correspondence, after December 1992, suggested the Generator/Motor Contractor might be responsible for correcting a vibration problem, the deficiency was eventually found to be turbine-related, and the December 1992 acceptance date for the Unit 7 generator/motor confirmed.

Based on these dates, along with the fact that there are no unresolved warranty issues, the Government finds the five-year warranties, on all four of the generator/motors, have expired with no outstanding Contractor action.

If you have any questions, please contact me at 706-283-7981.

Sincerely,

Thomas F. List, Jr. P.E.
Contracting Officer's
Representative

CF: CD-QM/Anderson
PM-C/Lynch
CT-P/Hackney
EN-DM/Mathis
EN/DE/Mixon
SAMEN/Mattei
CD-RR/Kennedy
OP-R/Barnes

[redacted]

Unit 7 Problems over the years (Taken from various folders) 25 Feb 2003

All information that was found is attached to this document. Thanks, Brian Craft

General Units 5-8 Problem

1) 24 March 1992, Thrust Runner Problem (document enclosed)

Unit 7 Problems:

1) 11 December 1992, Wiped Thrust Bearing on mechanical roll after replacing 'O' Ring.
2) April 1996, 770 Failure (Breaker Failure Relay Operated), causing switchyard breakers to trip; Caused a Full Load Rejection of Unit 8.
3) 1993, Servo Motor Leaking By, causing heating of Governor Oil; suggested to replace piston rings in servo motor.
4) September 1992, Grease Leaks on 2 wicket gate bushing seals.
5) 1993, Vibration Problem in Pump Mode, Turbine runner band gap is problem, to be fixed by Dominion Engineering.
6) 26 July 2002, wiped thrust bearing after running for 15 minutes as a generator.
7) 03 September 2002, wiped thrust bearing after running for 19 minutes as a generator.
8) 12 February 2003, wiped thrust bearing after running for 1 hour as a generator.

1.0-15 after full load

4 hrs out 1 hrs

Also attached is a history of problems with Unit 7 that was taken from the Operator Log Book by Michael Finley.

History of problems with unit 7, taken from logbooks

August 11, 1992	Headgate failed to lower
August 12, 1992	First test roll
August 12, 1992	Lowered headgate
August 26, 1992	Unit failed to condense
August 26, 1992	Load rejected four times
September 3, 1992	770 failed to close, governor problems
December 11, 1992	Generator thrust bearing, very high unit shut down by Miller
December 11, 1992	5M operations
May 13, 1993	5M, loss of AC oil pump
May 21, 1993	5E
May 25, 1993	No field breakers
June 22, 1993	5E
September 9, 1993	Field breaker failed to close
September 15, 1993	gates only opening to 18%
October 27, 1994	Generator air housing high temperature alarm, after shutdown
April 15,1995	Wear ring water problem
April 20, 1995	Exciter trouble
May 3, 1995	38GT, generator thrust bearing temperature relay, 5M (TR-48-95)
July 15, 1995	Governor locked
October 31,1995	Voltage Regulator troubles
April 4, 1996	Unable to start as a pump unit
April 6, 1996	Received creep detection
April 7, 1996	Took off line due to voltage regulator trouble, could not control MVAR's
April 23, 1996	Failed to prime, primed manually (TR-13-96 & TR-14-96)
May 12, 1996	failed to blow down
May 12, 1996	field breaker failed to close, 3 times
May 13, 1996	field breaker failed to close, 3 times
May 15, 1996	field breaker failed to close
May 25, 1996	5M, (38GT) TR-43-96
June 12, 1996	failed to blow down
July 6, 1996	brakes failed to release
July 10, 1996	5M, (38GT), tripped off line
July 16, 1996	Thrust bearing #3 alarm, 80.013
August 20,1996	field breakers failed to close, four times
May 1, 1997	failed to condense
June 23, 1997	5E, while starting to condense

