

Appendix A Overall vibration

Database: GC7_(BTF).rbm
Area: GC7
Period Reported: 03-Sep-21 To 01-May-24

Equipment 1: P-6981R

	DATE	TIME	OVERALL
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P-6981R - M1H-Motor Outboard Horizontal			mm/Sec
	03-Sep-21	17:59	.825
	03-Sep-21	18:29	.866
	03-Sep-21	20:02	.741
	29-Apr-24	15:38	.844→ Level is 1580 mm.
	29-Apr-24	15:49	.836→ Level is 1550 mm.
	29-Apr-24	16:03	.834→ Level is 1505 mm.
	29-Apr-24	16:20	.788→ Level is 1454 mm.
	29-Apr-24	16:36	.820→ Level is 1389 mm.
	29-Apr-24	16:52	.807→ Level is 1328 mm.
	29-Apr-24	17:18	.838→ Level is 1236 mm.
	29-Apr-24	17:40	.799→ Level is 1143 mm.
	29-Apr-24	18:01	.795→ Level is 1064 mm.
	29-Apr-24	18:20	.738→ Level is 1000 mm.
	29-Apr-24	18:39	.801→ Level is 934 mm.
	29-Apr-24	19:00	.804→ Level is 874 mm.
	29-Apr-24	19:21	.822→ Level is 752 mm.
	29-Apr-24	19:37	.812→ Level is 661 mm.
	29-Apr-24	20:02	.746→ Level is 528 mm.
	29-Apr-24	20:20	.827→ Level is 348 mm.
	29-Apr-24	20:39	.759→ Level is 170 mm.
P-6981R - M1P-Motor Outboard Horiz			Peakvue
			G-s
	03-Sep-21	17:59	.232
	03-Sep-21	18:29	.247
	03-Sep-21	20:02	.201
	29-Apr-24	15:38	.136
	29-Apr-24	15:49	.137
	29-Apr-24	16:03	.138
	29-Apr-24	16:20	.141
	29-Apr-24	16:36	.132
	29-Apr-24	16:52	.156
	29-Apr-24	17:18	.198
	29-Apr-24	17:40	.123
	29-Apr-24	18:01	.153
	29-Apr-24	18:20	.210
	29-Apr-24	18:39	.205
	29-Apr-24	19:00	.142
	29-Apr-24	19:21	.146
	29-Apr-24	19:37	.210
	29-Apr-24	20:02	.143
	29-Apr-24	20:20	.078
	29-Apr-24	20:39	.140
P-6981R - M1V-Motor Outboard Vertical			mm/Sec
	03-Sep-21	17:59	.333
	03-Sep-21	18:29	.453
	03-Sep-21	20:03	.304
	29-Apr-24	15:38	.485
	29-Apr-24	15:50	.345
	29-Apr-24	16:03	.447
	29-Apr-24	16:21	.444
	29-Apr-24	16:36	.518
	29-Apr-24	16:53	.513
	29-Apr-24	17:18	.394
	29-Apr-24	17:41	.397
	29-Apr-24	18:02	.370
	29-Apr-24	18:21	.536
	29-Apr-24	18:40	.384
	29-Apr-24	19:01	.407
	29-Apr-24	19:21	.421
	29-Apr-24	19:37	.411
	29-Apr-24	20:02	.494
	29-Apr-24	20:21	.298
	29-Apr-24	20:39	.484

P-6981R - M1A-Motor Outboard Axial

		mm/Sec
03-Sep-21	17:59	.343
03-Sep-21	18:30	.415
03-Sep-21	20:03	.454
29-Apr-24	15:38	.117
29-Apr-24	15:50	.120
29-Apr-24	16:04	.103
29-Apr-24	16:21	.111
29-Apr-24	16:36	.127
29-Apr-24	16:53	.127
29-Apr-24	17:19	.105
29-Apr-24	17:41	.110
29-Apr-24	18:02	.117
29-Apr-24	18:21	.107
29-Apr-24	18:40	.114
29-Apr-24	19:01	.116
29-Apr-24	19:22	.112
29-Apr-24	19:37	.117
29-Apr-24	20:02	.127
29-Apr-24	20:21	.117
29-Apr-24	20:39	.120

P-6981R - M2H-Motor Inboard Horizontal

		mm/Sec
03-Sep-21	17:59	.730
03-Sep-21	18:30	.789
03-Sep-21	20:03	.583
29-Apr-24	15:38	.629
29-Apr-24	15:50	.664
29-Apr-24	16:04	.642
29-Apr-24	16:21	.614
29-Apr-24	16:37	.660
29-Apr-24	16:54	.628
29-Apr-24	17:19	.600
29-Apr-24	17:41	.639
29-Apr-24	18:02	.596
29-Apr-24	18:21	.749
29-Apr-24	18:40	.636
29-Apr-24	19:01	.639
29-Apr-24	19:22	.619
29-Apr-24	19:37	.640
29-Apr-24	20:03	.634
29-Apr-24	20:22	.636
29-Apr-24	20:40	.638

P-6981R - M2P-Motor Inboard Horiz Peakvue

		G-s
03-Sep-21	17:59	.197
03-Sep-21	18:30	.303
03-Sep-21	20:03	.225
29-Apr-24	15:38	.120
29-Apr-24	15:50	.110
29-Apr-24	16:04	.123
29-Apr-24	16:21	.108
29-Apr-24	16:37	.109
29-Apr-24	16:54	.152
29-Apr-24	17:19	.126
29-Apr-24	17:41	.135
29-Apr-24	18:02	.110
29-Apr-24	18:21	.128
29-Apr-24	18:40	.117
29-Apr-24	19:01	.128
29-Apr-24	19:22	.126
29-Apr-24	19:37	.119
29-Apr-24	20:03	.122
29-Apr-24	20:22	.139
29-Apr-24	20:40	.119

P-6981R - M2V-Motor Inboard Vertical

		mm/Sec
03-Sep-21	18:00	.364
03-Sep-21	18:30	.450
03-Sep-21	20:03	.449
29-Apr-24	15:39	.317
29-Apr-24	15:50	.418
29-Apr-24	16:04	.399
29-Apr-24	16:22	.324
29-Apr-24	16:37	.417
29-Apr-24	17:00	.394
29-Apr-24	17:19	.488
29-Apr-24	17:42	.419
29-Apr-24	18:02	.502
29-Apr-24	18:21	.414
29-Apr-24	18:40	.498

	29-Apr-24	19:02	.477
	29-Apr-24	19:22	.408
	29-Apr-24	19:38	.506
	29-Apr-24	20:03	.356
	29-Apr-24	20:22	.426
	29-Apr-24	20:40	.451
P-6981R - M2A-Motor Inboard Axial			
			mm/Sec
	03-Sep-21	18:00	.373
	03-Sep-21	18:31	.358
	03-Sep-21	20:04	.435
	29-Apr-24	15:39	.373
	29-Apr-24	15:51	.430
	29-Apr-24	16:05	.457
	29-Apr-24	16:22	.469
	29-Apr-24	16:37	.365
	29-Apr-24	17:00	.472
	29-Apr-24	17:20	.487
	29-Apr-24	17:42	.494
	29-Apr-24	18:03	.491
	29-Apr-24	18:22	.429
	29-Apr-24	18:41	.460
	29-Apr-24	19:02	.415
	29-Apr-24	19:22	.482
	29-Apr-24	19:38	.440
	29-Apr-24	20:03	.467
	29-Apr-24	20:22	.462
	29-Apr-24	20:40	.471
P-6981R - P1H-Pump Inboard Horizontal			
			mm/Sec
	03-Sep-21	20:04	.498
	29-Apr-24	15:39	.529
	29-Apr-24	15:51	.556
	29-Apr-24	16:05	.499
	29-Apr-24	16:22	.543
	29-Apr-24	16:37	.619
	29-Apr-24	16:55	.684
	29-Apr-24	17:20	.730
	29-Apr-24	17:42	.721
	29-Apr-24	18:03	.634
	29-Apr-24	18:22	.635
	29-Apr-24	18:41	.709
	29-Apr-24	19:02	.832
	29-Apr-24	19:23	.660
	29-Apr-24	19:38	.691
	29-Apr-24	20:04	.699
	29-Apr-24	20:23	.594
	29-Apr-24	20:40	.564
P-6981R - P1P-Pump Inboard Horz Peakvue			
			G-s
	03-Sep-21	20:04	.136
	29-Apr-24	15:39	.123
	29-Apr-24	15:51	.135
	29-Apr-24	16:05	.121
	29-Apr-24	16:22	.176
	29-Apr-24	16:37	.194
	29-Apr-24	16:55	.176
	29-Apr-24	17:20	.164
	29-Apr-24	17:42	.118
	29-Apr-24	18:03	.145
	29-Apr-24	18:22	.093
	29-Apr-24	18:41	.135
	29-Apr-24	19:02	.110
	29-Apr-24	19:23	.096
	29-Apr-24	19:38	.081
	29-Apr-24	20:04	.136
	29-Apr-24	20:23	.176
	29-Apr-24	20:40	.137
P-6981R - P1V-Pump Inboard Vertical			
			mm/Sec
	03-Sep-21	20:04	.359
	29-Apr-24	15:40	.364
	29-Apr-24	15:51	.378
	29-Apr-24	16:05	.437
	29-Apr-24	16:22	.425
	29-Apr-24	16:38	.369
	29-Apr-24	16:55	.382
	29-Apr-24	17:20	.407
	29-Apr-24	17:42	.511
	29-Apr-24	18:03	.941
	29-Apr-24	18:23	.477

	29-Apr-24	18:42	.660
	29-Apr-24	19:02	.489
	29-Apr-24	19:23	.549
	29-Apr-24	19:38	.603
	29-Apr-24	20:05	.428
	29-Apr-24	20:23	.434
	29-Apr-24	20:41	.561
P-6981R - P1A-Pump Inboard Axial			
			mm/Sec
	03-Sep-21	20:05	.315
	29-Apr-24	15:40	.266
	29-Apr-24	15:51	.276
	29-Apr-24	16:05	.293
	29-Apr-24	16:23	.311
	29-Apr-24	16:38	.276
	29-Apr-24	16:55	.257
	29-Apr-24	17:20	.261
	29-Apr-24	17:43	.275
	29-Apr-24	18:03	.311
	29-Apr-24	18:23	.252
	29-Apr-24	18:42	.274
	29-Apr-24	19:03	.261
	29-Apr-24	19:23	.275
	29-Apr-24	19:39	.268
	29-Apr-24	20:05	.273
	29-Apr-24	20:23	.272
	29-Apr-24	20:41	.289
P-6981R - P2H-Pump Outboard Horizontal			
			mm/Sec
	03-Sep-21	20:05	.493
	29-Apr-24	15:40	.645
	29-Apr-24	15:52	.526
	29-Apr-24	16:06	.654
	29-Apr-24	16:23	.615
	29-Apr-24	16:38	.612
	29-Apr-24	16:55	.600
	29-Apr-24	17:21	.665
	29-Apr-24	17:43	.538
	29-Apr-24	18:04	.499
	29-Apr-24	18:23	.665
	29-Apr-24	18:42	.582
	29-Apr-24	19:03	.593
	29-Apr-24	19:24	.697
	29-Apr-24	19:39	.502
	29-Apr-24	20:05	.495
	29-Apr-24	20:23	.490
	29-Apr-24	20:41	.528
P-6981R - P2F-Pump Outboard Horiz Peakvue			
			G-s
	03-Sep-21	20:05	.187
	29-Apr-24	15:40	.100
	29-Apr-24	15:52	.135
	29-Apr-24	16:06	.079
	29-Apr-24	16:23	.144
	29-Apr-24	16:38	.128
	29-Apr-24	16:55	.129
	29-Apr-24	17:21	.094
	29-Apr-24	17:43	.163
	29-Apr-24	18:04	.157
	29-Apr-24	18:23	.275
	29-Apr-24	18:42	.156
	29-Apr-24	19:03	.139
	29-Apr-24	19:24	.122
	29-Apr-24	19:39	.235
	29-Apr-24	20:05	.210
	29-Apr-24	20:23	.167
	29-Apr-24	20:41	.179
P-6981R - P2V-Pump Outboard Vertical			
			mm/Sec
	03-Sep-21	20:05	.278
	29-Apr-24	15:40	.336
	29-Apr-24	15:52	.342
	29-Apr-24	16:06	.342
	29-Apr-24	16:23	.376
	29-Apr-24	16:39	.346
	29-Apr-24	16:56	.394
	29-Apr-24	17:21	.368
	29-Apr-24	17:43	.437
	29-Apr-24	18:04	.464
	29-Apr-24	18:24	.492
	29-Apr-24	18:43	.374

	29-Apr-24	19:03	.450
	29-Apr-24	19:24	.428
	29-Apr-24	19:39	.528
	29-Apr-24	20:05	.657
	29-Apr-24	20:24	.378
	29-Apr-24	20:41	.442
P-6981R - P2A-Pump Outboard Axial			
			mm/Sec
	03-Sep-21	20:05	.203
	29-Apr-24	15:41	.253
	29-Apr-24	15:52	.233
	29-Apr-24	16:06	.252
	29-Apr-24	16:23	.237
	29-Apr-24	16:39	.258
	29-Apr-24	16:56	.232
	29-Apr-24	17:21	.251
	29-Apr-24	17:44	.266
	29-Apr-24	18:04	.277
	29-Apr-24	18:24	.238
	29-Apr-24	18:43	.255
	29-Apr-24	19:03	.255
	29-Apr-24	19:24	.236
	29-Apr-24	19:39	.260
	29-Apr-24	20:06	.309
	29-Apr-24	20:24	.305
	29-Apr-24	20:42	.274
P-6981R - T1 -Temp. M1			
			C
	03-Sep-21	18:00	33.00
	03-Sep-21	18:31	34.00
	03-Sep-21	20:06	35.00
	29-Apr-24	15:41	39.00
	29-Apr-24	15:52	38.00
	29-Apr-24	16:06	36.00
	29-Apr-24	16:23	36.00
	29-Apr-24	16:39	40.00
	29-Apr-24	16:56	40.00
	29-Apr-24	17:21	38.00
	29-Apr-24	17:44	39.00
	29-Apr-24	18:04	40.00
	29-Apr-24	18:24	39.00
	29-Apr-24	18:43	38.00
	29-Apr-24	19:04	39.00
	29-Apr-24	19:24	39.00
	29-Apr-24	19:40	35.00
	29-Apr-24	20:06	35.00
	29-Apr-24	20:24	39.00
	29-Apr-24	20:42	38.00
P-6981R - T2 -Temp. M2			
			C
	03-Sep-21	18:00	37.00
	03-Sep-21	18:31	39.00
	03-Sep-21	20:06	40.00
	29-Apr-24	15:41	45.00
	29-Apr-24	15:52	47.00
	29-Apr-24	16:06	47.00
	29-Apr-24	16:23	47.00
	29-Apr-24	16:39	49.00
	29-Apr-24	16:56	52.00
	29-Apr-24	17:21	47.00
	29-Apr-24	17:44	47.00
	29-Apr-24	18:04	49.00
	29-Apr-24	18:24	51.00
	29-Apr-24	18:43	49.00
	29-Apr-24	19:04	50.00
	29-Apr-24	19:24	50.00
	29-Apr-24	19:40	49.00
	29-Apr-24	20:06	48.00
	29-Apr-24	20:24	48.00
	29-Apr-24	20:42	46.00
P-6981R - T3 -Temp. P1			
			C
	03-Sep-21	20:06	49.00
	29-Apr-24	15:41	52.00
	29-Apr-24	15:53	44.00
	29-Apr-24	16:06	43.00
	29-Apr-24	16:23	44.00
	29-Apr-24	16:39	44.00
	29-Apr-24	16:56	62.00
	29-Apr-24	17:21	61.00
	29-Apr-24	17:44	61.00

	29-Apr-24	18:04	61.00
	29-Apr-24	18:24	61.00
	29-Apr-24	18:43	59.00
	29-Apr-24	19:04	59.00
	29-Apr-24	19:24	58.00
	29-Apr-24	19:40	57.00
	29-Apr-24	20:06	57.00
	29-Apr-24	20:24	48.00
	29-Apr-24	20:42	52.00
P-6981R - T4 -Temp. P2			
			C
	03-Sep-21	20:06	39.00
	29-Apr-24	15:41	47.00
	29-Apr-24	15:53	49.00
	29-Apr-24	16:07	51.00
	29-Apr-24	16:24	51.00
	29-Apr-24	16:39	53.00
	29-Apr-24	16:56	53.00
	29-Apr-24	17:21	53.00
	29-Apr-24	17:44	52.00
	29-Apr-24	18:04	52.00
	29-Apr-24	18:24	50.00
	29-Apr-24	18:43	50.00
	29-Apr-24	19:04	50.00
	29-Apr-24	19:24	50.00
	29-Apr-24	19:40	50.00
	29-Apr-24	20:06	50.00
	29-Apr-24	20:25	49.00
	29-Apr-24	20:42	49.00
P-6981R - CR -Current			
			A
	03-Sep-21	18:00	7.000
	03-Sep-21	18:31	7.000
	03-Sep-21	20:10	16.00
	29-Apr-24	15:41	13.50
	29-Apr-24	15:53	13.50
	29-Apr-24	16:07	13.50
	29-Apr-24	16:24	13.50
	29-Apr-24	16:39	13.50
	29-Apr-24	16:56	13.50
	29-Apr-24	17:22	13.50
	29-Apr-24	17:44	13.50
	29-Apr-24	18:05	13.20
	29-Apr-24	18:24	13.20
	29-Apr-24	18:44	13.40
	29-Apr-24	19:04	13.40
	29-Apr-24	19:25	13.40
	29-Apr-24	19:40	13.40
	29-Apr-24	20:06	13.40
	29-Apr-24	20:25	13.40
	29-Apr-24	20:42	13.40
P-6981R - DP -Discharge			
			KG/Cm2
	03-Sep-21	20:10	14.00
	29-Apr-24	16:08	10.00
	29-Apr-24	16:08	10.00
	29-Apr-24	16:08	10.00
	29-Apr-24	16:24	10.00
	29-Apr-24	16:39	10.00
	29-Apr-24	16:56	10.00
	29-Apr-24	17:22	10.00
	29-Apr-24	17:44	10.00
	29-Apr-24	18:05	10.00
	29-Apr-24	18:25	10.00
	29-Apr-24	18:44	10.00
	29-Apr-24	19:04	10.00
	29-Apr-24	19:25	10.00
	29-Apr-24	19:40	10.00
	29-Apr-24	20:06	10.00
	29-Apr-24	20:25	10.00
	29-Apr-24	20:42	10.00
P-6981R - F -Flow rate			
			T/H
	29-Apr-24	15:41	8.000
	29-Apr-24	15:53	8.000
	29-Apr-24	16:07	8.000
	29-Apr-24	16:26	8.000
	29-Apr-24	16:39	8.000
	29-Apr-24	16:57	8.000
	29-Apr-24	17:45	8.000
	29-Apr-24	18:07	7.100

29-Apr-24	18:26	7.000
29-Apr-24	18:44	7.000
29-Apr-24	19:04	7.000
29-Apr-24	19:35	7.000
29-Apr-24	19:40	7.000
29-Apr-24	20:06	7.000
29-Apr-24	20:25	7.000
29-Apr-24	20:42	7.000

Clarification Of Vibration Units:

Acc --> G-s P-P
Vel --> mm/Sec RMS

Appendix B

Vibration Severity Listing

The following noteworthy information is a description of each stages of vibration severity.

- **Good** Fault in low level:

The lower limit that could be reasonably expected from the best application of the normal commercial manufacturing practice.

- **Fair** Keeps Monitoring Failure Trend:

A vibration severity level that is readily achieved by the great majority of machine that is well designed and constructed.

- **Alarm** Requires Attention at Next Opportunity:

A vibration severity level that is greater than normally expected from well designed and constructed machines/equipment, indicating a possible fault in the system. Provided that the vibration is not due to an unacceptable fault that will cause deterioration of the machines, or the vibration does not have other undesirable or unacceptable effects, that such a vibration level may be acceptable.

- **Danger** Requires Immediate Attention:

Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

Appendix C: Data collection by CSI2140



Vibration Analyzer: CSI 2140 No.14

Serial No.: B21402218840

Calibration Date: 09-Aug-23

Calibration Due: 08-Aug-25

ประจำเดือนพฤษภาคม 2567






Vibration Report

Prepared for

PTT Global Chemical Public Company Limited (GC7 BTF Plant)
Month of Survey and Data Collection: May 2024
Request for Measurement

Inspected by: PICHET SUKSAI
Reported by: WARUT KAUNBUMRUNG
Approved by: METEE MEERABEAB

Condition Monitoring Service Integrity and Reliability Department

 GC Maintenance and Engineering Company Limited
22/2 Pakornsonkhraorat Road, Tambon Maptaphut, Amphoe Muang rayong, Rayong 21150



GC Maintenance and Engineering Co., Ltd.

May 24

Contents

1. Executive Summary	3
2. Introduction	4
3. Reference Standard	5
4. Vibration Severity Listing	6
5. Vibration Summary Report	8
6. Vibration Analysis Report	8



Vibration condition monitoring

1. Executive Summary

Request for measurement 1 Equipment.

Including as below

- In planned 1 Equipment.
- Out of planned 0 Equipment.

List of machines for request to measure vibration as table below.

LIST OF REQUEST MACHINERY VIBRATION IN PLANNED			
No.	Tag	Date of request	Remark
1	P-6871R	21 – May – 24	After re-alignment and adjust soft foot.
		29 – May – 24	After 2 nd re-alignment and adjust soft foot.

