JETTECH MECHANICAL LLC
Rotating Equipment Specialist

Case Study: Boiler Feed Pump Impact Testing

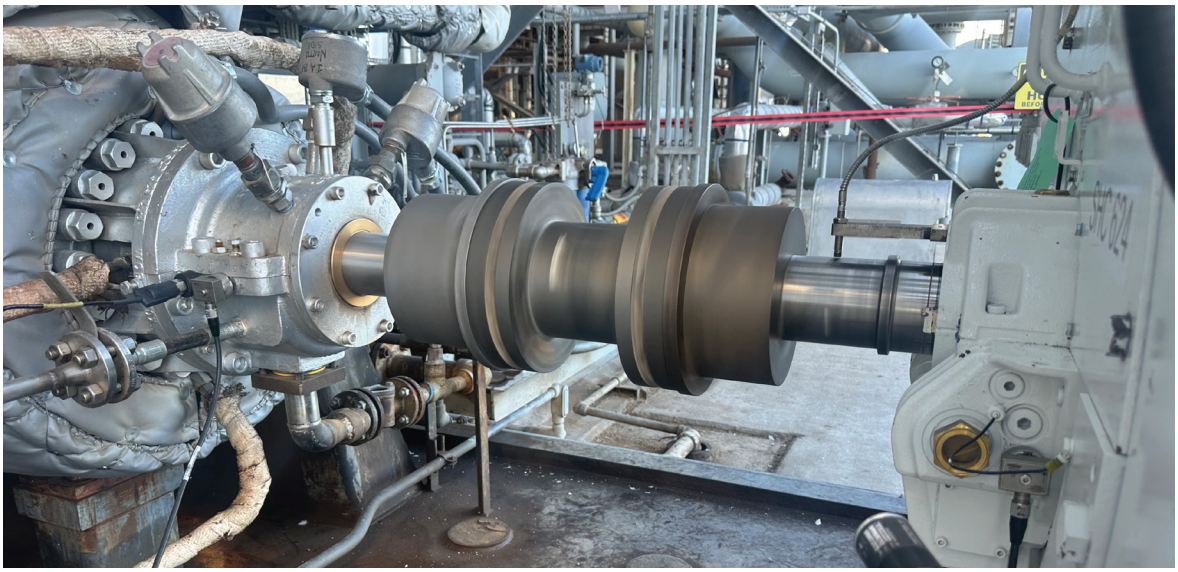
Introduction

Our friends at JetTech Mechanical were commissioned to collect and evaluate impact (modal) test data for the Sulzer Boiler Feed Pump bearing housings and shaft. The intent is to determine whether any structural or rotor natural frequencies are coincident with operating speeds, harmonics, or hydraulic excitations such as vane pass frequency.

Equipment

The subject machine is a Sulzer multistage boiler feed pump with the following key characteristics:

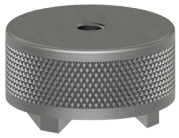
SULZER FQ-360-GSG BOILER FEED PUMP
Rated Power: ~3000 HP
Speed: 60 Hz
Actual Operating Speed: 3587 RPM
Stages: Eight (8)
Nominal Synchronous Speed: 3600 RPM
Actual Measured Speed (Keyphasor): 3587 RPM
Impeller Configurations Evaluated: 5-vane and 7-vane designs



Hardware

JetTech Mechanical utilized the following hardware to perform impact testing:

AC192-1D
Compact accelerometer, 100 mV/g, ±10% sensitivity tolerance



CTC MH114-3A
Multipurpose magnet, 50 lbs. pull strength

CTC CB103-K2C-010-F-SF
CB103 cable with K2C connector on the left, F connector on right, and SF breakaway safety feature connector; 10 ft. length

BETAVIB VibWorks King
Data collector

Operating Frequencies

Based on the measured operating speed of 3587 RPM, the following forcing frequencies apply:

1x Running Speed: 3587 CPM
2x Running Speed: 7174 CPM
5x Vane Pass Frequency (5-vane): 17,935 CPM
7x Vane Pass Frequency (7-vane): 25,109 CPM

Impact Test Summary

Impact testing identified multiple structural resonances within the pump bearing housings and shaft system. Of particular importance is a lightly damped vertical structural resonance centered near 25,800 CPM, with an identified danger zone spanning approximately 25,160 to 26,440 CPM.