April 6, 1998	failed to start (TR-15-98)
March 28, 2000	failed to start
April 3, 2000	failed to condense
November 14, 2000	low wear ring water flow
~~May 7, 2002~~	failed to start
May 21, 2002	voltage regulator failure
May 21, 2002	failed to condense
July 26, 2002	Tripped 38GT, generator thrust bearing relay
August 28, 2002	Shutdown unit
August 30, 2002	38GT, after 20 minutes on line
September 3, 2002	38GT, shutdown thrust bearing, high temperature

Thrust Runner Problems Units 5-8

CESAS-CD-RR (1180) 24 Mar 92

MEMORANDUM FOR RECORD

SUBJECT: Contract No. DACW 21-88-C-0031,
Construction of Pumped Storage Hydropower Units 5-8 at RBR Powerplant,
Richard B. Russell Dam & Lake, SAV River, GA & SC -
Revision to Thrust Bearing Runners at Connection Joint

1. The purpose of this MFR is to provide data pertaining to revision to thrust bearing runners at connection joint between halves.

2. On 24 Mar 92, Roger Provencher representing Marine Industries Limited, advised that a design problem had been noted during the rework of the thrust bearing runner surface in Montreal. It was noted that the chamfer designed on the bottom of the runner to prevent shaving the shoes was 0.005" deep and extends 1.5" on each side of the connection joint. (See attached MIL shop drawing) On-site testing was performed by Roger Provencher to collect data on the effect this chamfer had on the lifting force during start-up at various positions of the chamfer on the shoe surface. The worst condition will be when the chamfer is directly centered over oil injection hole in two shoes (shoe opposite each other). Roger Provencher also stated that this chamfer could have an effect on the orientation of the shoes during operation.

3. The MIL designers have advised that the runners are being reworked to provide a chamfer of approximately 0.0005" deep and 0.10" on each side of the connection joint.

Impact to Schedule

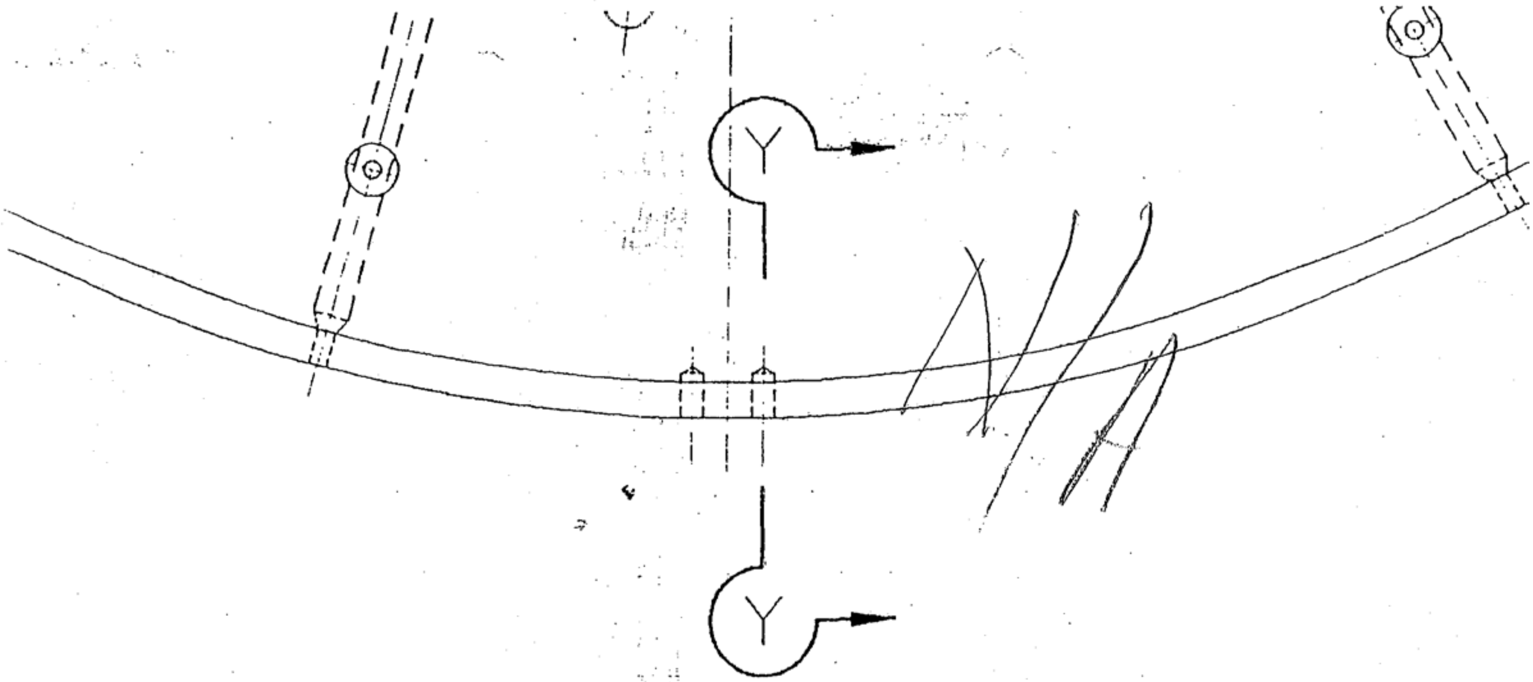
4. The reworked runner for unit 5 will arrive on 29 Mar 92. The contractor (MIL) is presently removing the coolers, shoes, and currently installed runner from unit 5. Installation of reworked runner and reinstallation of shoes and coolers will be completed on 3 Apr 92. Checkout and verification will be complete COB 5 Apr 92. Unit 5 start-up for continuing generator mode testing is 6 Apr 92.