LIST OF REQUEST MACHINERY VIBRATION OUT OF PLANNED			
No.	Tag	Date of request	Remark
-	-	-	-



2. Introduction

PTTGC and GCME has officially signed a yearly contract of “Vibration Monitoring” which a contract’s intention is to request GCME to collect a vibration data of specified equipment in accordance with a particular schedule. Vibration data gathered regularly shall be interpreted technically to PTTGC for further action.

Vibration data is carefully collected using portable device branded by EMERSON CSI whose model is “CSI2140; SN: B21402218840 and SN: B21401205571” equipped with an industrial standard accelerometer (CTC SN: 22730 and CTC SN: 323737) Software used for analysis is AMS Machinery Manager.

3. Reference Standard

In order to clearly certify a vibration severity of any equipment, an official international standard which is not only well recognized by worldwide equipment user but also approved by international organization shall be referred to.

PTTGC and GCME agreed to officially apply ISO10816-3 standard for vibration severity assessment for any equipment operated in Refinery plant (PTTGC Branch 6). The vibration severity chart which is an excerpt from ISO10816-3 is shown as the following table herewith.

ISO 10816 Part 3											
Industrial Machines with nominal power above 15 kW and nominal speeds between 120 rpm and 15,000 rpm when measured locally											
Vibration Limit 10-100 Hz, > 600 rpm 1-1,000 Hz, > 120 rpm	Pumps > 15 kW Radial, Axial, Mixed Flow Group 4			Medium Size Machines 15 kW < Power < 300 kW Group 2			Large Machines 300 kW < Power < 50 MW Group 1				
	Integrated Driver	External Driver	Flexible	Integrated Driver	External Driver	Flexible	Integrated Driver	External Driver	Flexible	Rigid	Flexible
Limit, mm/s, rms	Rigid	Flexible	Flexible	Rigid	Flexible	Flexible	Rigid	Flexible	Flexible	Rigid	Flexible
> 110	C	C	C	C	C	C	C	C	C	C	C
10-110	C	C	C	C	C	C	C	C	C	C	C
7.1-110	C	C	C	C	C	C	C	C	C	C	C
4.5-7.1	C	C	C	C	C	C	C	C	C	C	C
3.5-4.5	C	C	C	C	C	C	C	C	C	C	C
2.8-3.5	C	C	C	C	C	C	C	C	C	C	C
1.4-2.8	C	C	C	C	C	C	C	C	C	C	C
0.7-1.4	C	C	C	C	C	C	C	C	C	C	C
0.3-0.7	C	C	C	C	C	C	C	C	C	C	C
0.0-0.3											
	Newly Commissioned Unrestricted long-term operation Restricted long-term operation Vibration causes damage										

Vibration Peakvue Acceleration Severity

Speed of Machine (RPM)	Good	Fair	Alarm	Danger
500	≤ 0.2	> 0.2 - 0.5	> 0.5 - 1.8	> 1.8
1000	≤ 0.4	> 0.4 - 1.0	> 1.0 - 3.5	> 3.5
1500	≤ 0.6	> 0.6 - 1.4	> 1.4 - 4.0	> 4.0
3000	≤ 1.4	> 1.4 - 3.0	> 3.0 - 10.0	> 10.0

4. Vibration Severity Listing

Stage of vibration severity and Legend used in a report

The following noteworthy information is a description of each stage of vibration severity.

Stage 4: **Danger** Requires Immediate Attention.

A level of vibration severity at which the probability of a severe fault of machine condition, or other deleterious effects of vibration are considered to be unacceptably high

Group 4	Group 3	Group 2	Group 1
Pumps > 15 kW radial, axial, mixed flow	Medium sized machines 15 kW < P < 300 kW	Large sized machines 300 kW < P < 50 kW	
Integrated driver	Motor 160mm ≤ H < 315mm	Motor 315mm ≤ H	
Rigid	Rigid	Rigid	Rigid
> 4.5	> 7.1	> 4.5	> 7.1
	Flexible	Flexible	Flexible
	> 11	> 7.1	> 11
			> 11

Limit, g-s, RMS
Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)
Dia between 200 & 500 mm
Speed < 500 RPM
> 1.8
Dia between 50 & 300 mm
Speed Between 500 & 1000 RPM
> 3.5
Dia between 20 & 150 mm
Speed is either 1800 or 3600 RPM
> 10

Stage 3: **Alarm** Requires Attention at Next Opportunity.

A vibration severity level that is greater than normally expected from well designed and constructed machines/equipment, indicating a possible fault in the system. Provided that the vibration is not due to an unacceptable fault that will cause deterioration of the machines, or the vibration does not have other undesirable or unacceptable effects, that such a vibration level may be acceptable.

Group 4	Group 3	Group 2	Group 1
Pumps > 15 kW radial, axial, mixed flow	Medium sized machines 15 kW < P < 300 kW	Large sized machines 300 kW < P < 50 kW	
Integrated driver	Motor 160mm ≤ H < 315mm	Motor 315mm ≤ H	
Rigid	Rigid	Rigid	Rigid
> 2.8 - 4.5	> 4.5 - 7.1	> 2.8 - 4.5	> 4.5 - 7.1
	Flexible	Flexible	Flexible
	> 7.1 - 11	> 4.5 - 7.1	> 7.1 - 11

Limit, g-s, RMS
Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)
Dia between 200 & 500 mm
Speed < 500 RPM
> 0.5
Dia between 50 & 300 mm
Speed Between 500 & 1000 RPM
> 1.0
Dia between 20 & 150 mm
Speed is either 1800 or 3600 RPM
> 3.0

**Stage 2: Fair Keeps Monitoring Failure Trend.**

A vibration severity level that is readily achieved by the great majority of machine that is well designed and constructed.

Group 4	Group 3	Group 2	Group 1
Pumps > 15 kW radial, axial, mixed flow		Medium sized machines 15 kW<P<300 kW	Large sized machines 300 kW<P<50 kW
Integrated driver Rigid Flexible ≤ 1.4 - 2.8	External driver Rigid Flexible > 2.3 - 4.5	Motor 160mm ≤ H < 315mm Rigid Flexible > 1.4 - 2.8	Motor 315mm ≤ H Rigid Flexible > 2.3 - 4.5
			> 3.5 - 7.1

Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)	
Dia between 200 & 500 mm Speed < 500 RPM > 0.2	Dia between 50 & 300 mm Speed Between 500 & 1000 RPM > 0.4
	Dia between 20 & 150 mm Speed is either 1800 or 3600 RPM > 1.4

Stage 1: Good Fault in low level.

The lower limit that could be reasonably expected from the best application of the normal commercial manufacturing practice.

Group 4	Group 3	Group 2	Group 1
Pumps > 15 kW radial, axial, mixed flow		Medium sized machines 15 kW<P<300 kW	Large sized machines 300 kW<P<50 kW
Integrated driver Rigid Flexible ≤ 1.4	External driver Rigid Flexible ≤ 2.3	Motor 160mm ≤ H < 315mm Rigid Flexible ≤ 1.4	Motor 315mm ≤ H Rigid Flexible ≤ 2.3
			≤ 3.5

Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)	
Dia between 200 & 500 mm Speed < 500 RPM ≤ 0.2	Dia between 50 & 300 mm Speed Between 500 & 1000 RPM ≤ 0.4
	Dia between 20 & 150 mm Speed is either 1800 or 3600 RPM ≤ 1.4

**5. Vibration Summary Report**

Please see the attached table of "Requested Machine Vibration Summary Report" In Planned

Request machinery vibration (In planned) May 2024			
No.	Tag No.	Severity	Conclusion
1	P-6871R	ALARM	Engine: 1. Should be consider stop P-6871R to standby mode as soon as possible and action as below step. 2. Should be check baseplate and soft foot (baseplate weakness) Pump: Misalignment and soft foot (baseplate weakness) condition if found weakness should be corrected. 3. Should be check DBSE value. If found over limit should be adjust by refer OEM. 4. Should be try to re-alignment with high accuracy less than 0.02 mm. Pump: Should be keep monitored trend of vibration and peakvue in monthly interval.

Please see the attached table of "Requested Machine Vibration Summary Report" Out of Planned

Request machinery vibration (Out of planned) May 2024			
No.	Tag No.	Severity	Conclusion
-	-	-	-

6. Vibration Analysis Report

Any equipment whose vibration severity "Good, Fair, Alarm and Danger" for in planned and out of planned are explained an analysis detail separately. Please see each of them as attachment.

Tag: P-6871R Machine name: FIRE WATER PUMP Inspected by: Nardanal T.

Severity: **ALARM** Date of data measurement: 21 May 2024 Analyst by: Pichet S.

Area: GC7_BTF Main problem: After re-alignment and adjust soft foot. Misalignment and coupling problem. Another problem is possible to resonance problem. Review by: Warut K.

Reference criteria		Good	Fair	Alarm	Danger	Unit
ISO-10816 part 6 (Engine)	Class V	≤28.2	>28.2	>44.6	>44.6	mm/s RMS
Statistical alarm Acceleration of Peakvue mode		≤16.4	>16.4	>18.5	>18.5	G's, PK-PK
Statistical alarm velocity of pump		≤50.6	>50.6	>59.8	>59.8	mm/s RMS

Remark: ISO-10816 provides specific guidance for assessing the severity of vibration measured on machine in steady state, thus GCME will considers the magnitude of vibration, the changes in the magnitude and frequency for judging the severity of vibration.

Machine description and vibration measurement point

 <p>Note: Picture Sample</p>	<p>Engine Manufacturer: CATERPILLAR Type: DIESEL (CAT 3406C) Power: 217-359 kw Speed = 1,750-2,300 rpm DE Bearing: N/A NDE Bearing: N/A</p> <p>pump Manufacturer: Bombas vertical gear pump Type: N/A Shaft input speed (P1, P2): 1,750-2,300 rpm DE Bearing: NDE Bearing: Shaft output speed (P3, P4): N/A DE Bearing: N/A NDE Bearing: N/A Tooth of Gear /High speed: N/A Tooth of Gear /Low speed: N/A GMF1 = N/A</p>
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Vibration analysis

• Engine

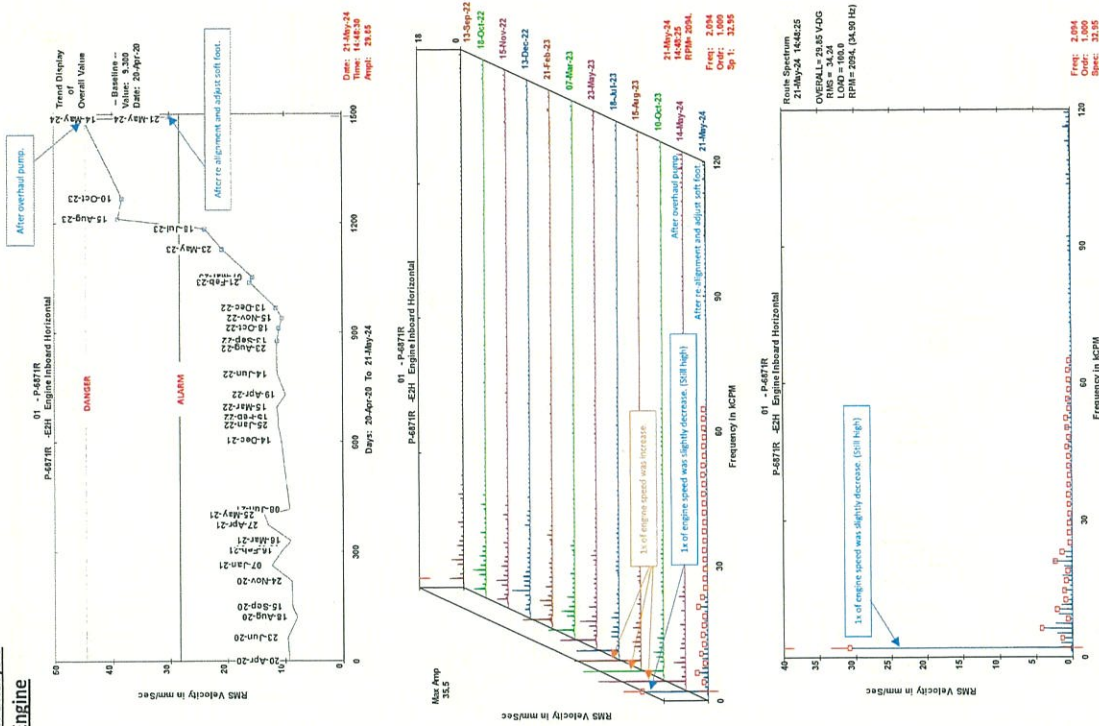


Fig1. Trend/Waterfall/Spectrum Plot Point E2: Engine - DE - Horizontal - Velocity.

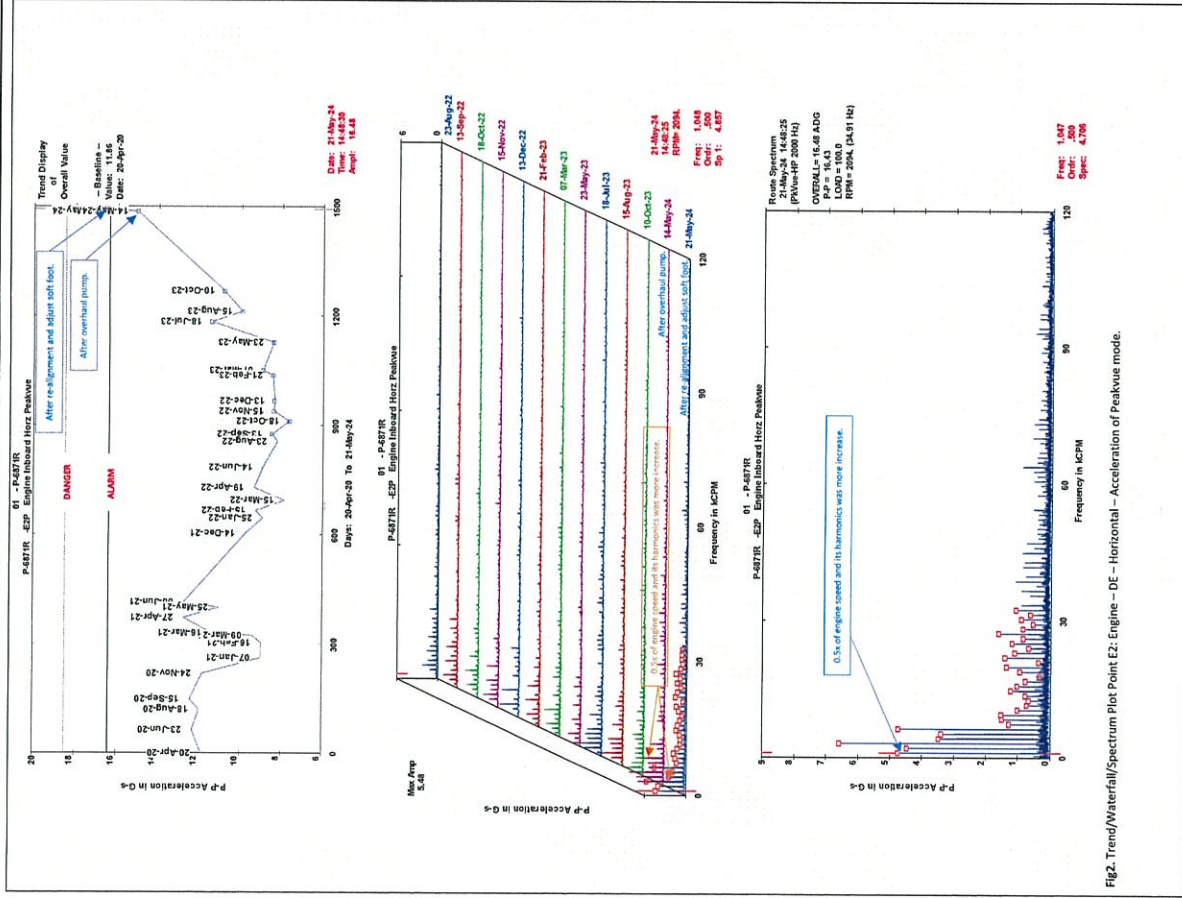


Fig2. Trend/Waterfall/Spectrum Plot E2: Engine - DE - Horizontal - Acceleration of Peakvue mode.