Additional resonances were identified near 1x and 2x running speed ranges; however, these were secondary in significance compared to vane pass interaction.

Impact Test Results

Impact testing conducted on the pump bearing housings and shaft system revealed several structural resonances. Notably, there is a lightly damped vertical structural resonance centered at approximately 25,800 CPM. This resonance is considered critical, as it defines a “danger zone” spanning from about 25,160 to 26,440 CPM, where structural response is significantly amplified.

Additional structural resonances were also detected near both the 1x and 2x running speed ranges. However, these resonances are of secondary importance when compared to the pronounced interaction occurring at the vane pass frequencies.

Please see the appendix beginning on page 5 for impact test data

Relationship to Operating Vibration Data

JetTech Mechanical’s operating vibration measurements show higher vibration levels at the 7x vane pass frequency, with the Pump Inboard Bearing (PIB) vertical direction being the most affected.

At the operating speed of 3587 RPM, the 7x vane pass frequency (25,109 CPM) is located right next to the identified vertical resonance range. Because this mode has low damping, the structure responds with strong amplification when subjected to hydraulic forces from the vane passes.

Root Cause Assessment

The primary factor contributing to elevated PIB vertical vibration is attributed to a resonance phenomenon established between the hydraulic forcing frequency of the 7-vane impeller and a vertical structural mode of the pump casing and bearing pedestal assembly.
This scenario is not associated with imbalance, misalignment, or bearing defects, as these conditions do not typically elicit excitation at vane pass frequencies.

Risk Assessment

Operating under this resonance condition may lead to:

- Accelerated bearing degradation
- Fretting and loosening at pedestal interfaces
- Fatigue-induced cracking in bearing housings or casing components
- Increased maintenance requirements and diminished equipment reliability

Primary Recommendation

Transition to a 5-vane impeller configuration to shift the vane pass excitation to 17,935 CPM, thereby avoiding the identified vertical resonance.