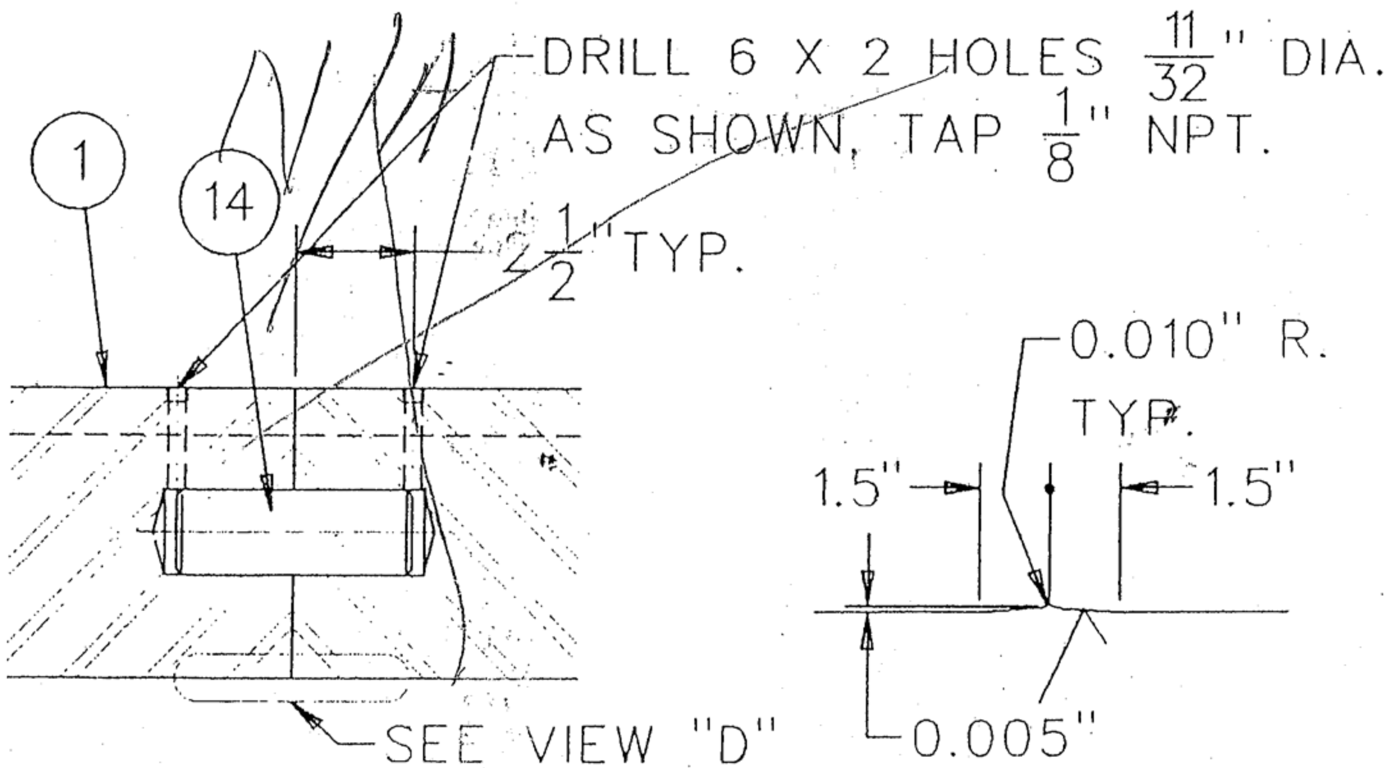
5. Unit 6 start-up date is revised to 20 Apr 92.