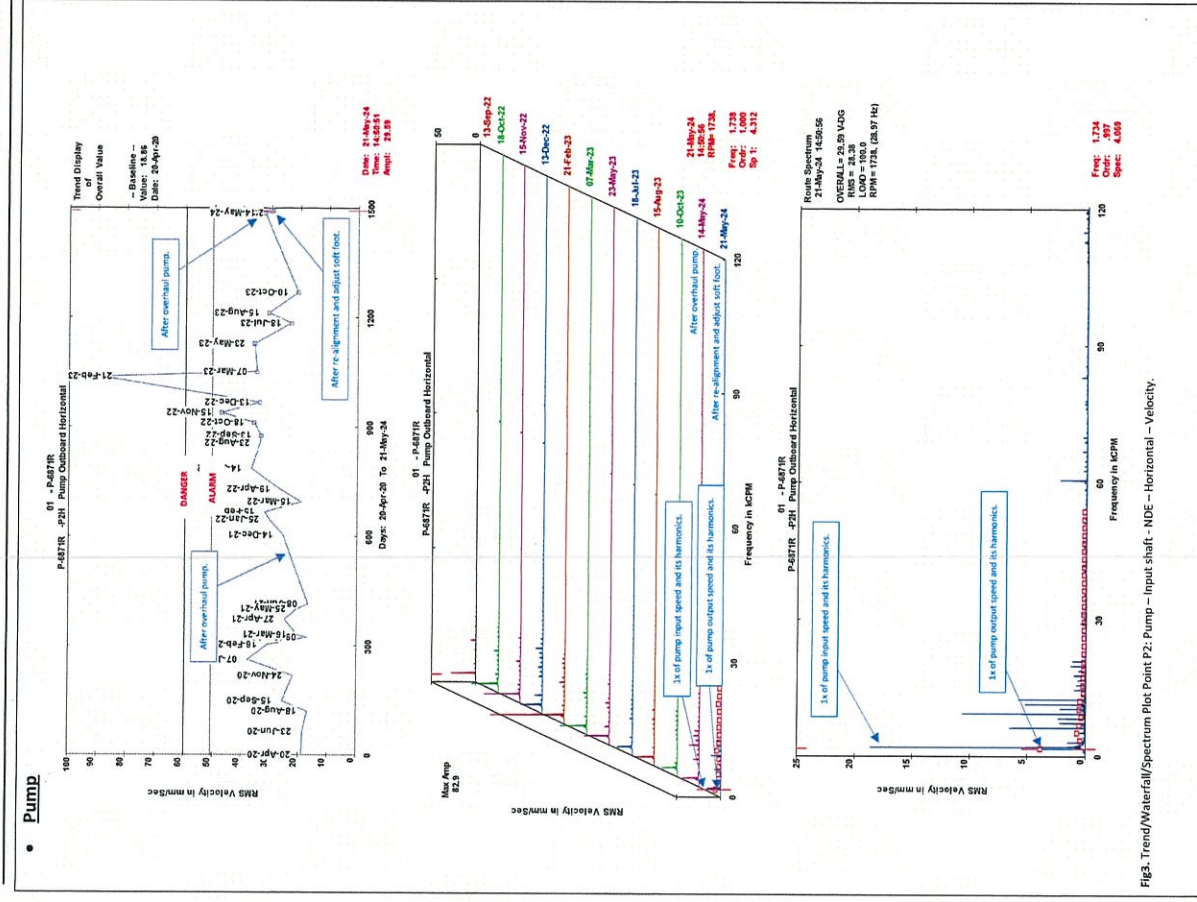
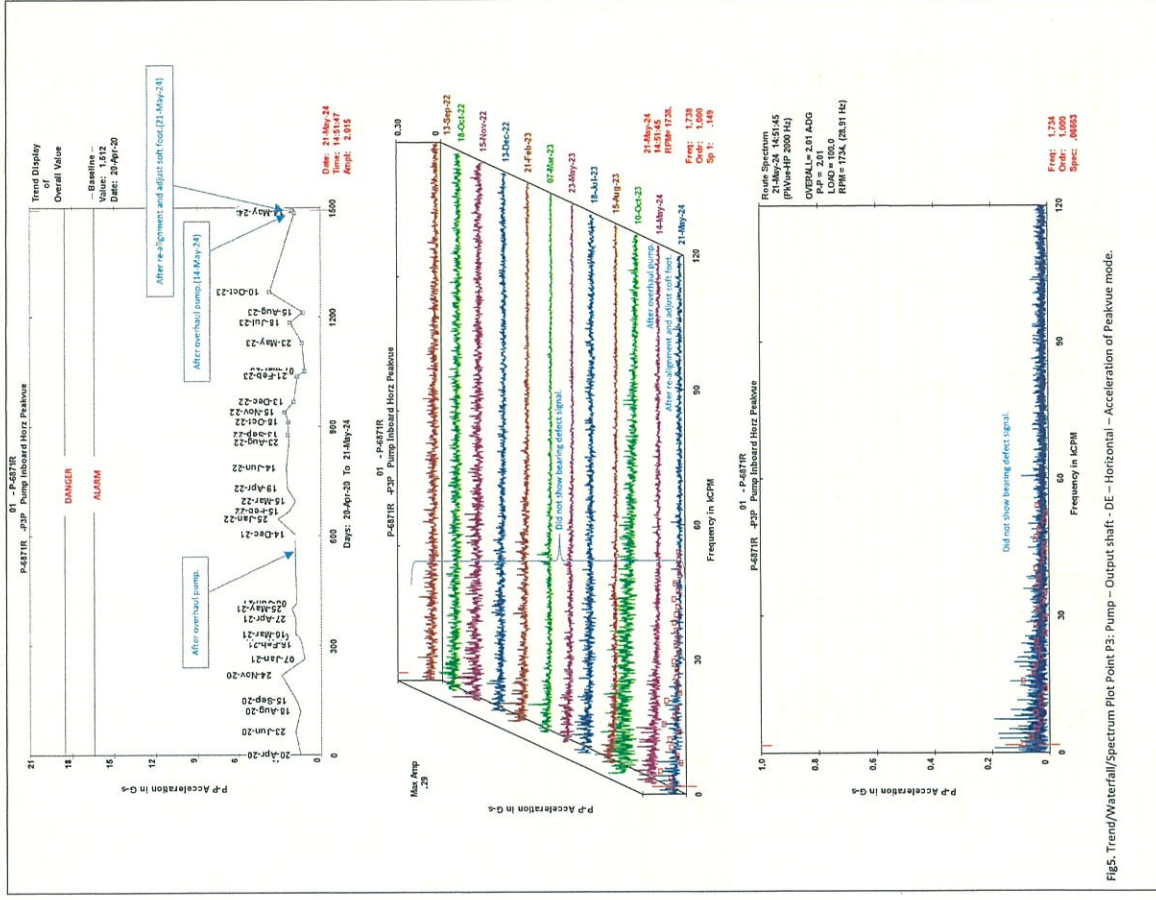
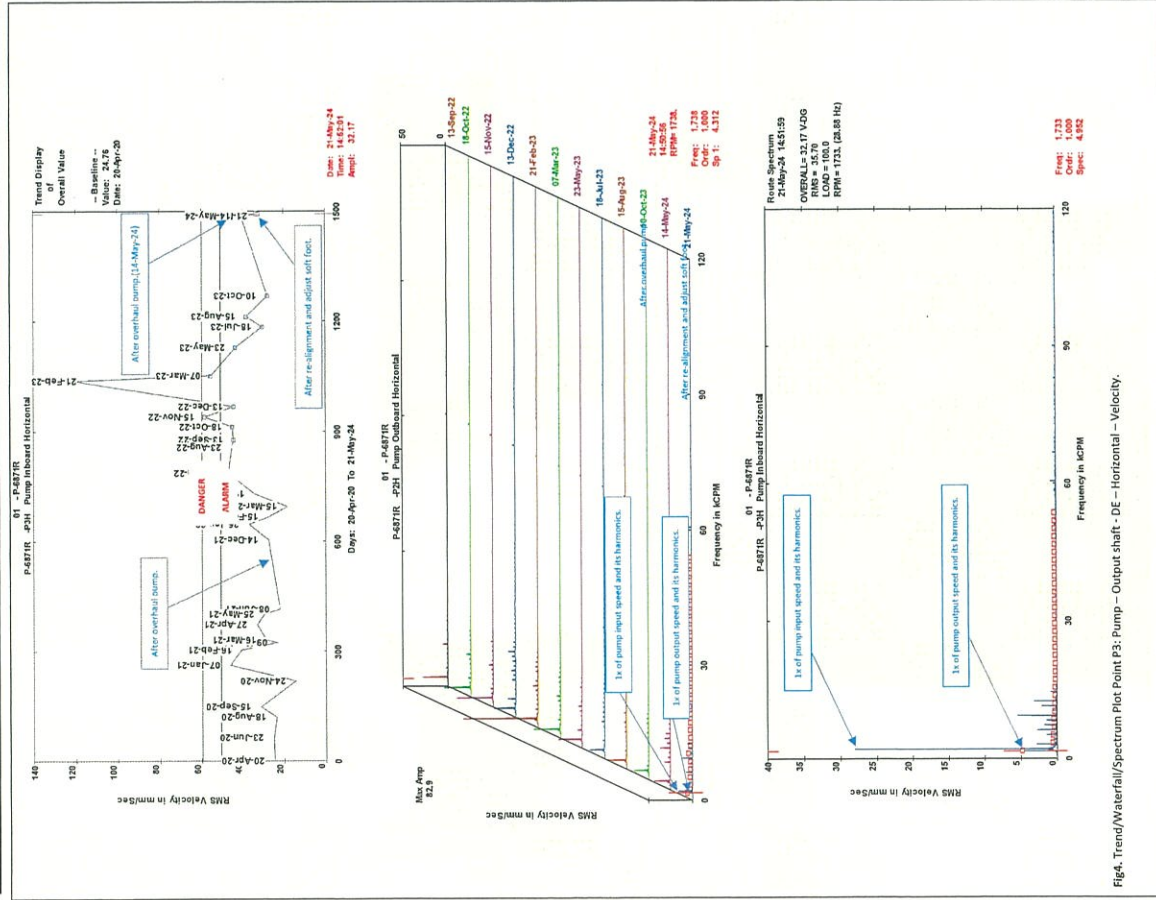
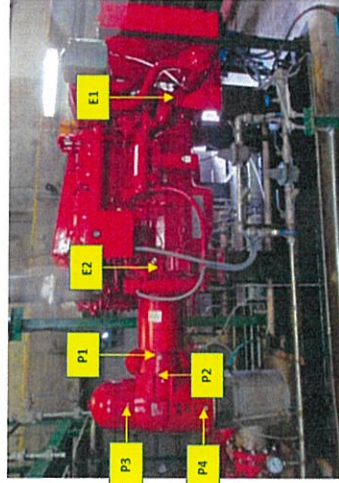


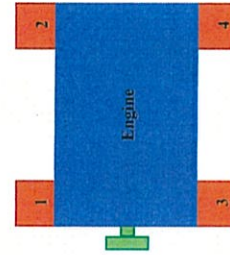
Fig3. Trend/Waterfall/Spectrum Plot P2: Pump - NDE - Horizontal - Velocity.



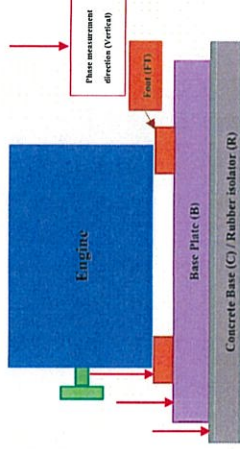
Phase analysis



Measurement Point	Phase Reading		Phase Result
	14-May-24	21-May-24	
E2H – P1H	164.01	174.50	Out of phase
E2V – P1V	116.95	150.42	
E2A – P1A	165.65	122.01	Out of phase
P3H – P4H	-3.49	In phase	
P3V – P4V	-23.46	In phase	In phase
P3A – P4A	-1.66	In phase	



Top view



Side view

Point (Vertical direction)	Phase Reading	Phase Result
FT(E)1 – B1	148.63	Out of phase
FT(E)2 – B2	-16.74	In phase
FT(E)3 – B3	-29.31	Out of phase
FT(E)4 – B4	-31.39	Out of phase

Inspection Finding

- Engine:
 - The overall velocity of vibration at point E2 Engine DE in horizontal direction was decrease from 44.90 to 29.85 mm/s, RMS and enter to "ALARM" severity by refer ISO 10816-6. The FFT spectrum shown dominant peak at 1x .05x its harmonics of engine speed. And amplitude at 1x of engine speed was slightly decrease (still high) which indicate to misalignment and soft foot (baseplate weakness) problem. (Refer phase analysis) (Fig 1)
 - The overall acceleration of Peakvue mode at point E2 Engine DE in horizontal direction was slightly increase from 15.05 to 16.48 G's, Pk-Pk and enter to "ALARM" severity by refer statistical alarm. The FFT shown dominant peak at 0.5x, 1x of engine speed and them harmonics which indicate to mechanical looseness problem. (Fig 2)
 - At site found base plate look like box steel. (Hollow)
- Gearbox/Pump: After overhaul pump.
 - The overall velocity of vibration at point P2 pump input shaft NDE in horizontal direction was decrease from 32.49 to 29.59 mm/s, RMS and enter to "FAIR" severity by refer statistical alarm. The FFT spectrum shown dominant peak at 1x of pump input speed and its harmonics. And amplitude at 1x pump speed was slightly decrease which indicate to misalignment. (Refer phase analysis) Other problem is mechanical looseness problem. (Fig 3)
 - The overall velocity of vibration at point P3 pump output shaft DE in horizontal direction was decrease from 40.43 to 32.17 mm/s, RMS and enter to "FAIR" severity by refer statistical alarm. The FFT spectrum shown dominant peak at 1x of pump input speed and its harmonics. And amplitude at 1x pump speed was slightly decrease which indicate to misalignment. (Refer phase analysis) Other problem is mechanical looseness problem. (Fig 4)
 - The overall acceleration of Peakvue mode at point P3 pump output shaft DE in horizontal direction was slightly increase from 1.90 to 2.02 G's, Pk-Pk. The FFT spectrum did not show bearing defect signal. (Fig 5)

Conclusion

- Engine: Misalignment and coupling problem. Another problem is possible to resonance problem.
- Pump: Misalignment and coupling problem. Another problem is possible to resonance problem.

Recommendation

- Engine:
 - Should be consider stop P-6871R to standby mode as soon as possible and action as below step.
 - Should be check baseplate and soft foot condition if found weakness should be corrected.
 - Should be check DBSE value. If found over limit should be adjust by refer OEM.
 - Should be try to re-alignment with high accuracy less than 0.02 mm.
- Pump: Should be keep monitored trend of vibration and peakvue in monthly interval.

Appendix A

Overall vibration

Database: GC7 (NTF).rbm
Area: GC7
Period Reported: 23-May-23 To 22-May-24

Equipment 1: P-6871R

	DATE	TIME	OVERALL
1	08-07-69	08:00	0.00
2	08-07-69	08:05	0.00
3	08-07-69	08:10	0.00
4	08-07-69	08:15	0.00
5	08-07-69	08:20	0.00
6	08-07-69	08:25	0.00
7	08-07-69	08:30	0.00
8	08-07-69	08:35	0.00
9	08-07-69	08:40	0.00
10	08-07-69	08:45	0.00
11	08-07-69	08:50	0.00
12	08-07-69	08:55	0.00
13	08-07-69	09:00	0.00
14	08-07-69	09:05	0.00
15	08-07-69	09:10	0.00
16	08-07-69	09:15	0.00
17	08-07-69	09:20	0.00
18	08-07-69	09:25	0.00
19	08-07-69	09:30	0.00
20	08-07-69	09:35	0.00
21	08-07-69	09:40	0.00
22	08-07-69	09:45	0.00
23	08-07-69	09:50	0.00
24	08-07-69	09:55	0.00
25	08-07-69	10:00	0.00
26	08-07-69	10:05	0.00
27	08-07-69	10:10	0.00
28	08-07-69	10:15	0.00
29	08-07-69	10:20	0.00
30	08-07-69	10:25	0.00
31	08-07-69	10:30	0.00
32	08-07-69	10:35	0.00
33	08-07-69	10:40	0.00
34	08-07-69	10:45	0.00
35	08-07-69	10:50	0.00
36	08-07-69	10:55	0.00
37	08-07-69	11:00	0.00
38	08-07-69	11:05	0.00
39	08-07-69	11:10	0.00
40	08-07-69	11:15	0.00
41	08-07-69	11:20	0.00
42	08-07-69	11:25	0.00
43	08-07-69	11:30	0.00
44	08-07-69	11:35	0.00
45	08-07-69	11:40	0.00
46	08-07-69	11:45	0.00
47	08-07-69	11:50	0.00
48	08-07-69	11:55	0.00
49	08-07-69	12:00	0.00
50	08-07-69	12:05	0.00
51	08-07-69	12:10	0.00
52	08-07-69	12:15	0.00
53	08-07-69	12:20	0.00
54	08-07-69	12:25	0.00
55	08-07-69	12:30	0.00
56	08-07-69	12:35	0.00
57	08-07-69	12:40	0.00
58	08-07-69	12:45	0.00
59	08-07-69	12:50	0.00
60	08-07-69	12:55	0.00
61	08-07-69	13:00	0.00
62	08-07-69	13:05	0.00
63	08-07-69	13:10	0.00
64	08-07-69	13:15	0.00
65	08-07-69	13:20	0.00
66	08-07-69	13:25	0.00
67	08-07-69	13:30	0.00
68	08-07-69	13:35	0.00
69	08-07-69	13:40	0.00
70	08-07-69	13:45	0.00
71	08-07-69	13:50	0.00
72	08-07-69	13:55	0.00
73	08-07-69	14:00	0.00
74	08-07-69	14:05	0.00
75	08-07-69	14:10	0.00
76	08-07-69	14:15	0.00
77	08-07-69	14:20	0.00
78	08-07-69	14:25	0.00
79	08-07-69	14:30	0.00
80	08-07-69	14:35	0.00
81	08-07-69	14:40	0.00
82	08-07-69	14:45	0.00
83	08-07-69	14:50	0.00
84	08-07-69	14:55	0.00
85	08-07-69	15:00	0.00
86	08-07-69	15:05	0.00
87	08-07-69	15:10	0.00
88	08-07-69	15:15	0.00
89	08-07-69	15:20	0.00
90	08-07-69	15:25	0.00
91			

F-6871R	- ELI-Engine Outboard		mm/Sec
	Horizontal	Vertical	
	23-May-23	14:16	35.66
	18-Jul-23	10:39	14.67
	15-Aug-23	11:06	14.07
	10-Oct-23	10:52	13.00
	14-May-24	14:04	14.13
	21-May-24	14:47	13.55

P-6871R	- E1F-Engine	Outboard	Horz	Reakvue	G-S
		23-May-23	14:16	10.79	
		18-Jul-23	10:39	12.95	
		15-Aug-23	11:06	11.77	
		10-Oct-23	10:52	12.74	
		14-May-24	14:04	15.45	
		21-May-24	14:44	15.96	

P-5871R	- EIV-Engine Outboard Vertical	mm/Sec
	23-May-23	14:16
	18-Jul-23	10:39
	6.626	6.626
	15-Aug-23	11:06
	9.452	9.452
	10-Oct-23	10:52
	6.293	6.293
	14-May-24	14:04
	9.773	9.773
	21-May-24	14:47
	8.983	8.983
	8.089	8.089

P-6871R	- EIA-Engine Outboard Axial	mm/Sec
	23-May-23	14.17
	18-Jul-23	10.39
	15-Aug-23	11.06
	10-Oct-23	10.53
	14-May-24	14.04
	21-May-24	14.49
		16.32
		18.14
		15.54
		19.15
		24.64
		14.05
		16.32

P-6871R	- E2H-Engine	Inboard	Horizontal	mm/Sec
	23-May-23	14:17	20.83	
	18-Jul-23	10:39	23.91	
	15-Aug-23	11:07	39.03	
	10-Oct-23	10:53	38.30	
	14-May-24	14:05	<u>44.90</u>	
	28-Jun-24	14:40	30.23	

P-6871R	- E2P-Engine	Inboard	Horz	Peakvue	G-s
			23-May-23	14:17	8.434
			18-Jul-23	10:39	11.45
			15-Aug-23	11:07	9.963
			10-Oct-23	10:53	10.84
			14-May-24	14:05	15.05

P-6871R	- E2V-Engine Inboard Vertical	mm/Sec
	23-May-23	14:17
		10.93
	18-Jul-23	10:40
		8.599
	15-Aug-23	11:07
		15.88
	10-Oct-23	10:54
		7.999
	14-May-24	14:05
		15.86

P-6871R	- E2A-Engine Inboard Axial	mm/Sec	mm/Sec	G-s
	23-May-23 14:17	20.09		
	18-Jul-23 10:40	17.02		
	15-Aug-23 11:08	22.27		
	10-Oct-23 10:54	28.14		
	14-May-24 14:05	19.86		
	21-May-24 14:50	18.65		
P-6871R	- P1H-Pump Inboard Horizontal	mm/Sec	mm/Sec	G-s
	23-May-23 14:18	35.18		
	18-Jul-23 10:40	22.49		
	15-Aug-23 11:08	30.06		
	10-Oct-23 10:54	22.64		
	14-May-24 14:05	34.73		
	21-May-24 14:50	28.26		
P-6871R	- P1P-Pump Inboard Horz PeakVue	mm/Sec	mm/Sec	G-s
	23-May-23 14:18	5.85		
	18-Jul-23 10:40	4.585		
	15-Aug-23 11:08	1.2318		
	10-Oct-23 10:54	7.307		
	14-May-24 14:05	3.045		
	21-May-24 14:50	3.000		
P-6871R	- P1V-Pump Inboard Vertical	mm/Sec	mm/Sec	G-s
	23-May-23 14:18	15.62		
	18-Jul-23 10:40	10.38		
	15-Aug-23 11:08	12.02		
	10-Oct-23 10:54	12.78		
	14-May-24 14:06	16.04		
	21-May-24 14:50	14.61		
P-6871R	- P2H-Pump Outboard Horizontal	mm/Sec	mm/Sec	G-s
	23-May-23 14:18	23.56		
	18-Jul-23 10:41	20.97		
	15-Aug-23 11:09	30.97		
	10-Oct-23 10:55	20.92		
	14-May-24 14:06	32.49		
	21-May-24 14:50	29.59		
P-6871R	- P2P-Pump Outboard Horz PeakVue	mm/Sec	mm/Sec	G-s
	23-May-23 14:18	2.134		
	18-Jul-23 10:41	2.682		
	15-Aug-23 11:09	2.442		
	10-Oct-23 10:55	4.252		
	14-May-24 14:06	1.293		
	21-May-24 14:50	3.302		
P-6871R	- P2V-Pump Outboard Vertical	mm/Sec	mm/Sec	G-s
	23-May-23 14:18	15.27		
	18-Jul-23 10:41	8.582		
	15-Aug-23 11:09	11.81		
	10-Oct-23 10:55	8.121		
	14-May-24 14:06	13.45		
	21-May-24 14:51	11.55		
P-6871R	- P2A-Pump Outboard Axial	mm/Sec	mm/Sec	G-s
	23-May-23 14:19	30.13		
	18-Jul-23 10:41	18.23		
	15-Aug-23 11:09	16.73		
	10-Oct-23 10:55	17.03		
	14-May-24 14:07	18.16		
	21-May-24 14:51	12.96		
P-6871R	- P3H-Pump Inboard Horizontal	mm/Sec	mm/Sec	G-s
	23-May-23 14:19	43.47		
	18-Jul-23 10:41	36.04		
	15-Aug-23 11:09	36.04		
	10-Oct-23 10:55	27.85		
	14-May-24 14:07	40.43		
	21-May-24 14:51	32.17		

P-6871R	- P3P-Pump Inboard Horz Peakvue	G-s	
		23-May-23 14:19	1.344
		18-Jul-23 10:41	2.210
		15-Aug-23 11:10	1.300
		10-Oct-23 10:55	3.708
P-6871R	- P3V-Pump Inboard Vertical	mm/Sec	
		23-May-23 14:19	44.50
		18-Jul-23 10:41	19.10
		15-Aug-23 11:10	14.78
		10-Oct-23 10:55	18.99
P-6871R	- P3A-Pump Inboard Axial	mm/Sec	
		23-May-23 14:19	9.303
		18-Jul-23 10:42	6.657
		15-Aug-23 11:10	7.613
		10-Oct-23 10:56	4.385
P-6871R	- P4H-Pump Outboard Horizontal	mm/Sec	
		23-May-23 14:19	19.99
		18-Jul-23 10:42	14.64
		15-Aug-23 11:10	18.95
		10-Oct-23 10:56	12.70
P-6871R	- P4V-Pump Outboard Vertical	mm/Sec	
		23-May-23 14:20	1.475
		18-Jul-23 10:42	1.489
		15-Aug-23 11:10	1.284
		10-Oct-23 10:56	1.709
P-6871R	- P4A-Pump Outboard Axial	mm/Sec	
		23-May-23 14:20	3.113
		18-Jul-23 10:42	3.113
		15-Aug-23 11:10	3.113
		10-Oct-23 10:56	3.113
P-6871R	- T1 -Temp engine NDE	mm/Sec	
		23-May-23 14:20	9.161
		18-Jul-23 10:42	7.417
		15-Aug-23 11:11	7.708
		10-Oct-23 10:57	6.129
P-6871R	- T2 -Temp engine DE	mm/Sec	
		23-May-23 14:20	95.00
		18-Jul-23 10:42	93.00
		15-Aug-23 11:11	94.00
		10-Oct-23 10:57	84.00
P-6871R	- T3 -Temp pump DE	mm/Sec	
		23-May-23 14:20	58.00
		18-Jul-23 10:43	50.00
		15-Aug-23 11:11	51.00
		10-Oct-23 10:57	58.00
P-6871R	- T4 -Temp pump NDE	mm/Sec	
		23-May-23 14:20	52.00
		18-Jul-23 10:43	45.00
		15-Aug-23 11:11	46.00
		10-Oct-23 10:57	55.00
P-6871R	- T5 -Temp pump DE	mm/Sec	
		23-May-23 14:20	55.00
		18-Jul-23 10:43	47.00
		15-Aug-23 11:12	49.00
		10-Oct-23 10:57	58.00
P-6871R	- T6 -Temp pump NDE	mm/Sec	
		23-May-23 14:21	38.00
		18-Jul-23 10:43	34.00
		15-Aug-23 11:12	33.00
		10-Oct-23 10:57	40.00
P-6871R	- DP -Discharge pressure	Bar	
		23-May-23 14:21	12.00
		18-Jul-23 10:43	12.00
		15-Aug-23 11:12	12.00
		10-Oct-23 10:57	12.00
P-6871R	- Sp -Speed	Rpm	
		23-May-23 14:21	2081.0
		18-Jul-23 10:43	2083.0
		15-Aug-23 11:12	2081.0
		10-Oct-23 10:58	2079.0
P-6871R	- T1 -Temp engine NDE	mm/Sec	
		23-May-23 14:20	9.161
		18-Jul-23 10:42	7.417
		15-Aug-23 11:11	7.708
		10-Oct-23 10:57	6.129
P-6871R	- T2 -Temp engine DE	mm/Sec	
		23-May-23 14:20	95.00
		18-Jul-23 10:42	93.00
		15-Aug-23 11:11	94.00
		10-Oct-23 10:57	84.00
P-6871R	- T3 -Temp pump DE	mm/Sec	
		23-May-23 14:20	58.00
		18-Jul-23 10:43	50.00
		15-Aug-23 11:11	51.00
		10-Oct-23 10:57	58.00
P-6871R	- T4 -Temp pump NDE	mm/Sec	
		23-May-23 14:20	52.00
		18-Jul-23 10:43	45.00
		15-Aug-23 11:11	46.00
		10-Oct-23 10:57	55.00
P-6871R	- T5 -Temp pump DE	mm/Sec	
		23-May-23 14:20	55.00
		18-Jul-23 10:43	47.00
		15-Aug-23 11:12	49.00
		10-Oct-23 10:57	58.00
P-6871R	- T6 -Temp pump NDE	mm/Sec	
		23-May-23 14:21	38.00
		18-Jul-23 10:43	34.00
		15-Aug-23 11:12	33.00
		10-Oct-23 10:57	40.00
P-6871R	- DP -Discharge pressure	Bar	
		23-May-23 14:21	12.00
		18-Jul-23 10:43	12.00
		15-Aug-23 11:12	12.00
		10-Oct-23 10:57	12.00
P-6871R	- Sp -Speed	Rpm	
		23-May-23 14:21	2081.0
		18-Jul-23 10:43	2083.0
		15-Aug-23 11:12	2081.0
		10-Oct-23 10:58	2079.0

Clarification of Vibration Units:
 Acc --> G-s
 Vel --> mm/Sec
 Rms

Tag: P-6871R
Severity: **ALARM**
Area: GC7_BTF

Machine name: FIRE WATER PUMP
Date of data measurement: 29 May 2024
Main problem: 2nd After re-alignment and adjust soft foot. Misalignment and soft foot (baseplate weakness) problem.