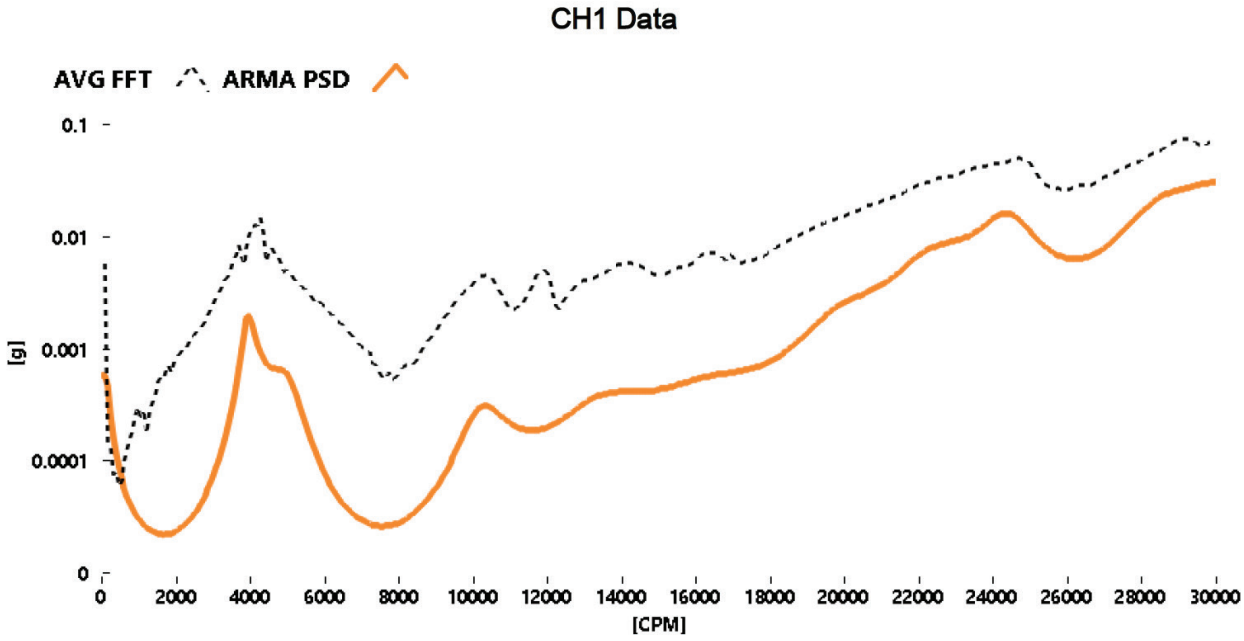
Secondary Mitigation Measures

- Inspect, and if necessary, re-grout the inboard bearing pedestal
- Verify proper torque of hold-down bolts and assess soleplate condition
- Confirm operation in proximity to the Best Efficiency Point (BEP)

APPENDIX

Impact Test Report 1

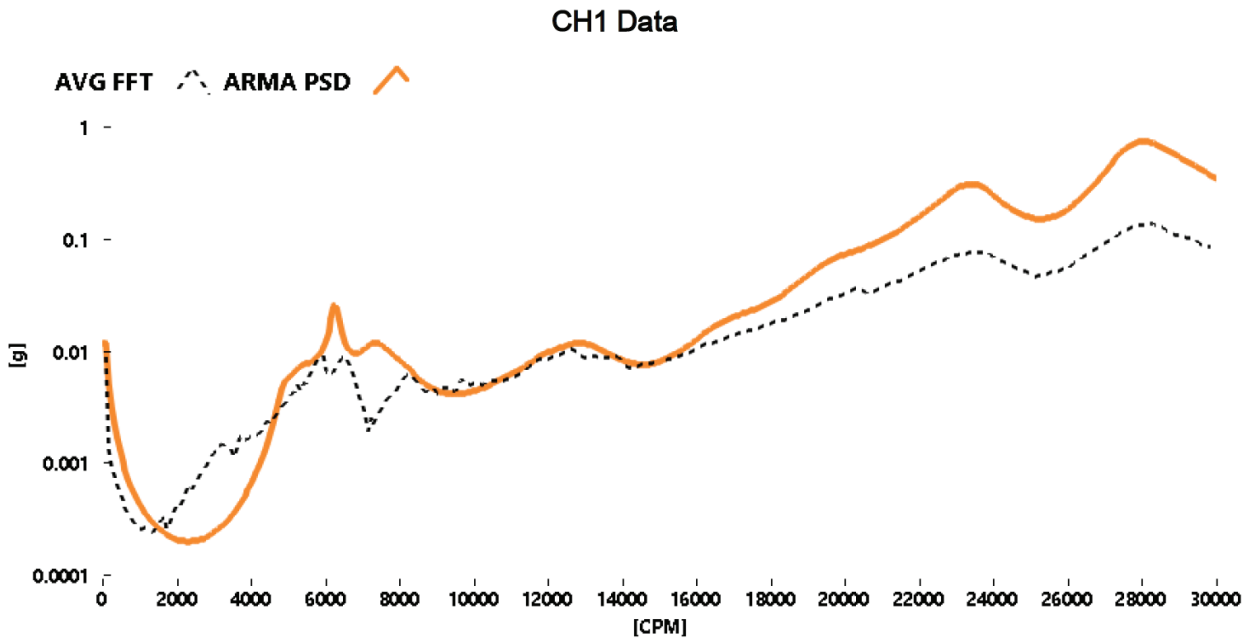
Department	Machine	Position
Boiler Feed Pumps	1A BFP	PIB H