Elton L. Cobb

ELTON L. COBB
Area Engineer

CF: MIL/Provencher
EN-DM/Mathis
PPM-C
OP-TR
OP-RP
CD-QC
DOck Brown
OP-H
CD-Q
BBI





SECTION "B–B"

SCALE: $\frac{1}{4}$"=1"

VIEW "D"

SCALE: NTS

MIL DRAWING NO.

Tracy (Quebec) Canada

TURBINE–GENERATOR GROUP

PROJECT: Russel Dam

TITLE: AIR GAP

UNIT NO. 7

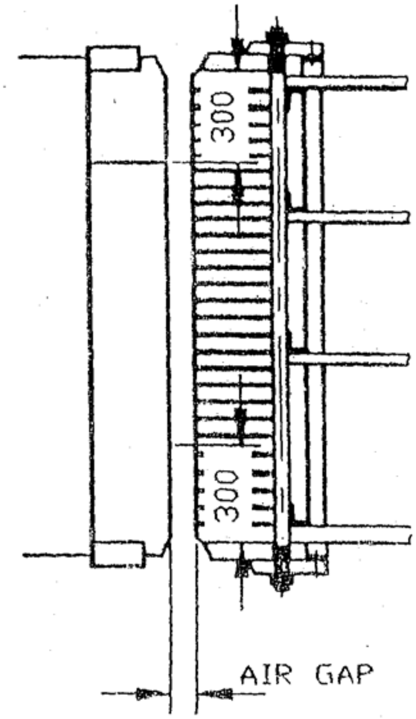
REF.:

NO.:

SHEET ____ TO ____

POLE	AIR GAP TOP	AIR GAP BOTTOM
1	.576	586
2	.575	576
3	.586	564
4	.572	558
5	.588	550
6	.579	547
7	.587	546
8	.578	544
9	.590	541
10	.602	561
11	.585	545
12	.591	572
13	.592	565
14	.581	557
15	.580	557
16	.575	564
17	.568	562
18	.570	551
19	.564	569
20	.567	556
21	.565	557
22	.570	570
23	.569	565
24	.552	565
25	.556	566
26	.568	575
27	.576	568
28	.572	563
29	.574	573
30	.595	574
31	.580	571
32	.584	590
33	.593	593
34	.598	578
35	.599	575
36	.588	580
37	.595	582
38	.591	567
39	.588	566
40	.593	565
41	.586	543
42	.584	569
43	.586	572
44	.586	576
45	.592	586
46	.595	581
47	.594	570
48	.593	570