Inspected by: Nattanai T.
Analyst by: Pichet S.
Review by: Warut K.

Appendix B

Vibration Severity Listing

The following noteworthy information is a description of each stages of vibration severity.

- Good** Fault in low level:
The lower limit that could be reasonably expected from the best application of the normal commercial manufacturing practice.
- Fair** Keeps Monitoring Failure Trend:
A vibration severity level that is readily achieved by the great majority of machine that is well designed and constructed.
- Alarm** Requires Attention at Next Opportunity:
A vibration severity level that is greater than normally expected from well designed and constructed machines/equipment, indicating a possible fault in the system. Provided that the vibration is not due to an unacceptable fault that will cause deterioration of the machines, or the vibration does not have other undesirable or unacceptable effects, that such a vibration level may be acceptable.
- Danger** Requires Immediate Attention:
Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

Appendix C: Data collection by CSI2140



Vibration Analyzer: CSI 2140 No.14
Serial No.: 821402218840
Calibration Date: 09-Aug-23
Calibration Due: 08-Aug-25

Reference criteria

Standard	Good	Fair	Alarm	Danger	Unit
ISO-10816 part 6 (Engine)	Class V				mm/s RMS
Statistical alarm Acceleration of Peakvue mode		≤28.2	>28.2 – 44.6	>44.6	G's PKPK
		≤16.4	>16.4 – 18.5	>18.5	mm/s RMS
Statistical alarm velocity of pump		≤50.6	>50.6 – 59.8	>59.8	mm/s RMS

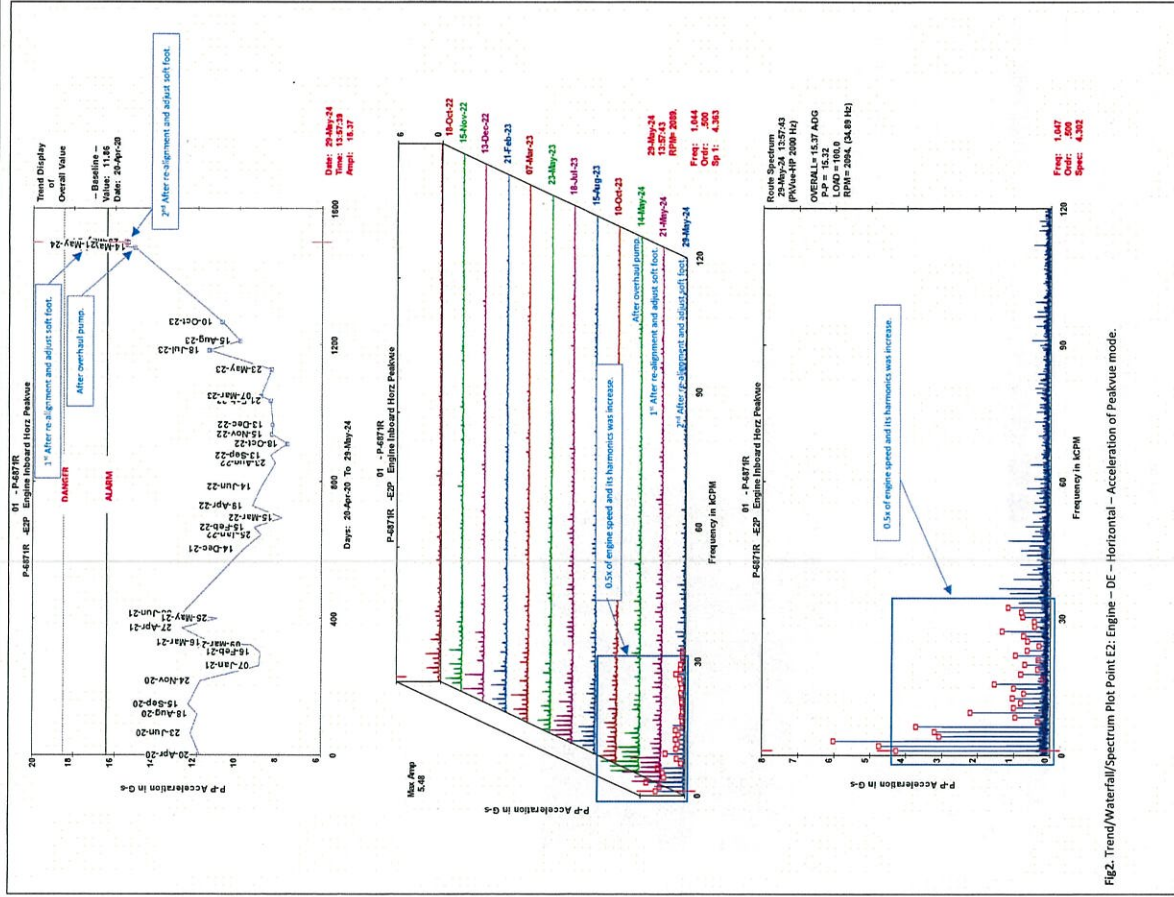
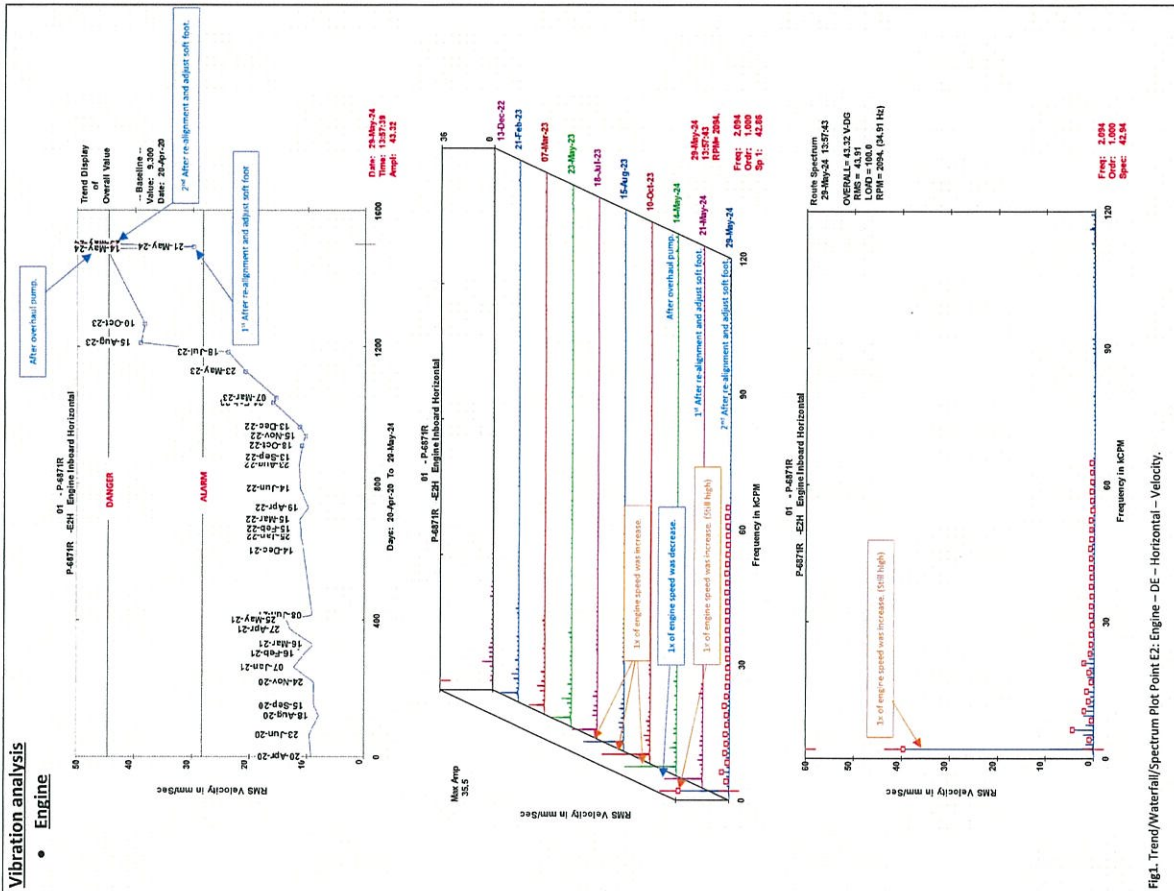
Remark: ISO-10816 provides specific guidance for assessing the severity of vibration measured on machine in steady state, thus GCME will consider the magnitude of vibration, the changes in the magnitude and frequency for judging the severity of vibration.

Machine description and vibration measurement point

	Engine Manufacturer: CATERPILLAR Type: DIESEL (CAT 3406C) Power: 217-359 kw Speed = 1,750-2,300 rpm DE Bearing: N/A NDE Bearing: N/A
	Pump Manufacturer: Bombas vertical gear pump Type: N/A Shaft input speed (P1, P2): 1,750-2,300 rpm DE Bearing: NDE Bearing: Shaft output speed (P3, P4): N/A DE Bearing: N/A NDE Bearing: N/A Tooth of Gear /High speed: N/A Tooth of Gear /Low speed: N/A GMF1 = N/A

Note: Picture Sample

Vibration analysis
• Engine



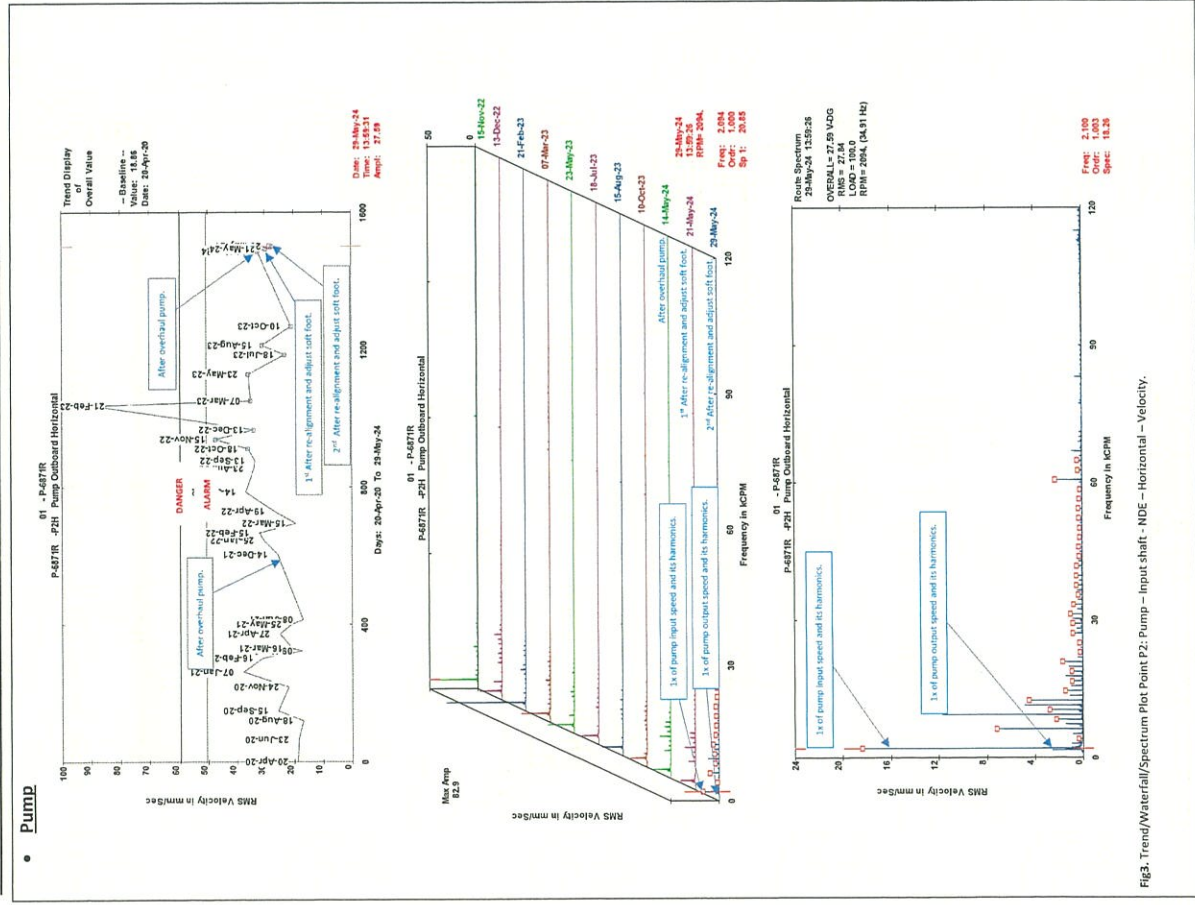


Fig3. Trend/Waterfall/Spectrum Plot Point P2: Pump – Input shaft - NDE – Horizontal – Velocity.

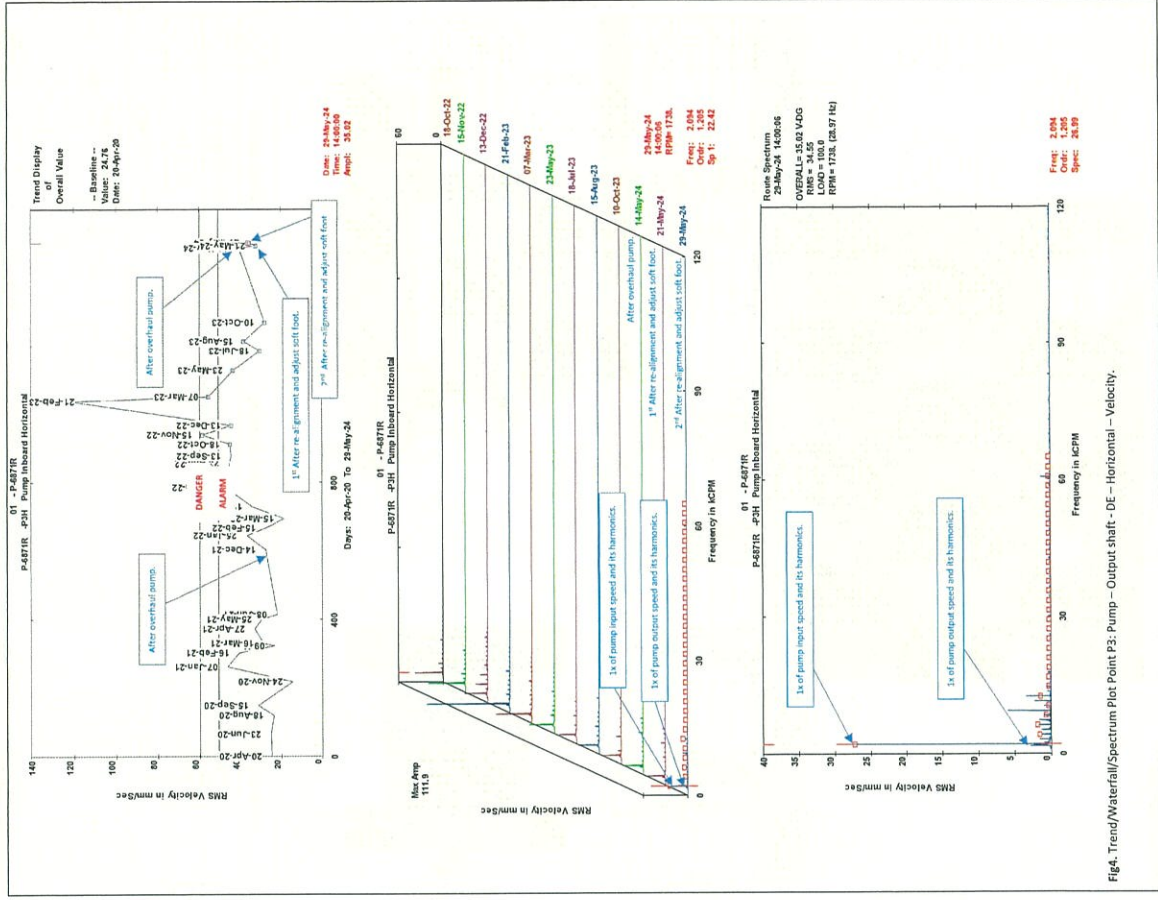
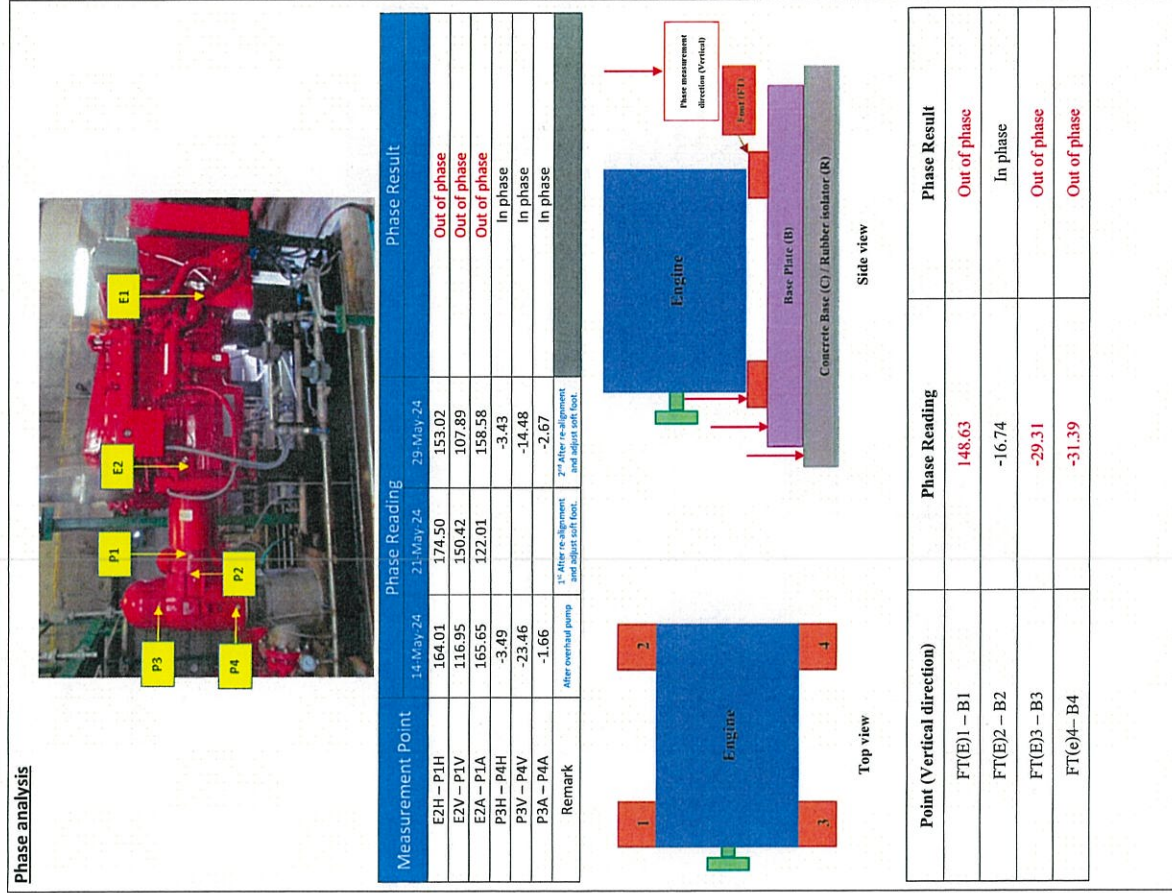
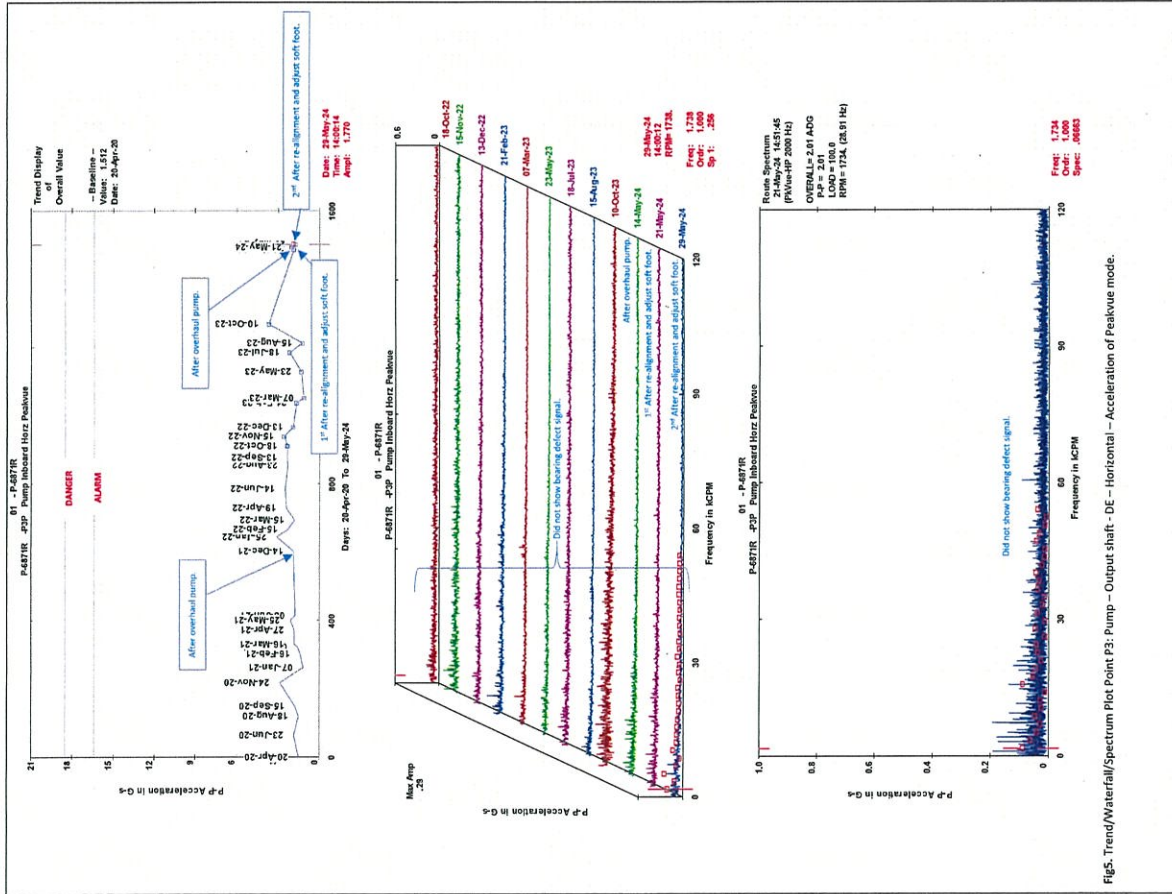