Avg FFT Fn	Amp	ARMA Fn	Damping	Danger Zone
3675.00	0.0082	3975.00	7.55 %	[3825.00 4125.00]
4275.00	0.0144	-	-	-
-	-	10275.00	9.49 %	[9787.50 10762.50]
11925.00	0.0050	-	-	-
14175.00	0.0058	-	-	-
16425.00	0.0072	-	-	-
16875.00	0.0070	-	-	-
22725.00	0.0341	-	-	-
24675.00	0.0499	24375.00	5.23 %	[23737.50 25012.50]
25725.00	0.0271	-	-	-
29175.00	0.0745	-	-	-

Impact Test Report 2

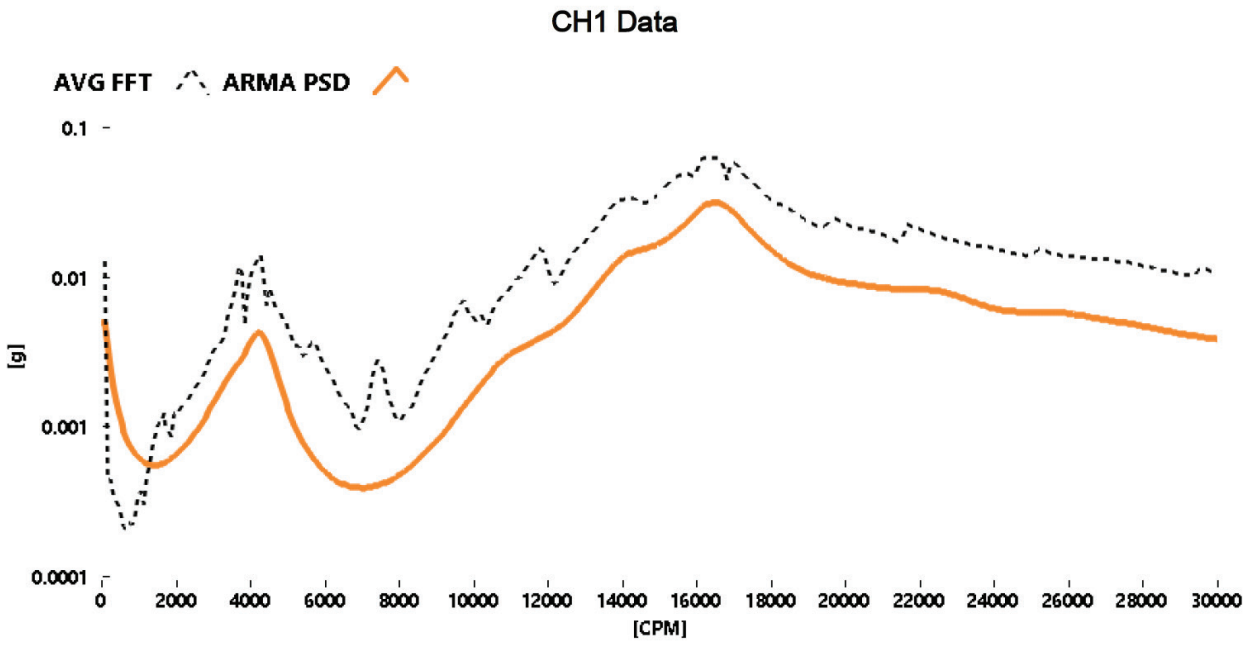
Department	Machine	Position
Boiler Feed Pumps	1A BFP	PIB V