POLE	AIR GAP TOP	AIR GAP BOTTOM
49	.592	596
50	.598	573
51	.591	572
52	.595	594
53	.589	577
54	.592	598
55	.594	574
56	.591	574
57	.584	578
58	.580	579
59	.579	578
60	.582	580



POLE NO: 1 UPSTREAM

THEO. AIR GAP : ________

REAL TOLERANCE" COMPARED WITH THEO.: < [ ]

SITE READING BY MIL TRACY	DATE	ROOM TEMPERATURE :
RECORDED BY: Chuck Surrett	9-05-92	INSTRUMENTATION:
RECORDED BY:		REMARK: 0° degree bottom.
CHECKED BY: Stan Hall		
CUSTOMER		
CHECKED BY:		
APPROVED BY:		

A99952414

RUSSELL DAM

AIR GAP AT 0 DEGREES
(measured)

Unit: 7 date: 9/5/92

Pole	TOP	BOTTOM
1	576	586
2	575	576
3	586	564
4	572	558
5	588	550
6	579	547
7	587	546
8	578	544
9	590	541
10	602	561
11	585	545
12	591	572
13	592	565
14	581	557
15	580	557
16	575	564
17	568	562
18	570	551
19	564	569
20	567	556
21	565	557
22	570	570
23	559	565
24	552	565
25	556	566
26	566	575
27	576	568
28	572	563
29	574	573
30	595	576

31	580	571
32	584	590
33	593	593
34	598	578
35	599	575
36	588	580
37	595	582
38	591	567
39	588	566
40	593	565
41	586	543
42	584	569
43	586	572
44	586	576
45	592	586
46	595	581
47	594	570
48	593	570
49	592	596
50	598	573
51	591	572
52	592	594
53	589	577
54	592	598
55	594	574
56	591	574
57	584	578
58	580	579
59	579	578
60	582	590
MEAN AIR GAP	584	570

SHAFT POSITION

X = 1

Y = -3

AIR GAP CORRECTED

POLE	TOP	BOTTOM
1	573	587
2	572	577
3	583	565
4	569	559
5	586	551
6	577	548
7	585	547
8	576	545
9	589	542
10	601	562
11	584	546
12	591	573
13	592	566
14	581	558
15	581	558
16	576	565
17	569	563
18	572	552
19	566	570
20	569	557
21	567	568
22	573	571
23	562	566
24	555	565
25	559	567
26	571	576
27	579	569
28	575	564
29	577	574
30	598	577

32	587	591
33	596	594
34	601	579
35	601	576
36	590	581
37	597	583
38	593	568
39	589	567
40	594	566
41	587	544
42	584	570
43	586	573
44	586	577
45	591	587
46	594	582
47	593	571
48	591	571
49	590	597
50	596	574
51	589	573
52	589	595
53	586	578
54	589	599
55	591	575
56	588	575
57	581	579
58	577	580
59	576	579
60	579	581

From Bentley-Nevada report
Jan 1994

* Bentley-Nevada brought their own equipment for monitoring.

2.0 PROJECT SUMMARY
Unit No. 7 Turbine Generator

The following report is the results of the vibration analysis performed on the Unit No. 7 [redacted] Generator located at Richard B. Russell Pump Storage in Elberton, Ga.

Unit No. 7 Turbine Generator was operated in the generation and pump modes. Plant personnel were not concerned with the vibration amplitudes observed during generation. The primary concern was the high vibration amplitudes observed during the pump mode. Plots 23-35 are representative of the data observed during generation mode. Plots 1-18 are representative of the data observed during the pump mode. The following conclusions are based on the data observed.