Fig4. Trend/Waterfall/Spectrum Plot Point P3: Pump – Output shaft - DE – Horizontal – Velocity.



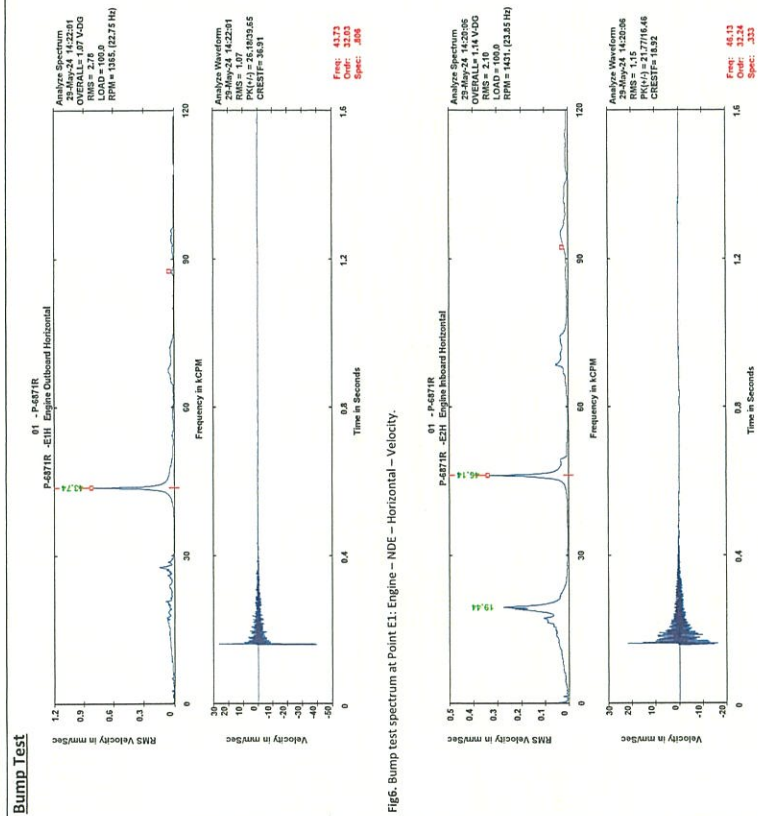


Fig6. Bump test spectrum at Point E1: Engine – NDE – Horizontal – Velocity.

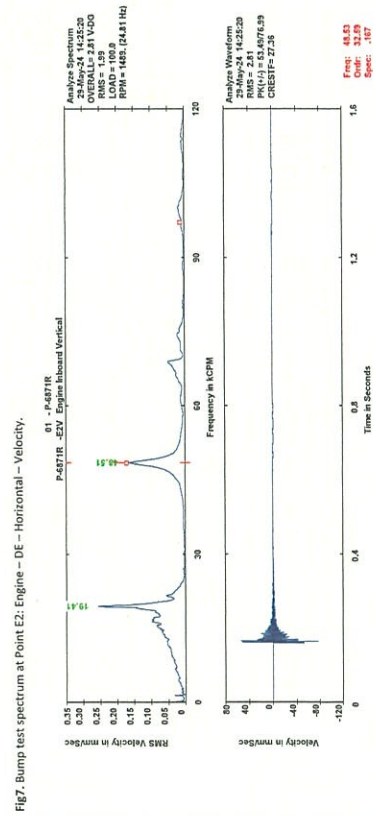


Fig. 8. Bump test spectrum at Point E2: Engine – DE – Vertical – Velocity.

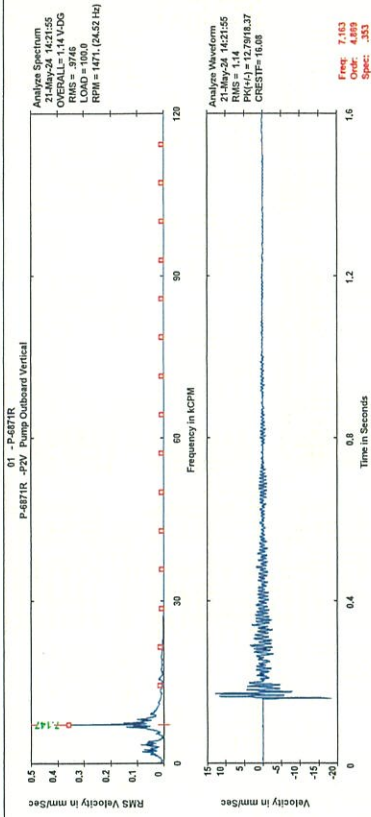


Fig9 . Bump test spectrum at Point E2: Engine – DE – Vertical– Velocity.

Inspection Finding**Engine:**

1. The overall velocity of vibration at point E2 Engine DE in horizontal direction was more increase from 29.85 to 43.32 mm/s. RMS and enter to "ALARM" severity by refer ISO 10816-6. The FFT spectrum shown dominant peak at 1x 0.5x its harmonics of engine speed. And amplitude at 1x of engine speed was increase (still high) which indicate to misalignment and soft foot (baseplate weakness) problem. (Refer phase analysis) (Fig 1)
2. The overall acceleration of Peakvue mode at point E2 Engine DE in horizontal direction was slightly decrease from 16.48 to 15.37 G's, Pk-Pk and enter to "ALARM" severity by refer statistical alarm. The FFT shown dominant peak at 0.5x, 1x of engine speed and them harmonics which indicate to mechanical looseness problem. (Fig 2)
3. At site found base plate look like box steel. (Hollow)

Gearbox/Pump: After overhaul pump.

1. The overall velocity of vibration at point P2 pump input shaft NDE in horizontal direction was slightly decrease from 29.59 to 27.59 mm/s, RMS and enter to "FAIR" severity by refer statistical alarm. The FFT spectrum shown dominant peak at 1x of pump input speed and its harmonics. And amplitude at 1x pump input speed was slightly decrease which indicate to misalignment. (Refer phase analysis) Other problem is mechanical looseness problem. (Fig 3)
2. The overall velocity of vibration at point P3 pump output shaft DE in horizontal direction was slightly increase from 32.17 to 35.02 mm/s, RMS and enter to "FAIR" severity by refer statistical alarm. The FFT spectrum shown dominant peak at 1x of pump input speed and its harmonics. And amplitude at 1x pump speed was slightly increase which indicate to misalignment. (Refer phase analysis) Other problem is mechanical looseness problem. (Fig 4)
3. The overall acceleration of Peakvue mode at point P3 pump output shaft DE in horizontal direction was slightly decrease from 2.02 to 1.77 G's, Pk-Pk. The FFT spectrum did not show bearing defect signal. (Fig 5)

Bump test:

1. From bump test at point E1 engine NDE in horizontal direction shown highest peak in zone at 43,740 CPM. (Fig 6)
2. From bump test at point E2 engine DE in horizontal direction shown highest peak in zone at 19,440 and 46,140 CPM. (Fig 7)
3. From bump test at point E2 engine DE in vertical direction shown highest peak in zone at 19,410 and 48,530 CPM. (Fig 8)
4. From bump test at point P2 pump input DE in vertical direction shown highest peak in zone at 7,147 CPM. (Fig 9)

Conclusion

- Engine: Misalignment and soft foot (baseplate weakness) problem.
- Pump: Misalignment and soft foot (baseplate weakness) problem.

Recommendation**Engine:**

1. Should be consider stop P-6871R to standby mode as soon as possible and action as below step.
 2. Should be check baseplate and soft foot condition if found weakness should be corrected.
 3. Should be check DBSE value. If found over limit should be adjust by refer OEM.
 4. Should be try to re-alignment with high accuracy less than 0.02 mm.
- Pump: Should be keep monitored trend of vibration and peakvue in monthly interval.

Appendix A
Overall vibration

Database: GC7_BTF.rbm
Area: GC7
Period Reported: 18-Jul-23 To 29-May-24

Equipment 1: P-6871R

DATE TIME OVERALL

P-6871R - E1H-Engine Outboard Horizontal

mm/Sec
18-Jul-23 10:39 14.67
15-Aug-23 11:06 14.07
10-Oct-23 10:52 13.00
14-May-24 14:04 14.13
21-May-24 14:47 13.55
29-May-24 13:56 14.62

P-6871R - E1P-Engine Outboard Horz Peakvue

G-s
18-Jul-23 10:39 12.95
15-Aug-23 11:06 11.77
10-Oct-23 10:52 12.74
14-May-24 14:04 15.45
21-May-24 14:47 15.96
29-May-24 13:56 13.37

P-6871R - E1V-Engine Outboard Vertical

mm/Sec
18-Jul-23 10:39 6.696
15-Aug-23 11:06 9.452
10-Oct-23 10:52 6.293
14-May-24 14:04 9.773
21-May-24 14:47 9.893
29-May-24 13:57 11.26

P-6871R - E1A-Engine Outboard Axial

mm/Sec
18-Jul-23 10:39 15.54
15-Aug-23 11:06 19.15
10-Oct-23 10:53 24.64
14-May-24 14:04 14.05
21-May-24 14:49 16.32
29-May-24 13:57 17.05

P-6871R - E2H-Engine Inboard Horizontal

mm/Sec
18-Jul-23 10:39 23.91
15-Aug-23 11:07 39.03
10-Oct-23 10:53 38.30
14-May-24 14:05 44.30
21-May-24 14:48 49.85
29-May-24 13:57 43.32

P-6871R - E2P-Engine Inboard Horz Peakvue

G-s
18-Jul-23 10:39 11.45
15-Aug-23 11:07 9.94
10-Oct-23 10:53 10.84
14-May-24 14:05 15.05
21-May-24 14:48 16.48
29-May-24 13:57 15.37

P-6871R - E2V-Engine Inboard Vertical

mm/Sec
18-Jul-23 10:40 8.599
15-Aug-23 11:07 15.88
10-Oct-23 10:54 7.999
14-May-24 14:05 15.86
21-May-24 14:48 11.70
29-May-24 13:58 15.77


44.30 -> After overhaul pump.
29.85 -> 1" After re-alignment and adjust soft foot.
43.32 -> 2" After re-alignment and adjust soft foot.

P-6871R	- E2A-Engine Inboard Axial	mm/Sec	
		18-Jul-23 10:40	17.02
		15-Aug-23 11:08	22.27
		10-Oct-23 10:54	28.14
		14-May-24 14:05	19.86
		21-May-24 14:50	18.65
P-6871R	- P1H-Pump Inboard Horizontal	mm/Sec	
		29-May-24 13:58	21.63
P-6871R	- P1H-Pump Inboard Horizontal	mm/Sec	
		18-Jul-23 10:40	22.49
		15-Aug-23 11:08	30.06
		10-Oct-23 10:54	22.64
		14-May-24 14:05	34.73
P-6871R	- P1P-Pump Inboard Horiz PeakVue	G-s	
		18-Jul-23 10:40	4.555
		15-Aug-23 11:08	1.218
		10-Oct-23 10:54	7.307
		14-May-24 14:05	3.485
		21-May-24 14:50	3.000
P-6871R	- P1V-Pump Inboard Vertical	mm/Sec	
		29-May-24 13:58	1.163
P-6871R	- P1V-Pump Inboard Vertical	mm/Sec	
		18-Jul-23 10:40	10.38
		15-Aug-23 11:08	12.02
		10-Oct-23 10:54	12.78
		14-May-24 14:06	16.04
P-6871R	- P2H-Pump Outboard Horizontal	mm/Sec	
		21-May-24 14:50	14.61
P-6871R	- P2H-Pump Outboard Horizontal	mm/Sec	
		18-Jul-23 10:41	20.97
		15-Aug-23 11:09	20.97
		10-Oct-23 10:55	20.92
P-6871R	- P2P-Pump Outboard Horiz PeakVue	G-s	
		18-Jul-23 10:41	2.682
		15-Aug-23 11:09	2.442
		10-Oct-23 10:55	4.252
		14-May-24 14:06	1.293
		21-May-24 14:50	3.362
P-6871R	- P2V-Pump Outboard Vertical	mm/Sec	
		29-May-24 13:59	2.156
P-6871R	- P2A-Pump Outboard Axial	mm/Sec	
		18-Jul-23 10:41	8.592
		15-Aug-23 11:09	8.458
		10-Oct-23 10:55	8.121
		14-May-24 14:06	13.45
P-6871R	- P2H-Pump Inboard Horizontal	mm/Sec	
		21-May-24 14:51	11.55
P-6871R	- P2H-Pump Inboard Horizontal	mm/Sec	
		18-Jul-23 10:41	18.23
		15-Aug-23 11:09	16.77
		10-Oct-23 10:55	17.03
P-6871R	- P3H-Pump Inboard Horizontal	mm/Sec	
		14-May-24 14:07	18.16
P-6871R	- P3H-Pump Inboard Horizontal	mm/Sec	
		21-May-24 14:51	12.96
		29-May-24 13:59	17.79
P-6871R	- P3H-Pump Inboard Horizontal	mm/Sec	
		18-Jul-23 10:41	30.38
		15-Aug-23 11:09	38.04
		10-Oct-23 10:55	27.85
		14-May-24 14:07	40.43
P-6871R	- P3H-Pump Inboard Horizontal	mm/Sec	
		21-May-24 14:51	32.17
		29-May-24 14:00	35.02

P-6871R	- P3P-Pump Inboard Horiz PeakVue	G-s	
		18-Jul-23 10:41	2.210
		15-Aug-23 11:10	1.300
		10-Oct-23 10:55	3.708
		14-May-24 14:07	2.892
		21-May-24 14:51	2.152
P-6871R	- P3V-Pump Inboard Vertical	mm/Sec	
		29-May-24 14:00	1.770
P-6871R	- P3A-Pump Inboard Axial	mm/Sec	
		18-Jul-23 10:41	19.10
		15-Aug-23 11:10	14.78
		10-Oct-23 10:55	18.99
P-6871R	- P3A-Pump Inboard Axial	mm/Sec	
		14-May-24 14:07	16.88
P-6871R	- P4H-Pump Outboard Horizontal	mm/Sec	
		21-May-24 14:52	17.23
P-6871R	- P4H-Pump Outboard Horizontal	mm/Sec	
		29-May-24 14:00	17.84
P-6871R	- P4H-Pump Outboard Horizontal	mm/Sec	
		18-Jul-23 10:42	14.64
		15-Aug-23 11:10	18.95
P-6871R	- P4V-Pump Outboard Horiz PeakVue	G-s	
		18-Jul-23 10:42	1.480
		15-Aug-23 11:10	1.284
		10-Oct-23 10:56	1.709
		14-May-24 14:08	1.370
P-6871R	- P4V-Pump Outboard Vertical	mm/Sec	
		21-May-24 14:52	3.113
P-6871R	- P4A-Pump Outboard Axial	mm/Sec	
		29-May-24 14:01	2.042
P-6871R	- P4A-Pump Outboard Axial	mm/Sec	
		18-Jul-23 10:42	16.63
		15-Aug-23 11:11	15.97
P-6871R	- T1 -Temp engine NDE	G	
		18-Jul-23 10:42	93.00
		15-Aug-23 11:11	94.00
		10-Oct-23 10:57	6.129
		14-May-24 14:08	11.63
		21-May-24 14:53	9.898
P-6871R	- T2 -Temp engine DE	G	
		29-May-24 14:01	12.76
P-6871R	- T2 -Temp engine DE	mm/Sec	
		18-Jul-23 10:42	93.00
		15-Aug-23 11:11	94.00
		10-Oct-23 10:57	80.00
P-6871R	- T2 -Temp engine DE	mm/Sec	
		14-May-24 14:09	82.00
		21-May-24 14:53	82.00
P-6871R	- T2 -Temp engine DE	mm/Sec	
		29-May-24 14:01	83.00
P-6871R	- T2 -Temp engine DE	mm/Sec	
		18-Jul-23 10:42	83.00
		15-Aug-23 11:11	92.00
		10-Oct-23 10:57	82.00
		14-May-24 14:09	82.00
		21-May-24 14:53	86.00
		29-May-24 14:01	85.00

P-6871R - T3 -Temp pump DE		C
18-Jul-23	10:43	50.00
15-Aug-23	11:11	51.00
10-Oct-23	10:57	58.00
14-May-24	14:09	44.00
21-May-24	14:53	46.00
29-May-24	14:01	45.00
P-6871R - T4 -Temp pump NDE		C
18-Jul-23	10:43	45.00
15-Aug-23	11:11	46.00
10-Oct-23	10:57	58.00
14-May-24	14:09	38.00
21-May-24	14:53	39.00
29-May-24	14:02	40.00
P-6871R - T5 -Temp pump DE		C
18-Jul-23	10:43	47.00
15-Aug-23	11:12	49.00
10-Oct-23	10:57	58.00
14-May-24	14:09	41.00
21-May-24	14:53	43.00
29-May-24	14:02	43.00
P-6871R - T6 -Temp pump NDE		C
18-Jul-23	10:43	34.00
15-Aug-23	11:12	33.00
10-Oct-23	10:57	40.00
14-May-24	14:09	32.00
21-May-24	14:53	35.00
29-May-24	14:02	34.00
P-6871R - DP -Discharge pressure		Bar
18-Jul-23	10:43	12.00
15-Aug-23	11:12	12.00
10-Oct-23	10:57	12.00
14-May-24	14:09	17.00
21-May-24	14:54	11.50
29-May-24	14:02	11.00
P-6871R - Sp -Speed		Rpm
18-Jul-23	10:43	2083.0
15-Aug-23	11:12	2081.0
10-Oct-23	10:58	2079.0
14-May-24	14:10	2088.0
21-May-24	14:54	2085.0
29-May-24	14:03	2086.0

Clarification Of Vibration Units:
 Acc --> G-s
 Vel --> mm/sec
 P-P RMS

<p>Vibration Severity Listing</p> <p>The following noteworthy information is a description of each stages of vibration severity.</p> <ul style="list-style-type: none"> Good Fault in low level: The lower limit that could be reasonably expected from the best application of the normal commercial manufacturing practice. Fair Keeps Monitoring Failure Trend: A vibration severity level that is readily achieved by the great majority of machine that is well designed and constructed. Alarm Requires Attention at Next Opportunity: A vibration severity level that is greater than normally expected from well designed and constructed machines/equipment, indicating a possible fault in the system. Provided that the vibration is not due to an unacceptable fault that will cause deterioration of the machines, or the vibration does not have other undesirable or unacceptable effects, that such a vibration level may be acceptable. Requires Immediate Attention: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine. 	
<p>Appendix B</p>	
<p>Appendix C: Data collection by CSI2140</p> <div>  <div> <p>Vibration Analyzer: CSI 2140 No.14</p> <p>Serial No.: B21402218840</p> <p>Calibration Date: 09-Aug-23</p> <p>Calibration Due: 08-Aug-25</p> </div> </div>	

ประจำเดือน มิถุนายน 2567





Vibration Report

Prepared for

PTT Global Chemical Public Company Limited (GC7 BTF Plant)
Month of Survey and Data Collection: June 2024

Inspected by: PICHET SUKSAI
Reported by: WARUT KAUNBUMRUNG
Approved by: METEE MEERABEAB

Condition Monitoring Service Integrity and Reliability Department

 GC Maintenance and Engineering Company Limited

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Contents

1. Executive Summary	3
2. Introduction	4
3. Reference Standard	5
4. Vibration Severity Listing	6
5. Vibration Summary Report	8
6. Vibration Analysis Report	8
7. Appendix A: Severity of machine	24

Vibration condition monitoring

1. Executive Summary

Measurement Start-Finish: 11 and 17 Jun 2024

Measurement plan 38 Equipment.
 Checked 12 Equipment.
 Standby 26 Equipment.