Avg FFT Fn	Amp	ARMA Fn	Damping	Danger Zone
5850.00	0.0090	-	-	-
6525.00	0.0091	6225.00	6.02 %	[6037.50 6412.50]
-	-	7350.00	29.59 %	[6262.50 8437.50]
12225.00	0.0094	-	-	-
12600.00	0.0103	12825.00	16.37 %	[11775.00 13875.00]
13725.00	0.0091	-	-	-
20325.00	0.0363	-	-	-
23550.00	0.0760	23400.00	6.09 %	[22687.50 24112.50]
25650.00	0.0516	-	-	-
28125.00	0.1357	28050.00	5.88 %	[27225.00 28875.00]
29925.00	0.0857	-	-	-

Impact Test Report 3

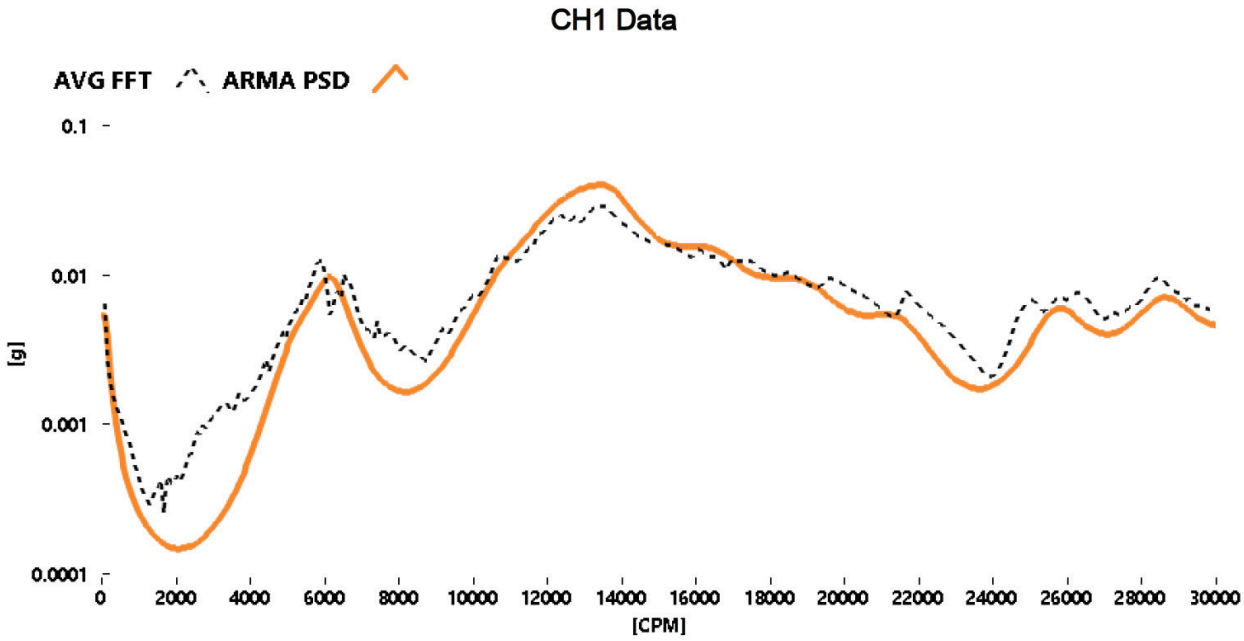
Department	Machine	Position
Boiler Feed Pumps	1A BFP	POB H



Avg FFT Fn	Amp	ARMA Fn	Damping	Danger Zone
-	-	4200.00	14.29 %	[3900.00 4500.00]
11775.00	0.0155	-	-	-
13875.00	0.0335	-	-	-
14250.00	0.0339	-	-	-
15675.00	0.0500	-	-	-
16500.00	0.0631	16500.00	7.73 %	[15862.50 17137.50]
16950.00	0.0591	-	-	-
19650.00	0.0245	-	-	-
20400.00	0.0211	-	-	-
21675.00	0.0223	-	-	-
25200.00	0.0154	-	-	-