GENERATION MODE:

1. The data indicates a fluid induced instability during operation of the machine train in the generation mode. As load was increased, the vibration amplitudes decreased. An approximate 1/2X or 1 hz component is observed in the orbit and spectrum data. While the spectrum data indicates that the component is exactly 1/2X, observation of the unfiltered orbit data shows that the component is NOT an exact submultiple of running speed. The orbit data also shows the vibration direction to be in forward precession or in the direction of rotation, a characteristic of fluid induced instability. The location of the instability is not evident. This phenomenon may occur at any location on the machinery train where there is a cylinder within a cylinder and a fluid present. Typical suspect locations are bearings and seals. **Recommendations:** 1. Inspect bearings to ensure that the clearances are within manufacturers specifications. 2. The wear rings are also an excellent location for instability. If sufficient air volume is available, injecting air, preferably against rotation, in the seal may eliminate the instability.

2. The data also indicates imbalance of the rotor system. Balancing the rotor system with runout compensated data should reduce the vibration amplitudes observed. **Recommendation:** The force from imbalance will help control the fluid induced instability. Therefore, further balancing should not be performed until the instability phenomenon can be resolved.

PUMP MODE:

1. During the transition from condensing mode when the water is blown down in the draft tube to pump mode, the machinery train goes through extreme vibration excursions. The vibration amplitudes observed by the proximity transducers may exceed 50 mils pp. The diametral bearing clearances provided to MDS for the generator bearings and turbine bearing are 20 mils and 12 mils, respectively. The vibration amplitudes CANNOT exceed the bearing clearances unless the bearing is damaged allowing excess motion of the shaft, or the transducer mounting bracket is vibrating indicating a large relative motion. **Recommendations:** 1. Mount an appropriate seismic transducer (velocity or velometer) to

the proximity transducer mounting bracket. Integrate the transducer output to mils pp. Determine the motion of the bracket and bearing relative to free space and the motion of the shaft to free space while the machine is operating in a pump mode. 2. In lieu of Item 1, inspect the bearings for excessive clearances.

2. Plots 1-18 represent the data observed from condensing mode to pumping mode. Plots 1-4 are orbit data during pump mode. Plots 9-14 are 1X amplitude and phase versus time (APHT) plots from condensing mode through pumping mode. Figures 1 and 2 are representative of the orbit and 1X APHT plots observed.

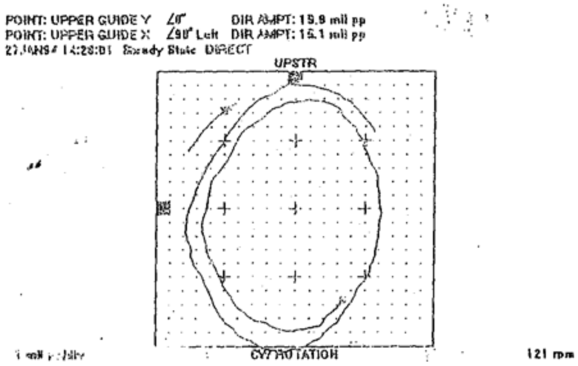


Figure 1: Plot 1

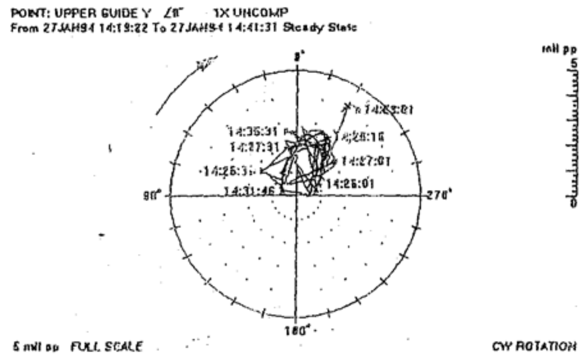


Figure 2: Plot 7

Figure 1 is an orbit for one revolution of the shaft (Plot 1-Appendix A for eight revolutions). This plot exhibits a primary frequency at 3.5-3.65 hz. This frequency component is not related to any common rotor related machinery malfunction, as will be discussed later.