As show in Fig 1 And Table 1

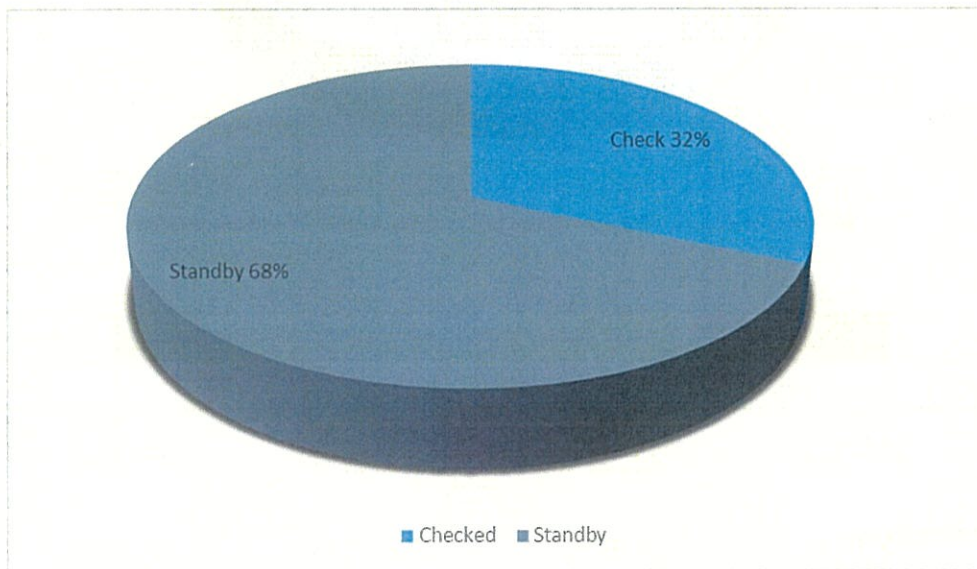
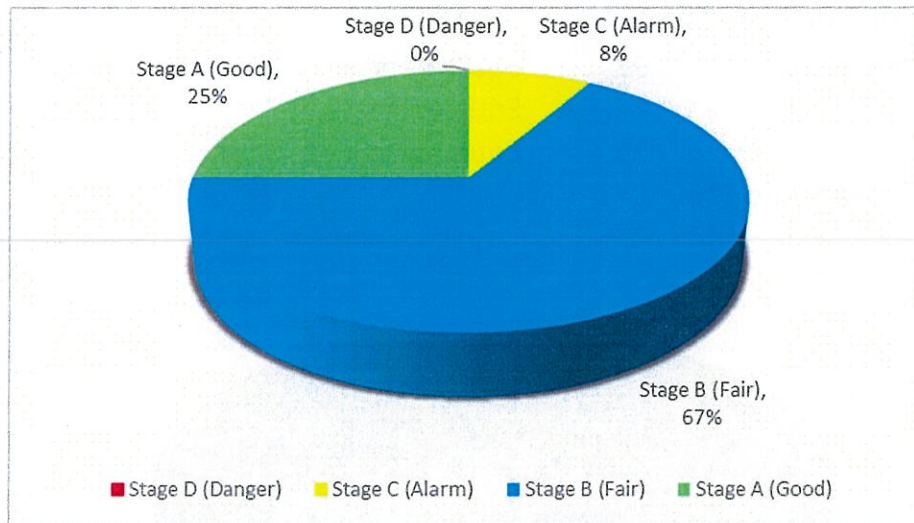


Fig 1

Table 1: Summary of Collected of vibration on PTT GC7 BTF

Item/Status	Measurement plan	Checked	Standby	Grand Total
Unit	38	12	26	38
Percentage	100%	32%	68%	100%

During this period, GCME has collected a vibration data are 12 Equipment. The result can be categorized into each severity kindly see attachment more detailed as following list.



Severity	Stage D (Danger)	Stage C (Alarm)	Stage B (Fair)	Stage A (Good)	Grand Total
Unit	0	1	8	3	12
Percentage	0%	8%	67%	25%	100%

2. Introduction

PTTGC and GCME has officially signed a yearly contract of "Vibration Monitoring" which a contract's intention is to request GCME to collect a vibration data of specified equipment in accordance with a particular schedule. Vibration data gathered regularly shall be interpreted technically to PTTGC for further action.

Vibration data is carefully collected using portable device branded by EMERSON CSI whose model is "CSI2140; SN: B21402218840 and SN: B21401205571" equipped with an industrial standard accelerometer (CTC SN: 22730 and CTC SN: 323737) Software used for analysis is AMS Machinery Manager.

3. Reference Standard

In order to clearly certify a vibration severity of any equipment, an official international standard which is not only well recognized by worldwide equipment user but also approved by international organization shall be referred to.

PTTGC and GCME agreed to officially apply ISO10816-3 standard for vibration severity assessment for any equipment operated in Refinery plant (PTTGC Branch 6). The vibration severity chart which is an excerpt from ISO10816-3 is shown as the following table herewith.

ISO 10816 Part 3									
Industrial Machines with nominal power above 15 kW and nominal speeds between 120 rpm and 15,000 rpm when measured in situ									
Velocity	Pumps > 15 kW				Medium Size Machines		Large Machines		
10 - 1000 Hz, r > 600 rpm	Radial, Axial, Mixed Flow				15 kW < Power < 300 kW		300 kW < Power < 50 MW		
2 - 1000 Hz, r > 120 rpm	Group 4		Group 3		Group 2		Group 1		
	Integrated Driver		External Driver		160 mm < Motor Height < 315 mm		315 mm < Motor Height		
Limit, mm/s, rms	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	
> 10.0									
11.0 - 10.0									
7.1 - 11.0									
4.5 - 7.1									
3.5 - 4.5									
2.8 - 3.5									
2.3 - 2.8									
1.4 - 2.3									
0.7 - 1.4									
0.0 - 0.7									
	Newly Commissioned								
	Unrestricted long-term operation								
	Restricted long-term operation								
	Vibration causes damage								

Vibration Peakvue Acceleration Severity

Speed of Machine (RPM)	G's, Pk-Pk			
	Stage A (GOOD)	Stage B (FAIR)	Stage C (ALARM)	Stage D (DANGER)
500	≤ 0.56	> 0.56 - 1.41	> 1.41 - 5.08	> 5.08
1000	≤ 1.13	> 1.13 - 2.82	> 2.82 - 9.87	> 9.87
1500	≤ 1.68	> 1.68 - 3.95	> 3.95 - 11.28	> 11.28
3000	≤ 3.95	> 3.95 - 8.46	> 8.46 - 28.2	> 28.2

4. Vibration Severity Listing

Stage of vibration severity and Legend used in a report

The following noteworthy information is a description of each stage of vibration severity.

Stage 4: **Stage D (DANGER)** Requires Immediate Attention.

A level of vibration severity at which the probability of a sever fault of machine condition, or other deleterious effects of vibration are considered to be unacceptably high

Group 4		Group 3		Group 2		Group 1		Limit, mm/s, RMS
Pumps > 15 kW radial, axial, mixed flow				Medium sized machines 15 kW<P<300 kW		Large sized machines 300 kW<P<50 kW		
Integrated driver		External driver		Motor 160mm ≤ H <315mm		Motor 315mm ≤ H		
Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	
> 4.5	> 7.1	> 7.1	> 11	> 4.5	> 7.1	> 7.1	> 11	

Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)			Limit, g-s, RMS
Dia between 200 & 500 mm Speed < 500 RPM	Dia between 50 & 300 mm Speed Between 500 & 1000 RPM	Dia between 20 & 150 mm Speed is either 1800 or 3600 RPM	
> 1.8	> 3.5	> 10	

Stage 3: **Stage C (ALARM)** Requires Attention at Next Opportunity.

A vibration severity level that is greater than normally expected from well designed and constructed machines/equipment, indicating a possible fault in the system. Provided that the vibration is not due to an unacceptable fault that will cause deterioration of the machines, or the vibration does not have other undesirable or unacceptable effects, that such a vibration level may be acceptable.

Group 4		Group 3		Group 2		Group 1		Limit, mm/s, RMS
Pumps > 15 kW radial, axial, mixed flow				Medium sized machines 15 kW<P<300 kW		Large sized machines 300 kW<P<50 kW		
Integrated driver		External driver		Motor 160mm ≤ H <315mm		Motor 315mm ≤ H		
Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	
>2.8 -4.5	>4.5 -7.1	>4.5 -7.1	>7.1 -11	>2.8 -4.5	>4.5 -7.1	>4.5 -7.1	>7.1 -11	

Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)			Limit, g-s, RMS
Dia between 200 & 500 mm Speed < 500 RPM	Dia between 50 & 300 mm Speed Between 500 & 1000 RPM	Dia between 20 & 150 mm Speed is either 1800 or 3600 RPM	
> 0.5	> 1.0	> 3.0	

Stage 2: Stage B (FAIR) Keeps Monitoring Failure Trend.

A vibration severity level that is readily achieved by the great majority of machine that is well designed and constructed.

Group 4		Group 3		Group 2		Group 1		Limit, mm/s, RMS
Pumps > 15 kW radial, axial, mixed flow				Medium sized machines 15 kW<P<300 kW		Large sized machines 300 kW<P<50 kW		
Integrated driver		External driver		Motor 160mm ≤ H <315mm		Motor 315mm ≤ H		
Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	
>1.4 - 2.8	>2.3 - 4.5	>2.3 - 4.5	>3.5 - 7.1	>1.4 - 2.8	>2.3 - 4.5	>2.3 - 4.5	>3.5 - 7.1	

Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)			Limit, g-s, RMS
Dia between 200 & 500 mm Speed < 500 RPM	Dia between 50 & 300 mm Speed Between 500 & 1000 RPM	Dia between 20 & 150 mm Speed is either 1800 or 3600 RPM	
> 0.2	> 0.4	> 1.4	

Stage 1: Stage A (GOOD) Fault in low level.

The lower limit that could be reasonably expected from the best application of the normal commercial manufacturing practice.

Group 4		Group 3		Group 2		Group 1		Limit, mm/s, RMS
Pumps > 15 kW radial, axial, mixed flow				Medium sized machines 15 kW<P<300 kW		Large sized machines 300 kW<P<50 kW		
Integrated driver		External driver		Motor 160mm ≤ H <315mm		Motor 315mm ≤ H		
Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible	
≤ 1.4	≤ 2.3	≤ 2.3	≤ 3.5	≤ 1.4	≤ 2.3	≤ 2.3	≤ 3.5	

Vibration Peakvue Acceleration Severity (Shaft Diameter Speed)			Limit, g-s, RMS
Dia between 200 & 500 mm Speed < 500 RPM	Dia between 50 & 300 mm Speed Between 500 & 1000 RPM	Dia between 20 & 150 mm Speed is either 1800 or 3600 RPM	
≤ 0.2	≤ 0.4	≤ 1.4	

5. Vibration Summary Report

Please see the attached table of "Vibration Summary Report"

June 2024				
No.	Tag No.	Severity	Conclusion	Recommended
1	P-6871R	Stage C (ALARM)	Engine: Misalignment and soft foot (baseplate weakness) problem. Another problem is rotating part looseness. (Suspect flywheel/endplay bearing looseness.) Pump: Misalignment problem. Another problem is mechanical looseness.	Engine: 1. Should be consider stop P-6871R to standby mode <u>as soon as possible</u> and action as below step. 2. Should be plan to <u>inspect flywheel condition and endplay bearing</u> . If found abnormal condition should be corrected. 3. Should be <u>consider to recheck baseplate condition and leveling if found abnormal condition and/or weakness should be corrected</u> . 4. Should be check DBSE value. If found over limit should be adjust <u>by refer OEM</u> . 5. Should be try to re-alignment with high accuracy <u>by refer OEM</u> . 6. Should be consider to overhaul engine for inspect internal part of engine. If found abnormal should be corrected and include replace new bearing. Pump: Should be keep monitored trend of vibration and Peakvue in <u>monthly interval</u> .

6. Vibration Analysis Report

Any equipment whose vibration severity "Alarm" is explained an analysis detail separately.

Please see each of them as attachment.

Tag: P-6871R

Machine name: FIRE WATER PUMP

Inspected by: Natdanai T.

Severity: **Stage C (ALARM)**

Date of data measurement: 11 June 2024

Analyst by: Pichet S.

Area: GC7_BTF

Main problem: Routine. (After re-tightening bolt of baseplate.) Misalignment and soft foot (baseplate weakness) problem. Another problem is rotating part looseness. (Suspect flywheel/endplay bearing looseness.)

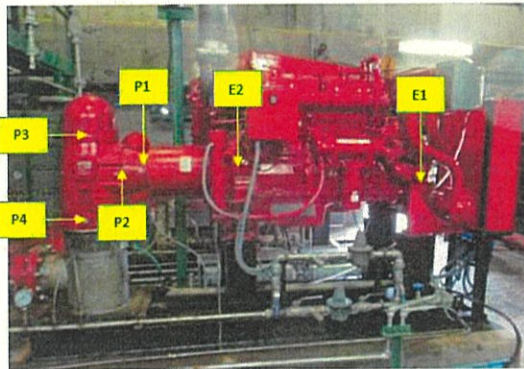
Review by: Warut K.

Reference criteria

Standard		Stage A (GOOD)	Stage B (FAIR)	Stage C (ALARM)	Stage D (DANGER)	Unit
ISO-10816 part 6 (Engine)	Class V	≤14.1	>14.1 – 28.2	>28.2 – 44.6	>44.6	mm/S RMS
Statistical alarm Acceleration of Peakvue mode		≤8.2	>8.2 – 16.4	>16.4 – 18.5	>18.5	G's, Pk-PK
Statistical alarm velocity of pump		≤25.3	>25.3 – 50.6	>50.6 – 59.8	>59.8	mm/S RMS

Remark: ISO-10816 provides specific guidance for assessing the severity of vibration measured on machine in steady state, thus GCME will considers the magnitude of vibration, the changes in the magnitude and frequency for judging the severity of vibration.

Machine description and vibration measurement point



Note: Picture Sample

Engine

Manufacturer: CATERPILLAR
Type: DIESEL (CAT 3406C)
Power: 217-359 kw
Speed = 1,750-2,300 rpm
DE Bearing: N/A
NDE Bearing: N/A

Pump

Manufacturer: Bombas vertical gear pump
Type: N/A
Shaft input speed (P1, P2): 1,750-2,300 rpm
DE Bearing:
NDE Bearing:
Shaft output speed (P3, P4): N/A
DE Bearing: N/A
NDE Bearing: N/A
Tooth of Gear /High speed: N/A
Tooth of Gear /Low speed: N/A
GMF1 = N/A

Vibration analysis

• Engine

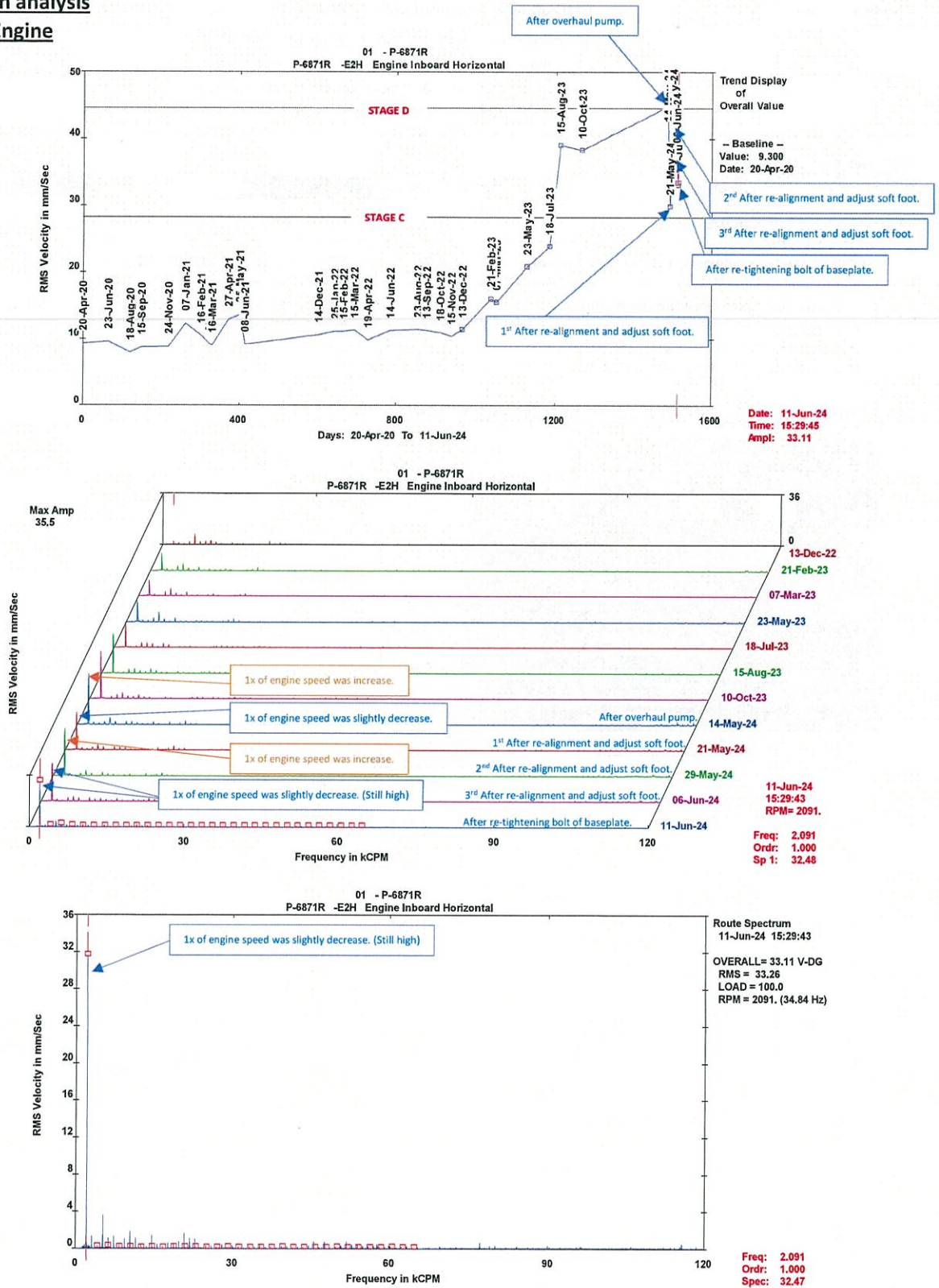


Fig1. Trend/Waterfall/Spectrum Plot Point E2: Engine – DE – Horizontal – Velocity.