Impact Test Report 4

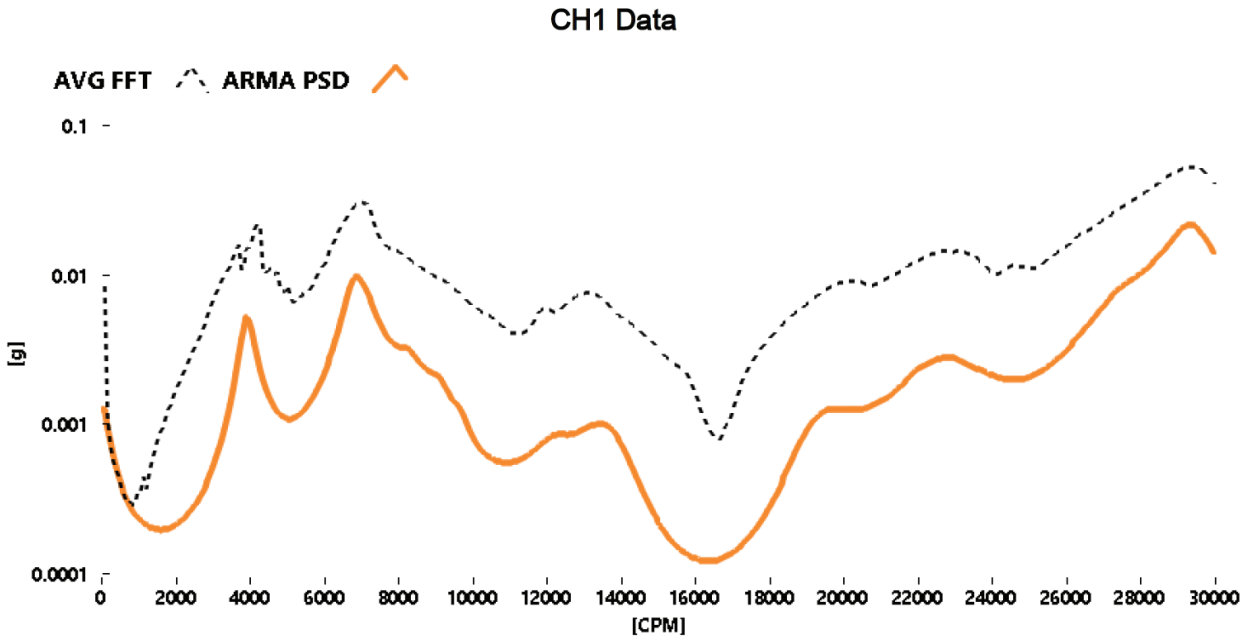
Department	Machine	Position
Boiler Feed Pumps	1A BFP	POB V



Avg FFT Fn	Amp	ARMA Fn	Damping	Danger Zone
-	-	6150.00	13.41 %	[5737.50 6562.50]
10725.00	0.0136	-	-	-
11475.00	0.0152	-	-	-
12375.00	0.0251	-	-	-
12750.00	0.0244	-	-	-
13425.00	0.0291	13425.00	13.41 %	[12525.00 14325.00]
15150.00	0.0161	-	-	-
16050.00	0.0150	-	-	-
16425.00	0.0133	-	-	-
16950.00	0.0126	-	-	-
17325.00	0.0126	-	-	-
-	-	25800.00	4.94 %	[25162.50 26437.50]
-	-	28650.00	5.24 %	[27900.00 29400.00]