Figure 2 shows represents the 1X APHT for the Upper Guide Y transducer. This is typical for the other transducer locations as shown in Appendix A. The APHT plots are typical for a rub malfunction. The rub may be initiated during the transient high vibration that occurs during the change from condensing operation to pumping operation. Once the rub is initiated, then it continues throughout the pumping mode. This may be further aggravated by the axial position of the rotor. Data supplied by plant personnel after MDS left the site indicates significant axial change from a cold starting/operating condition to a hot (heat soaked) operating condition. This may account for the low vibration levels observed on Unit No. 8 Turbine Generator since it was heat soaked in a generating mode prior to operating in a pump mode. It is also well documented in may case histories that rubs modify machinery resonances. This may account for the unusual frequency observed in Figure 1. Also, more than one malfunction may be present, but the rub malfunction must be resolved. **Recommendation:** Visually and mechanically inspect seal areas, wear rings, and other parts for evidence of rotor to any stationary part rubbing.

3. Another malfunction possibility is a resonance excited during the pump mode. This resonance may not be excited during the generation mode because the excitation energy and the mechanism exciting the resonance are not present. Item 2 has already discussed one such mechanism, a rub. Two other possibilities exist which may be exciting a resonance. These are cavitation and acoustic liquid resonances. Detailed discussions of these phenomenon are

contained in various handbooks concerning pumps and hydraulic turbines. Suggested resources are:

[1] Elliot. Standard Handbook of Power Plant Engineering

[2] Karassik, et. al. Pump Handbook, 2nd Edition

[3] Baumeister, et. al. Mark's Standard Handbook for Mechanical Engineers, 8th Edition

Cavitation occurs when the absolute pressure of the water drops to the vapor pressure of water. This allows vapor cavities to form which collapse (implode) when the absolute pressure exceeds the vapor pressure. Localized water hammer occurs with extremely high pressure during these implosions. This water hammer may be exciting a natural resonance of the system. The turbine runner must be set such that cavitation does not occur. The parameter utilized to minimize this phenomenon in vertical pumps is the *Thoma cavitation coefficient* (Ref. 1, pp 2.177-2.180). The plant cavitation coefficient must be greater than the turbine cavitation coefficient or excessive cavitation will occur. This may be further aggravated by the vortex forming at the tail race inlet which could be starving flow during the pump mode. Several remedies have been utilized to reduce cavitation including flow splitters and injecting compressed air into the runner. A limited amount of compressed air was available for injection during this testing. Injection of air appeared to modify the vibration frequency from 3.65 hz to 3.5 hz. **Recommendations:** 1. This item should be investigated further with the appropriate design personnel to ensure that the pump is not operating near the plant cavitation coefficient. The affect of the vortex should also be investigated further to ensure that the vortex is not starving inlet flow during pumping operation. 2. If a large volume of compressed air is available, injection into the turbine runner may reduce vibration amplitudes.

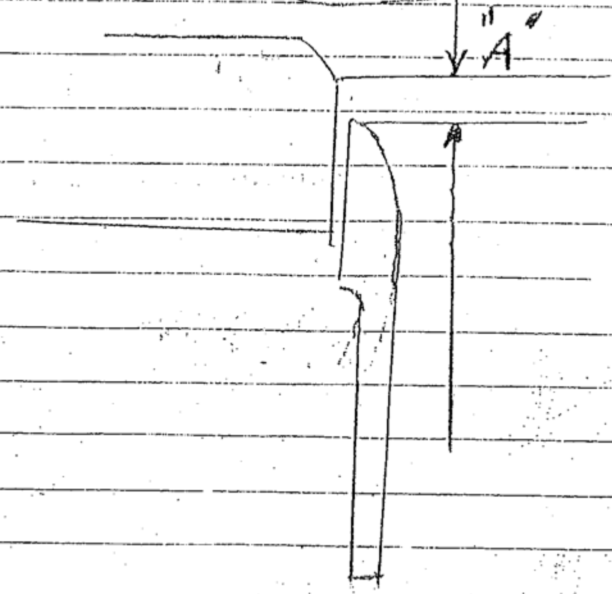
Acoustic liquid resonances occur in piping systems of finite length. These resonances selectively amplify some pulsation frequencies. The resonance frequencies depend on the velocity of sound in water, pipe length, and end conditions. **Recommendations:** 1. Dynamic pressure measurements with an appropriate transducer should be obtained at various locations to confirm the pressure pulsations and associated frequencies. 2. Seismic measurements should be obtained to determine if structural components should be stiffened to prevent excitation of natural frequencies.