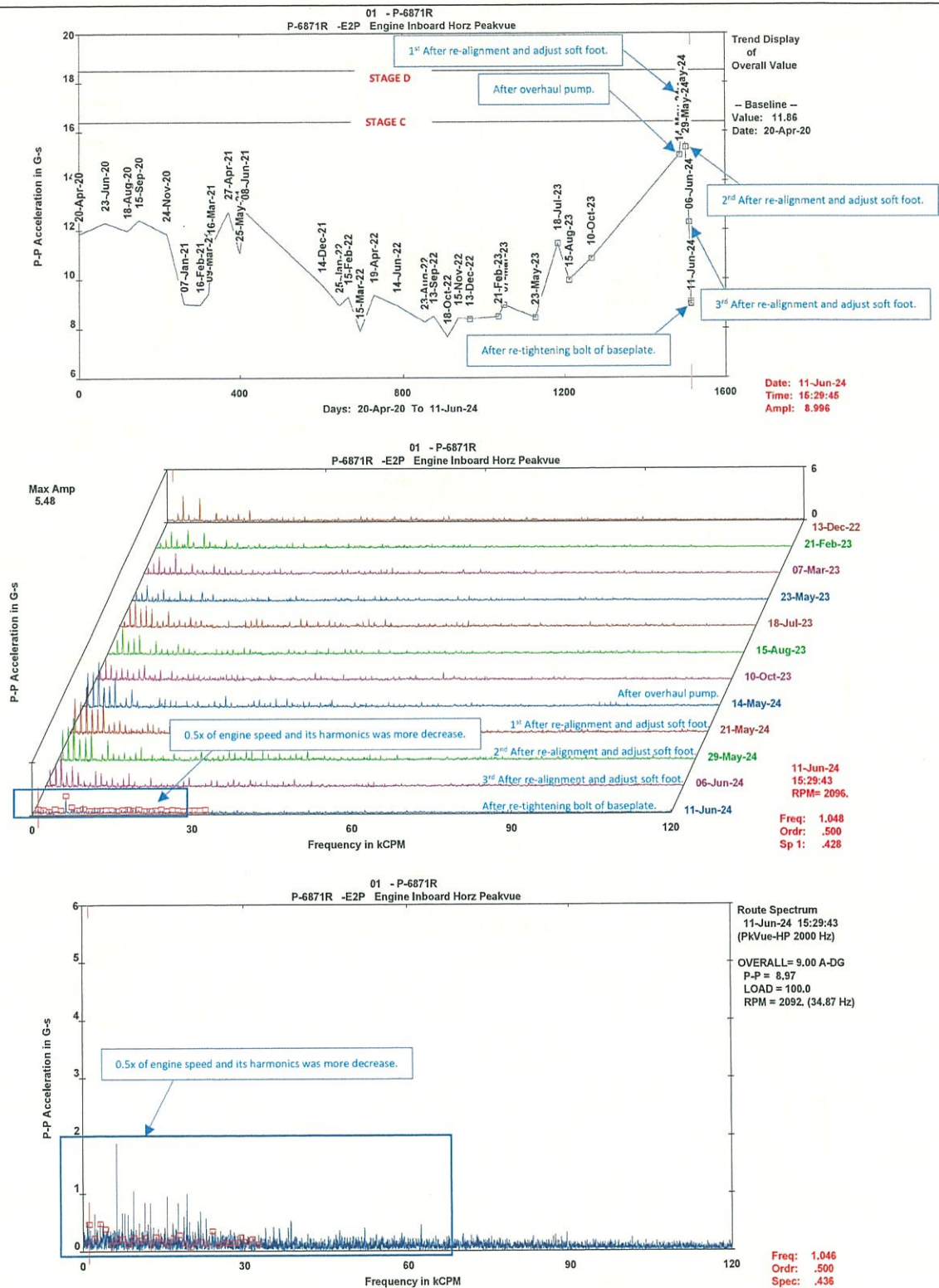


Fig2. Trend/Waterfall/Spectrum Plot Point E2: Engine – DE – Horizontal – Acceleration of Peakvue mode.

• Pump

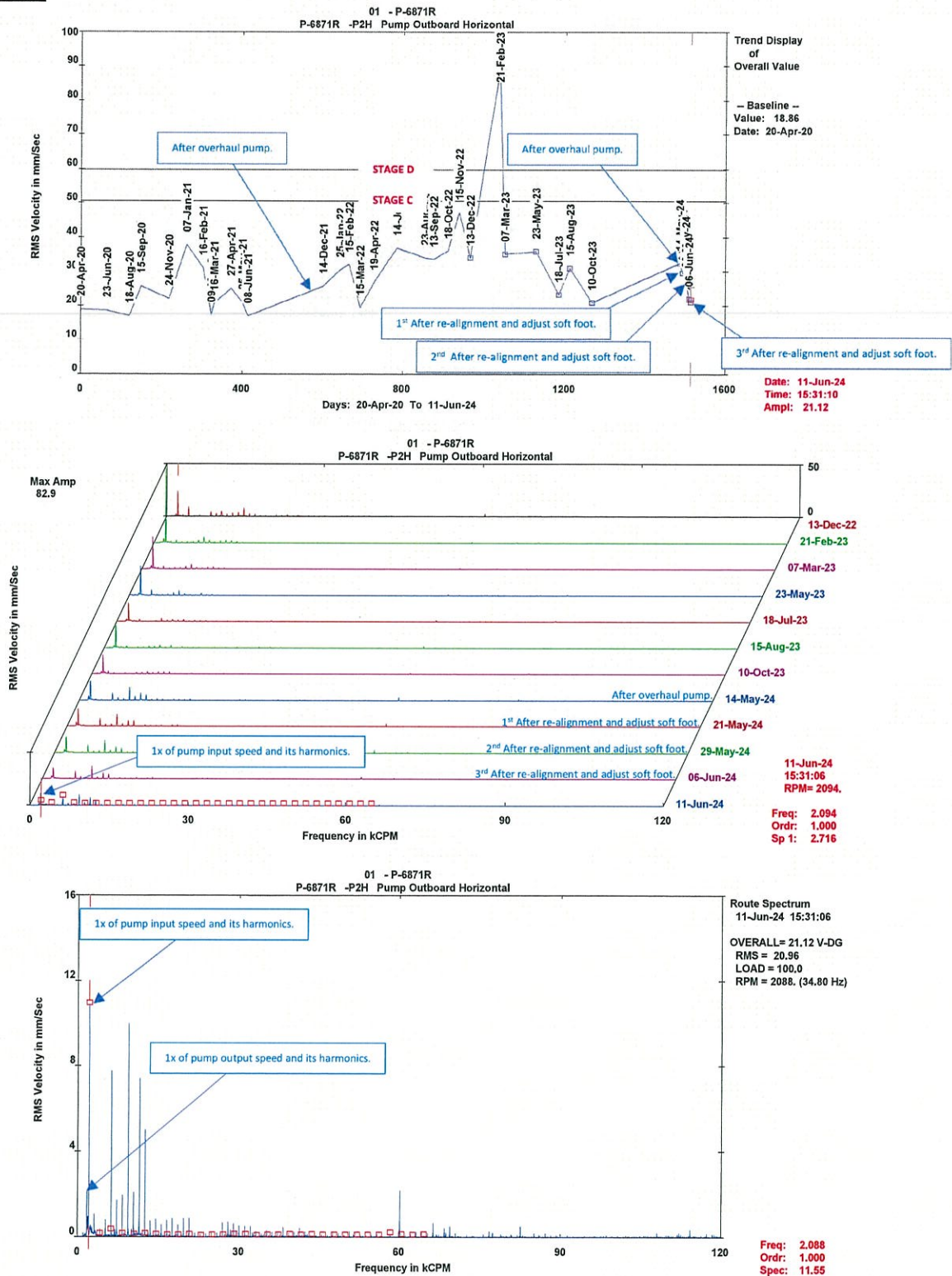


Fig3. Trend/Waterfall/Spectrum Plot Point P2: Pump – Input shaft - NDE – Horizontal – Velocity.

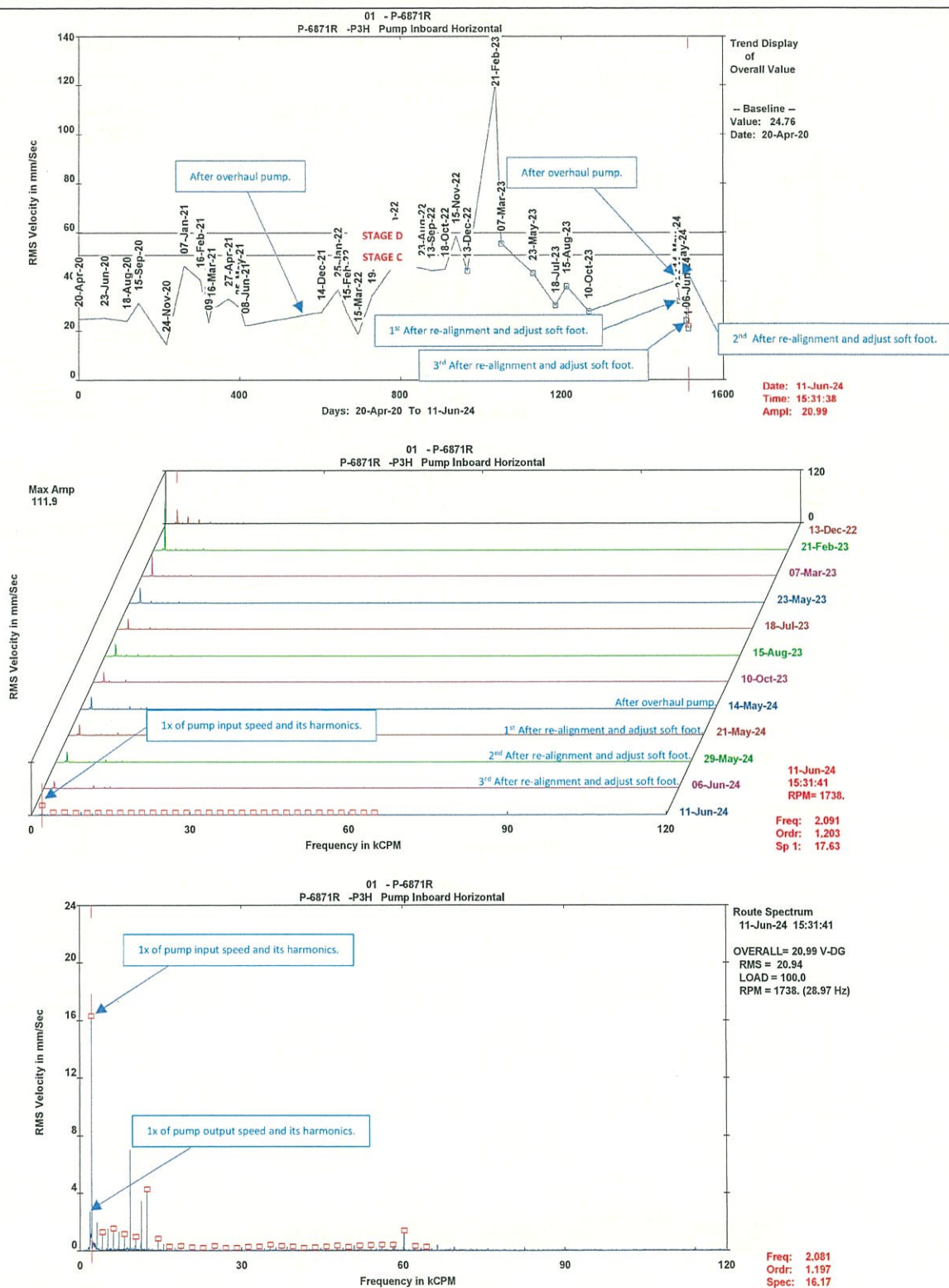
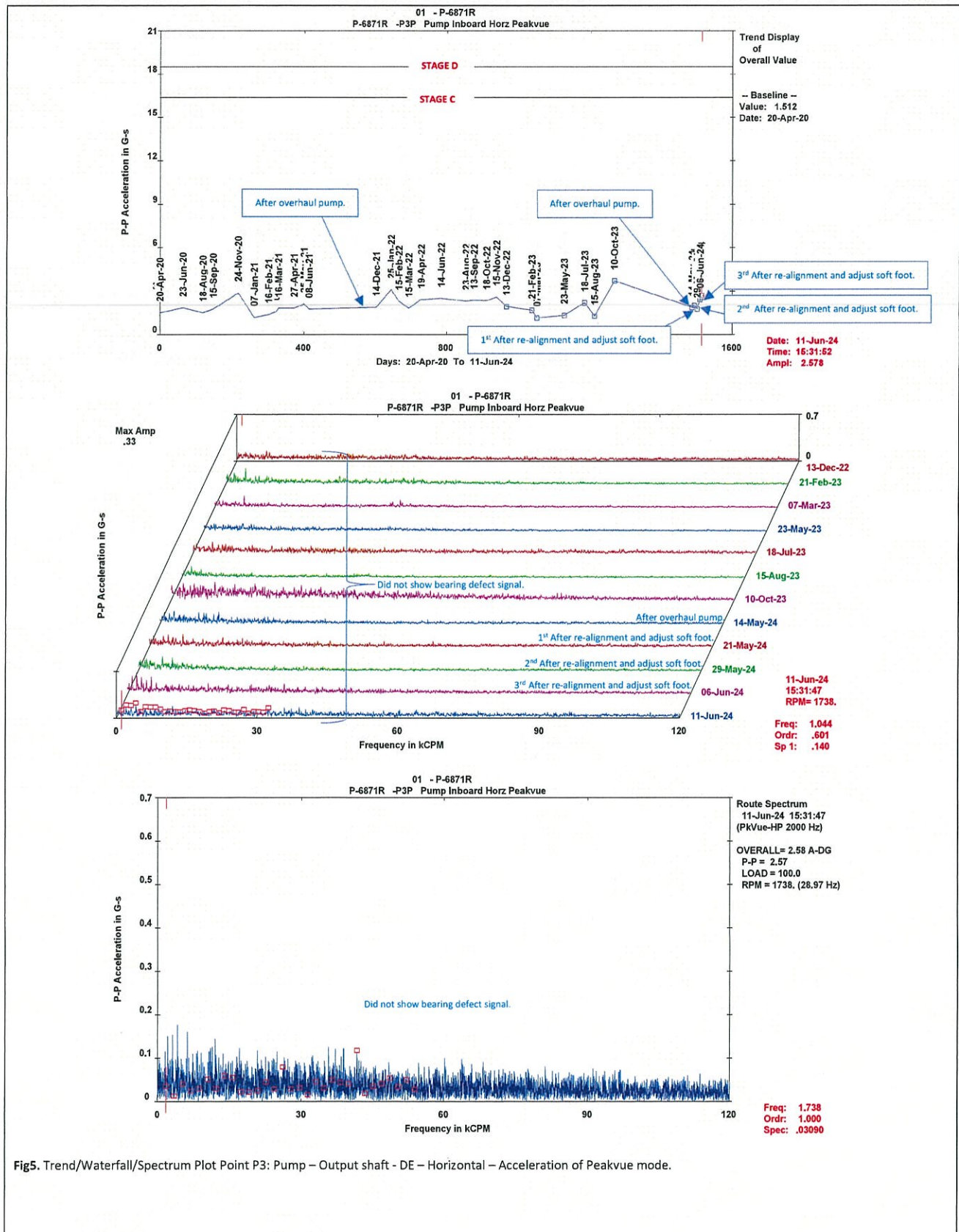
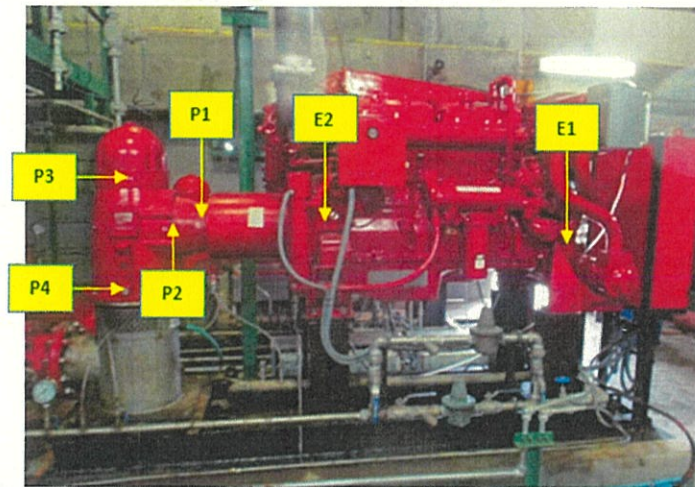


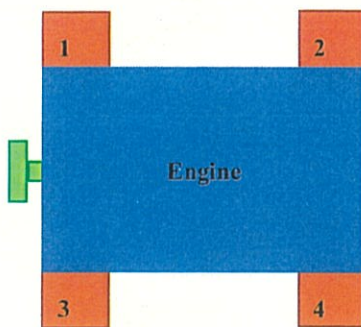
Fig4. Trend/Waterfall/Spectrum Plot Point P3: Pump – Output shaft - DE – Horizontal – Velocity.



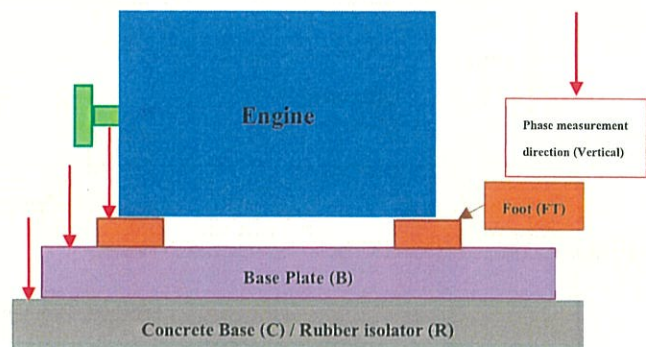
Phase analysis



Measurement Point	Phase Reading					Phase Result
	14-May-24	21-May-24	29-May-24	06-Jun-24	11-Jun-24	
E2H – P1H	164.01	174.50	153.02	132.95	126.03	Out of phase
E2V – P1V	116.95	150.42	107.89	69.44	56.49	Out of phase
E2A – P1A	165.65	122.01	158.58	150.69	148.19	Out of phase
P3H – P4H	-3.49		-3.43	-7.66	-3.92	In phase
P3V – P4V	-23.46		-14.48	-8.73	21.85	In phase
P3A – P4A	-1.66		-2.67	1.86	8.90	In phase
Remark	After overhaul pump	1 st After re-alignment and adjust soft foot.	2 nd After re-alignment and adjust soft foot.	3 rd After re-alignment and adjust soft foot.	4 th After re-tightening bolt of baseplate.	



Top view



Side view

Point (Vertical direction)	Phase Reading			Phase Result
	21-May-24	06-Jun-24	11-Jun-24	
FT(E)1 – B1	148.63	114.07	23.37	In phase
FT(E)2 – B2	-16.74	8.78	158.45	Out of phase
FT(E)3 – B3	-29.31	-2.09	-176.74	Out of phase
FT(E)4 – B4	-31.39	-168.55	-150.56	Out of phase

Bump Test

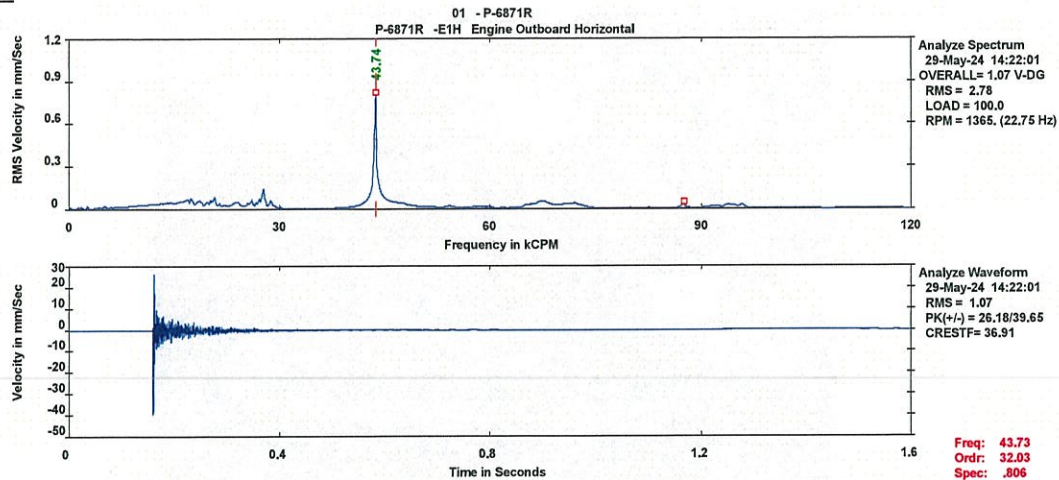


Fig6. Bump test spectrum at Point E1: Engine – NDE – Horizontal – Velocity.

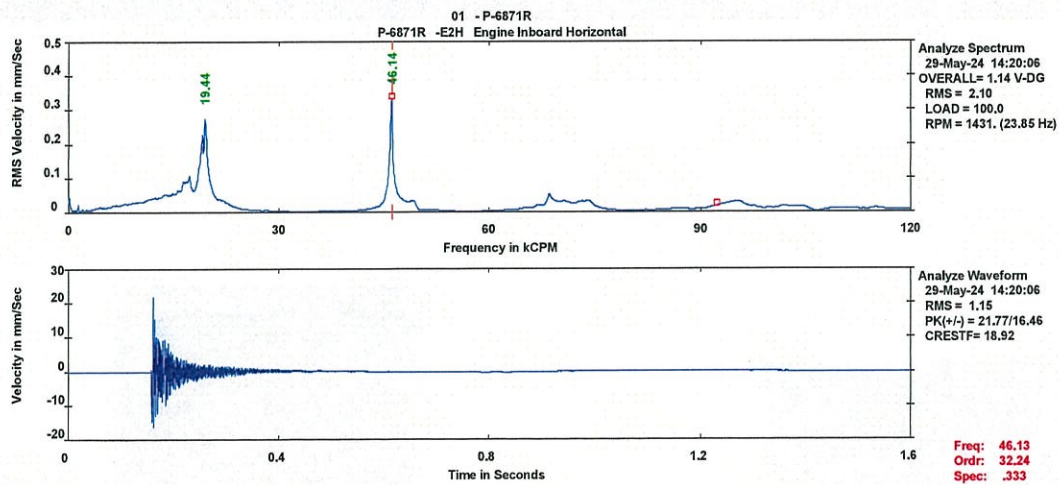


Fig7. Bump test spectrum at Point E2: Engine – DE – Horizontal – Velocity.