Impact Test Report 5

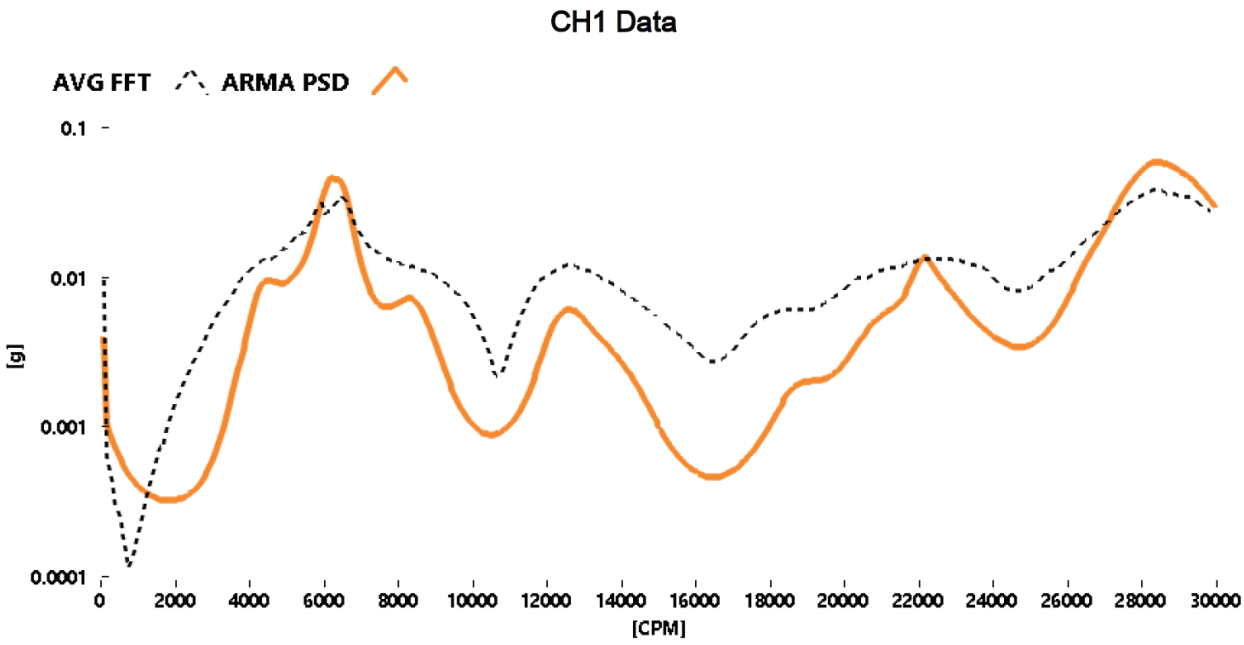
Department	Machine	Position
Boiler Feed Pumps	1A BFP	PIB Shaft H



Avg FFT Fn	Amp	ARMA Fn	Damping	Danger Zone
3675.00	0.0157	3900.00	9.62 %	[3712.50 4087.50]
4200.00	0.0220	-	-	-
4575.00	0.0111	-	-	-
6975.00	0.0309	6900.00	8.70 %	[6600.00 7200.00]
13125.00	0.0076	13425.00	15.64 %	[12375.00 14475.00]
20250.00	0.0092	-	-	-
22725.00	0.0145	22800.00	9.87 %	[21675.00 23925.00]
23100.00	0.0145	-	-	-
24525.00	0.0116	-	-	-
29475.00	0.0529	29325.00	3.84 %	[28762.50 29887.50]

Impact Test Report 6

Department	Machine	Position
Boiler Feed Pumps	1A BFP	PIB Shaft V



Avg FFT Fn	Amp	ARMA Fn	Damping	Danger Zone
4425.00	0.0136	-	-	-
5250.00	0.0189	-	-	-
5925.00	0.0317	6225.00	13.25 %	[5812.50 6637.50]
6450.00	0.0354	-	-	-
7350.00	0.0153	-	-	-
7875.00	0.0131	-	-	-
12600.00	0.0121	12600.00	10.71 %	[11925.00 13275.00]
22350.00	0.0133	22125.00	4.07 %	[21675.00 22575.00]
28425.00	0.0387	28425.00	6.86 %	[27450.00 29400.00]
28800.00	0.0358	-	-	-