FOR
FLOYD
KING

UNIT 7
TAKEN BY DOMENION.
DUE TO VIBRATION PROBLE
3/16/94

INNER BAND

16/3/94



"A" HIGHT

0°	.172
90°	.180
180°	.184 .187
270°	.200

"B" CLEARANCE

0	.121
90	.133
180°	.152
270°	.129

UNIT 7

94

16-3-94

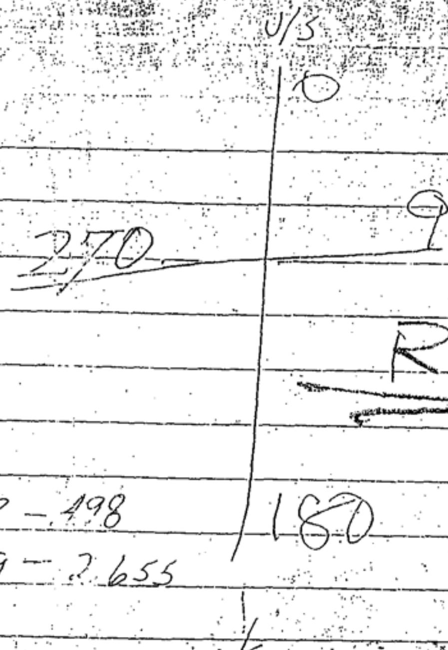
TOP HEAD COVER

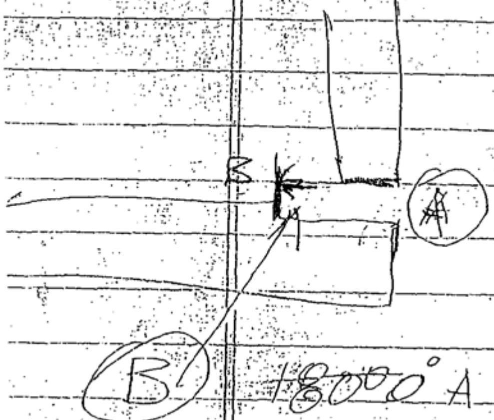
0° .038 CROWN IN
90° .035 CROWN IN
180° .040 CROWN IN
270° .042 CROWN IN

CLEARANCE
0° - .067
90° .078
180° .085
270° .077 - .076

UNIT 7

16-3-94





RUNNER BAND

Bottom

0° A .498 - .498
B 2.659 - 2.655

90 A .497 - .498
B 2.648 - 2.651

180 A .493 - .496 (494.5)
B ~~2.606 - 2.605~~
2.653 - 2.632

270 A .496 - .496
B 2.658 - 2.663

UNIT 7 AIR GAP READINGS 3-17-94

U.S. TOP .545
BOTTOM .558

pole 51

pole 51 WAS AT U.S. POSITION

GA. Side pole 36

TOP .571
BOTTOM .556

pole 6 — S.C. Side

TOP .555
BOTTOM .552

pole 21

O.S. TOP .547
BOTTOM .555

UNIT 7 AIR GAP READINGS 3-17-94

U.S. TOP .545
BOTTOM .558

pole 51

POLE 51
WAS AT U.S.
POSITION

G.A. side pole 36

TOP .571"
BOTTOM .556

POLE 6 — S.C. side

TOP .555
BOTTOM .552

POLE 21

O.S. TOP .547"
BOTTOM .555