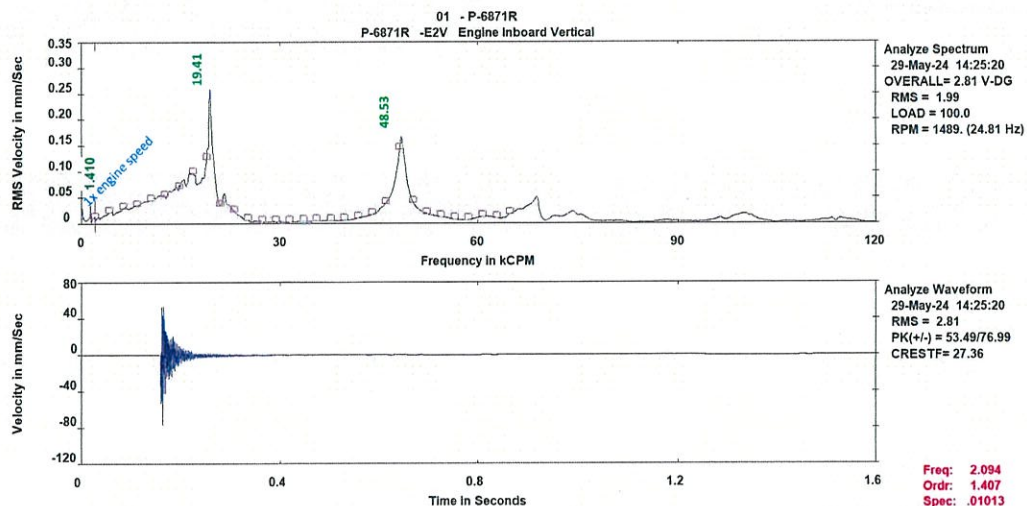


Fig8. Bump test spectrum at Point E2: Engine – DE – Vertical- Velocity.

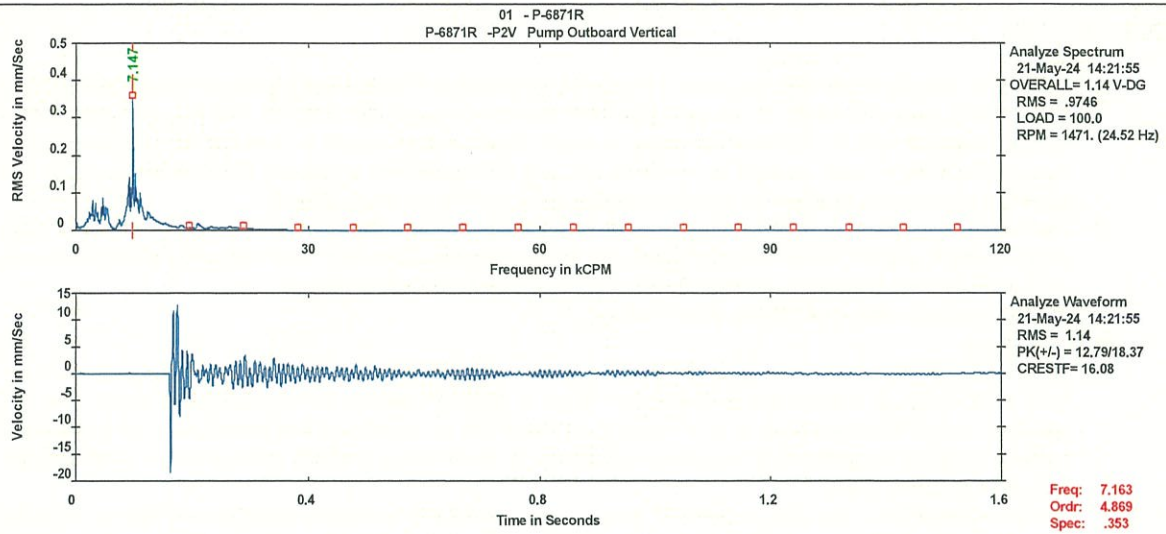


Fig9 . Bump test spectrum at Point E2: Engine – DE – Vertical– Velocity.

Inspection Finding

- **Engine:** Routine. (After re-tightening bolt of baseplate.)
 1. The overall velocity of vibration at point E2 Engine DE in horizontal direction was slightly decrease from 37.60 to 33.11 mm/s, RMS and enter to "Stage C (ALARM)" severity by refer ISO 10816-6. The FFT spectrum shown dominant peak at 0.5x, 1x and them harmonics of engine speed. And amplitude at 1x of engine speed was slightly decrease (still high) which indicate to misalignment, soft foot (baseplate weakness) (Refer phase analysis) and rotating part looseness problem. (Suspect flywheel/endplay bearing looseness.) (Fig 1)
 2. The overall acceleration of Peakvue mode at point E2 Engine DE in horizontal direction was decrease from 12.30 to 9.00 G's, Pk-Pk. The FFT shown dominant peak at 0.5x, 1x of engine speed and them harmonics which indicate to mechanical looseness problem. (Suspect flywheel/endplay bearing looseness.) (Fig 2)
 3. At site found base plate look like box steel. (Hollow)
- **Gearbox/Pump:**
 1. The overall velocity of vibration at point P2 pump input shaft NDE in horizontal direction was slightly decrease from 22.00 to 21.12 mm/s, RMS and enter to "Stage A (GOOD)" severity by refer statistical alarm. The FFT spectrum shown dominant peak at 1x of pump input speed and its harmonics. And amplitude at 1x pump input speed was slightly decrease which indicate to misalignment. (Refer phase analysis) Other problem is rotating part looseness problem. (Fig 3)
 2. The overall velocity of vibration at point P3 pump output shaft DE in horizontal direction was slightly decrease from 24.13 to 20.99 mm/s, RMS and enter to "Stage A (GOOD)" severity by refer statistical alarm. The FFT spectrum shown dominant peak at 1x of pump input speed and its harmonics. And amplitude at 1x pump speed was slightly decrease which indicate to misalignment. (Refer phase analysis) Other problem is rotating part looseness problem. (Fig 4)
 3. The overall acceleration of Peakvue mode at point P3 pump output shaft DE in horizontal direction was slightly increase from 2.42 to 2.57 G's, Pk-Pk. The FFT spectrum did not show bearing defect signal. (Fig 5)
- **Bump test:**
 1. From bump test at point E1 engine NDE in horizontal direction shown highest peak in zone at 43,740 CPM. (Fig 6)
 2. From bump test at point E2 engine DE in horizontal direction shown highest peak in zone at 19,440 and 46,140 CPM. (Fig 7)
 3. From bump test at point E2 engine DE in vertical direction shown highest peak in zone at 19,410 and 48,530 CPM. (Fig 8)
 4. From bump test at point P2 pump input DE in vertical direction shown highest peak in zone at 7,147 CPM. (Fig 9)

Conclusion

- **Engine:** Misalignment and soft foot (baseplate weakness) problem. Another problem is rotating part looseness. (Suspect flywheel/endplay bearing looseness.)
- **Pump:** Misalignment problem. Another problem is mechanical looseness.

Recommendation

- **Engine:**
 1. Should be consider stop P-6871R to standby mode as soon as possible and action as below step.
 2. Should be plan to inspect flywheel condition and endplay bearing. If found abnormal condition should be corrected.
 3. Should be consider to recheck baseplate condition and leveling if found abnormal condition and/or weakness should be corrected.
 4. Should be check DBSE value. If found over limit should be adjust by refer OEM.
 5. Should be try to re-alignment with high accuracy by refer OEM.
 6. Should be consider to overhaul engine for inspect internal part of engine. If found abnormal should be corrected and include replace new bearing.
- **Pump:** Should be keep monitored trend of vibration and Peakvue in monthly interval.

Appendix A Overall vibration

Database: GC7_(BTF).rbm
Area: GC7
Period Reported: 10-Oct-23 To 12-Jun-24

Equipment 1: P-6871R

	DATE	TIME	OVERALL
	----	----	-----
P-6871R - E1H-Engine Outboard Horizontal			mm/Sec
	10-Oct-23	10:52	13.00
	14-May-24	14:04	14.13
	21-May-24	14:47	13.55
	29-May-24	13:56	14.62
	06-Jun-24	14:27	17.13
	11-Jun-24	15:28	16.97
P-6871R - E1P-Engine Outboard Horz Peakvue			G-s
	10-Oct-23	10:52	12.74
	14-May-24	14:04	15.45
	21-May-24	14:47	15.96
	29-May-24	13:56	13.37
	06-Jun-24	14:27	13.38
	11-Jun-24	15:28	11.46
P-6871R - E1V-Engine Outboard Vertical			mm/Sec
	10-Oct-23	10:52	6.293
	14-May-24	14:04	9.773
	21-May-24	14:47	9.893
	29-May-24	13:57	11.26
	06-Jun-24	14:27	6.859
	11-Jun-24	15:28	8.991
P-6871R - E1A-Engine Outboard Axial			mm/Sec
	10-Oct-23	10:53	24.64
	14-May-24	14:04	14.05
	21-May-24	14:49	16.32
	29-May-24	13:57	17.03
	06-Jun-24	14:28	17.60
	11-Jun-24	15:28	13.99
P-6871R - E2H-Engine Inboard Horizontal			mm/Sec
	10-Oct-23	10:53	38.30
	14-May-24	14:05	44.90-> After overhaul pump.
	21-May-24	14:48	29.85->1 st After re-alignment and adjust soft foot.
	29-May-24	13:57	43.32->2 nd After re-alignment and adjust soft foot.
	06-Jun-24	14:28	37.60->3 rd After re-alignment and adjust soft foot.
	11-Jun-24	15:29	33.11->Routine. (After re-tightening bolt of baseplate.)
P-6871R - E2P-Engine Inboard Horz Peakvue			G-s
	10-Oct-23	10:53	10.84
	14-May-24	14:05	15.05
	21-May-24	14:48	16.48
	29-May-24	13:57	15.37
	06-Jun-24	14:28	12.30
	11-Jun-24	15:29	8.996
P-6871R - E2V-Engine Inboard Vertical			mm/Sec
	10-Oct-23	10:54	7.999
	14-May-24	14:05	15.86
	21-May-24	14:48	11.70
	29-May-24	13:58	15.77
	06-Jun-24	14:28	10.19
	11-Jun-24	15:30	8.260

P-6871R - E2A-Engine Inboard Axial			
			mm/Sec
	10-Oct-23	10:54	28.14
	14-May-24	14:05	19.86
	21-May-24	14:50	18.65
	29-May-24	13:58	21.63
	06-Jun-24	14:28	18.75
	11-Jun-24	15:30	15.25
P-6871R - P1H-Pump Inboard Horizontal			
			mm/Sec
	10-Oct-23	10:54	22.64
	14-May-24	14:05	34.73
	21-May-24	14:50	28.26
	29-May-24	13:58	31.46
	06-Jun-24	14:29	27.73
	11-Jun-24	15:30	25.09
P-6871R - P1P-Pump Inboard Horz Peakvue			
			G-s
	10-Oct-23	10:54	7.307
	14-May-24	14:05	3.045
	21-May-24	14:50	3.000
	29-May-24	13:58	1.163
	06-Jun-24	14:29	2.855
	11-Jun-24	15:30	5.588
P-6871R - P1V-Pump Inboard Vertical			
			mm/Sec
	10-Oct-23	10:54	12.78
	14-May-24	14:06	16.04
	21-May-24	14:50	14.61
	29-May-24	13:59	15.62
	06-Jun-24	14:29	14.53
	11-Jun-24	15:30	15.33
P-6871R - P2H-Pump Outboard Horizontal			
			mm/Sec
	10-Oct-23	10:55	20.92
	14-May-24	14:06	32.49
	21-May-24	14:50	29.59
	29-May-24	13:59	27.59
	06-Jun-24	14:29	22.00
	11-Jun-24	15:31	21.12
P-6871R - P2P-Pump Outboard Horz Peakvue			
			G-s
	10-Oct-23	10:55	4.252
	14-May-24	14:06	1.293
	21-May-24	14:50	3.302
	29-May-24	13:59	2.156
	06-Jun-24	14:29	2.254
	11-Jun-24	15:31	3.740
P-6871R - P2V-Pump Outboard Vertical			
			mm/Sec
	10-Oct-23	10:55	8.121
	14-May-24	14:06	13.45
	21-May-24	14:51	11.55
	29-May-24	13:59	13.70
	06-Jun-24	14:29	11.59
	11-Jun-24	15:31	12.70
P-6871R - P2A-Pump Outboard Axial			
			mm/Sec
	10-Oct-23	10:55	17.03
	14-May-24	14:07	18.16
	21-May-24	14:51	12.96
	29-May-24	13:59	17.79
	06-Jun-24	14:30	16.45
	11-Jun-24	15:31	15.27
P-6871R - P3H-Pump Inboard Horizontal			
			mm/Sec
	10-Oct-23	10:55	27.85
	14-May-24	14:07	40.43
	21-May-24	14:51	32.17
	29-May-24	14:00	35.02
	06-Jun-24	14:30	24.13
	11-Jun-24	15:31	20.99

P-6871R	- P3P-Pump Inboard Horz Peakvue		G-s
		10-Oct-23 10:55	3.708
		14-May-24 14:07	1.899
		21-May-24 14:51	2.015
		29-May-24 14:00	1.770
		06-Jun-24 14:30	2.423
		11-Jun-24 15:31	2.578
P-6871R	- P3V-Pump Inboard Vertical		mm/Sec
		10-Oct-23 10:55	18.99
		14-May-24 14:07	16.88
		21-May-24 14:52	17.23
		29-May-24 14:00	17.84
		06-Jun-24 14:30	16.69
		11-Jun-24 15:31	17.28
P-6871R	- P3A-Pump Inboard Axial		mm/Sec
		10-Oct-23 10:56	4.365
		14-May-24 14:07	11.07
		21-May-24 14:52	10.71
		29-May-24 14:00	10.95
		06-Jun-24 14:30	9.522
		11-Jun-24 15:32	9.818
P-6871R	- P4H-Pump Outboard Horizontal		mm/Sec
		10-Oct-23 10:56	12.70
		14-May-24 14:08	19.34
		21-May-24 14:52	12.38
		29-May-24 14:00	15.20
		06-Jun-24 14:31	12.57
		11-Jun-24 15:32	12.37
P-6871R	- P4P-Pump Outboard Horz Peakvue		G-s
		10-Oct-23 10:56	1.709
		14-May-24 14:08	1.370
		21-May-24 14:52	3.113
		29-May-24 14:01	2.042
		06-Jun-24 14:31	2.145
		11-Jun-24 15:32	2.635
P-6871R	- P4V-Pump Outboard Vertical		mm/Sec
		10-Oct-23 10:56	15.37
		14-May-24 14:08	15.52
		21-May-24 14:52	15.36
		29-May-24 14:01	14.86
		06-Jun-24 14:31	15.28
		11-Jun-24 15:32	15.92
P-6871R	- P4A-Pump Outboard Axial		mm/Sec
		10-Oct-23 10:57	6.129
		14-May-24 14:08	11.63
		21-May-24 14:53	9.838
		29-May-24 14:01	12.76
		06-Jun-24 14:31	8.776
		11-Jun-24 15:32	10.84
P-6871R	- T1 -Temp engine NDE		C
		10-Oct-23 10:57	94.00
		14-May-24 14:09	80.00
		21-May-24 14:53	82.00
		29-May-24 14:01	83.00
		06-Jun-24 14:31	87.00
		11-Jun-24 15:33	96.00
P-6871R	- T2 -Temp engine DE		C
		10-Oct-23 10:57	95.00
		14-May-24 14:09	82.00
		21-May-24 14:53	86.00
		29-May-24 14:01	85.00
		06-Jun-24 14:31	86.00
		11-Jun-24 15:33	95.00

P-6871R - T3 -Temp pump DE			
			C
10-Oct-23	10:57	58.00	
14-May-24	14:09	44.00	
21-May-24	14:53	46.00	
29-May-24	14:01	45.00	
06-Jun-24	14:32	47.00	
11-Jun-24	15:33	68.00	
P-6871R - T4 -Temp pump NDE			
			C
10-Oct-23	10:57	55.00	
14-May-24	14:09	38.00	
21-May-24	14:53	39.00	
29-May-24	14:02	40.00	
06-Jun-24	14:32	41.00	
11-Jun-24	15:33	65.00	
P-6871R - T5 -Temp pump DE			
			C
10-Oct-23	10:57	58.00	
14-May-24	14:09	41.00	
21-May-24	14:53	43.00	
29-May-24	14:02	43.00	
06-Jun-24	14:32	45.00	
11-Jun-24	15:33	69.00	
P-6871R - T6 -Temp pump NDE			
			C
10-Oct-23	10:57	40.00	
14-May-24	14:09	32.00	
21-May-24	14:53	35.00	
29-May-24	14:02	34.00	
06-Jun-24	14:32	34.00	
11-Jun-24	15:33	56.00	
P-6871R - DP -Discharge pressure			
			Bar
10-Oct-23	10:57	12.00	
14-May-24	14:09	17.00	
21-May-24	14:54	11.50	
29-May-24	14:02	11.00	
06-Jun-24	14:32	11.00	
11-Jun-24	15:33	11.00	
P-6871R - SP -Speed			
			Rpm
10-Oct-23	10:58	2079.0	
14-May-24	14:10	2088.0	
21-May-24	14:54	2085.0	
29-May-24	14:03	2086.0	
06-Jun-24	14:33	2083.0	
11-Jun-24	15:33	2075.0	
P-6871R - FW -Flow rate			
			Rpm
11-Jun-24	15:33	2075.0	

Clarification Of Vibration Units:

Acc	-->	G-s	P-P
Vel	-->	mm/Sec	RMS

Appendix B

Vibration Severity Listing

The following noteworthy information is a description of each stages of vibration severity.

- **Stage A (Good)** Fault in low level:

The lower limit that could be reasonably expected from the best application of the normal commercial manufacturing practice.

- **Stage B (Fair)** Keeps Monitoring Failure Trend:

A vibration severity level that is readily achieved by the great majority of machine that is well designed and constructed.

- **Stage C (Alarm)** Requires Attention at Next Opportunity:

A vibration severity level that is greater than normally expected from well designed and constructed machines/equipment, indicating a possible fault in the system. Provided that the vibration is not due to an unacceptable fault that will cause deterioration of the machines, or the vibration does not have other undesirable or unacceptable effects, that such a vibration level may be acceptable.

- **Stage D (Danger)** Requires Immediate Attention:

Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

Appendix C: Data collection by CSI2140



Vibration Analyzer: CSI 2140 No.14

Serial No.: B21402218840

Calibration Date: 09-Aug-23

Calibration Due: 08-Aug-25

Appendix A: Severity of machine

GC7_BTf Plant

GC7_BTf Plant																
No.	Eq. Tag	Name Machine	Machine Class	Interval	kW	Summary of Severity	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-2024			Summary of Severity	Jun-24
						Summary of Severity	Summary of Severity	Summary of Severity	Summary of Severity	Summary of Severity	Summary of Severity	W3	W4	W5	W6	23Jun-30Jun
1	B-6921A	Air Compressor	B	1M		Not operate as running program	Stage B (Fail)	Not operate as running program	Not operate as running program	Not operate as running program	Stage B (Fail)					Stage B (Fail)
16	G-6871		A	1M		Not operate as running program	Not operate as running program	Not operate as running program	Stage A (GOOD)	Stage A (GOOD)	Stage A (GOOD)					Stage B (Fail)
21	P-6871A	Fire water pump	B	1M		Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Stage B (Fail)	Stage B (Fail)					Stage B (Fail)
22	P-6871R	Fire water pump	B	1M		Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Stage C (ALARM)					Stage C (ALARM)
23	P-6872		B	1M		Not operate as running program	Not operate as running program	Not operate as running program	Stage A (GOOD)	Stage A (GOOD)	Stage A (GOOD)	6-Jun-24	11-Jun-24			Stage A (GOOD)
26	P-6925-01A	Fire water pump	B	1M		Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)					Stage B (Fail)
27	P-6925-01B	Fire water pump	B	1M		Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)					Stage B (Fail)
28	P-6925-01C	Fire water pump	B	1M		Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)	Stage B (Fail)					Stage B (Fail)
36	P-6925-07A	Fire water pump	S	1M		Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Stage B (Fail)					Stage B (Fail)
37	P-6925-07B	Fire water pump	S	1M		Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Not operate as running program	Stage B (Fail)					Stage B (Fail)
53	N-P-6983-01B			1M		Not operate as running program	Not operate as running program	Not operate as running program	Stage A (GOOD)	Stage A (GOOD)	Not operate as running program					Stage A (GOOD)
60	N-P-6983-04A		B	1M		Stage A (GOOD)	Stage A (GOOD)	Stage A (GOOD)	Stage A (GOOD)	Stage A (GOOD)	Not operate as running program					Stage A (GOOD)
Number of inspected machine						10	13	14	22	17						12

Stage A (GOOD)	Stage A : (good) The vibration of newly commissioned machines would normally fall within this zone
Stage B (Fair)	Stage B : (allowable) Machines with vibration within this zone are normally considered acceptable for unrestricted long term operation
Stage C (ALARM)	Stage C : (just tolerable) Machines with vibration within this zone are normally considered unsatisfactory for long term continuous operation. Generally, the machine may be operated with limited service in this zone for short periods of time
Stage D (DANGER)	Stage D : (not permitted) Vibration within this zone is normally considered to be in excess of what is acceptable for long term operation
Not operate as running program	Not operate as running program : Machine do not run as running program
Out of service	Out of service : Cannot measure due to machine do not run as a result of machine overhaul to repair inaccessible, shut down, turn around
Cannot check	Cannot check: Cannot measure even though machine is running caused by prohibited area, gas leaks, no platform or other problems from the factory.
Eliminated	Eliminated : Machine do not have vibration measurement or data for running program