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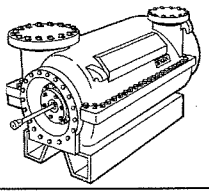

Analysis Report

Torsional Analysis Summary

Job: Mustang **Date**: 06-15-09 **Application**: Refrigeration	**S.O.#:** 08-177539-01 **Compressor Designation:** 555B3 **Design Speed:** 3234 rpm

Prepared by: K Heimberger

Keith Heimberger
Principal Engineer

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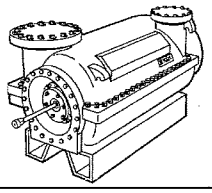

Analysis Report

Torsional Analysis Summary

This report presents the results of a torsional critical speed analysis. The analysis was completed using a computer program which utilizes a finite element method to model the system components. For this analysis it is necessary to model the entire compressor string which consists of the electric motor, low speed coupling, gear box, high speed coupling, and compressor. The details of these components are given below.

Motor:	Manufacturer:	TECO Westinghouse
	Operating Speed:	1772 rpm
	Type:	Induction
L.S. Coupling:	Manufacturer:	Rexnord
	Type:	29410052P14
Gear Box:	Manufacturer:	Lufkin
	Type:	SK14738-2 (N1800C)
	Gear Ratio:	1.825 : 1
H.S. Coupling:	Type:	Riverhawk HC-4291
Compressor:	Type:	York Turbomaster
	Designation:	555B3
	Operating Speed:	3234 rpm

The system model is shown schematically in Figure 1. The model schematic shows the node numbers used in the analysis and the locations of the added inertias. The gear mesh was assumed to have infinite stiffness and therefore modeled as a single node.

To evaluate the system due to the calculated natural frequencies, an interference graph (Campbell Diagram) was created and shown in Figure 2. The following items were used to create the Campbell Diagram.

Operating speed ranges:	Motor (low speed train)	1772 +/-10% rpm
	Compressor (high speed train)	3234 +/-10% rpm

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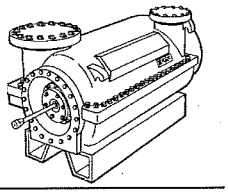


Analysis Report

Excitation Frequencies: 1X synchronous speed
2X synchronous speed

The first two natural frequencies were calculated and plotted on the diagram in Figure 2 as horizontal lines (1224 and 2764 cps). The compressor and motor speeds +/-10% are shown as two pairs of vertical lines. Finally, the two lines starting at the origin represent the two most common excitation frequencies for this system, 1X and 2X running speed. The table below shows that neither excitation curve intersects with the critical speed curve within 14.5 % of the design speed.

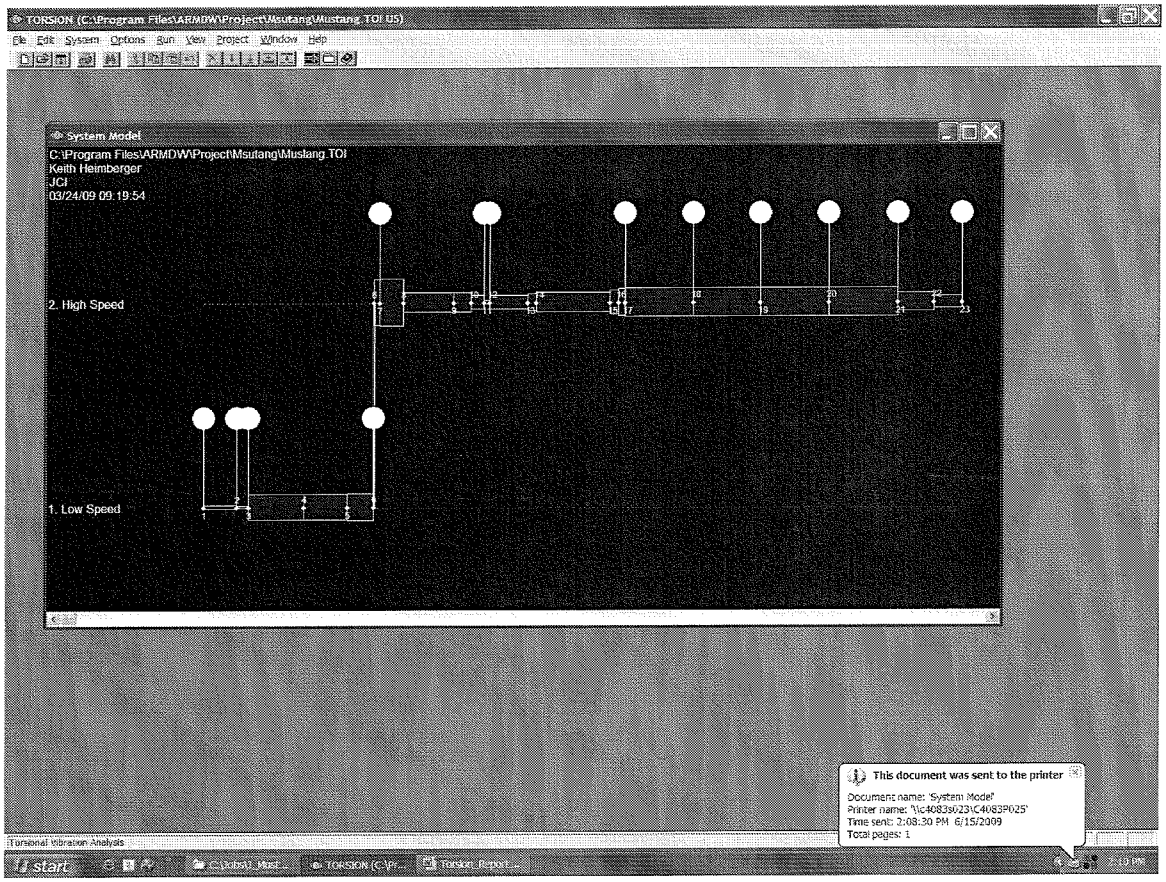
Torsional Critical Speeds Determined:

Mode Number / Intersection Point	Natural Frequency (cpm)	Margin from operating point to nearest intersection point (%)
1	1224	31.0
2	2764	14.5

Figures 3 through 5 show the mode shapes for the first three modes.

Conclusion:

The analysis shows that first and second mode torsional natural frequencies for 1X and 2X are adequately separated from the compressor and motor operating speeds. Based on these results, the compressor string is torsionally acceptable for the conditions studied.


TORSION (C:\Program Files\ARMDW\Project\Msutang\Mustang.TOI US)
File Edit System Options Run View Project Window Help
System Model
C:\Program Files\ARMDW\Project\Msutang\Muslang.TOI
Keith Heimberger
JCI
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2. High Speed
1. Low Speed
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Torsional Vibration Analysis
start

Figure 1

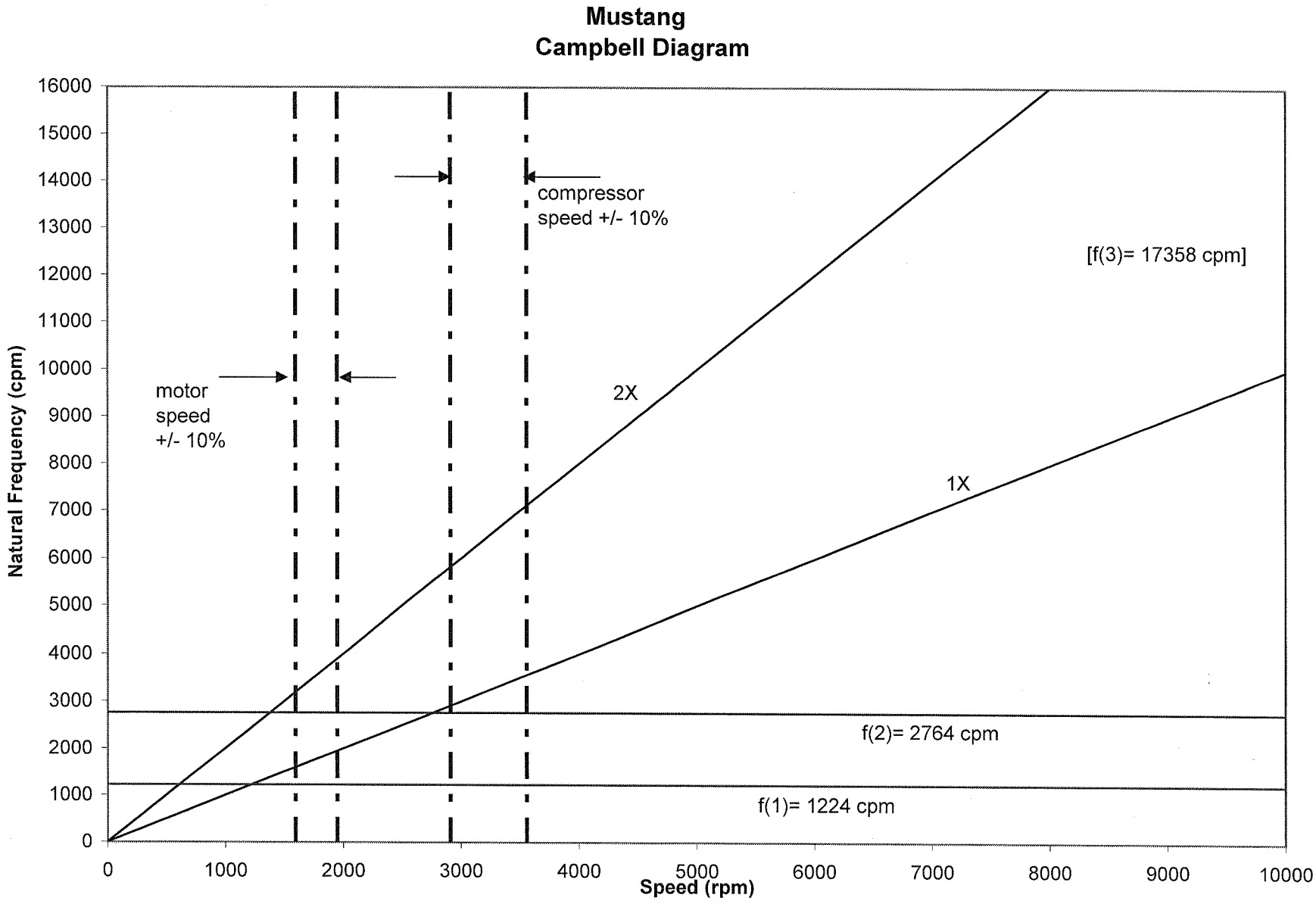
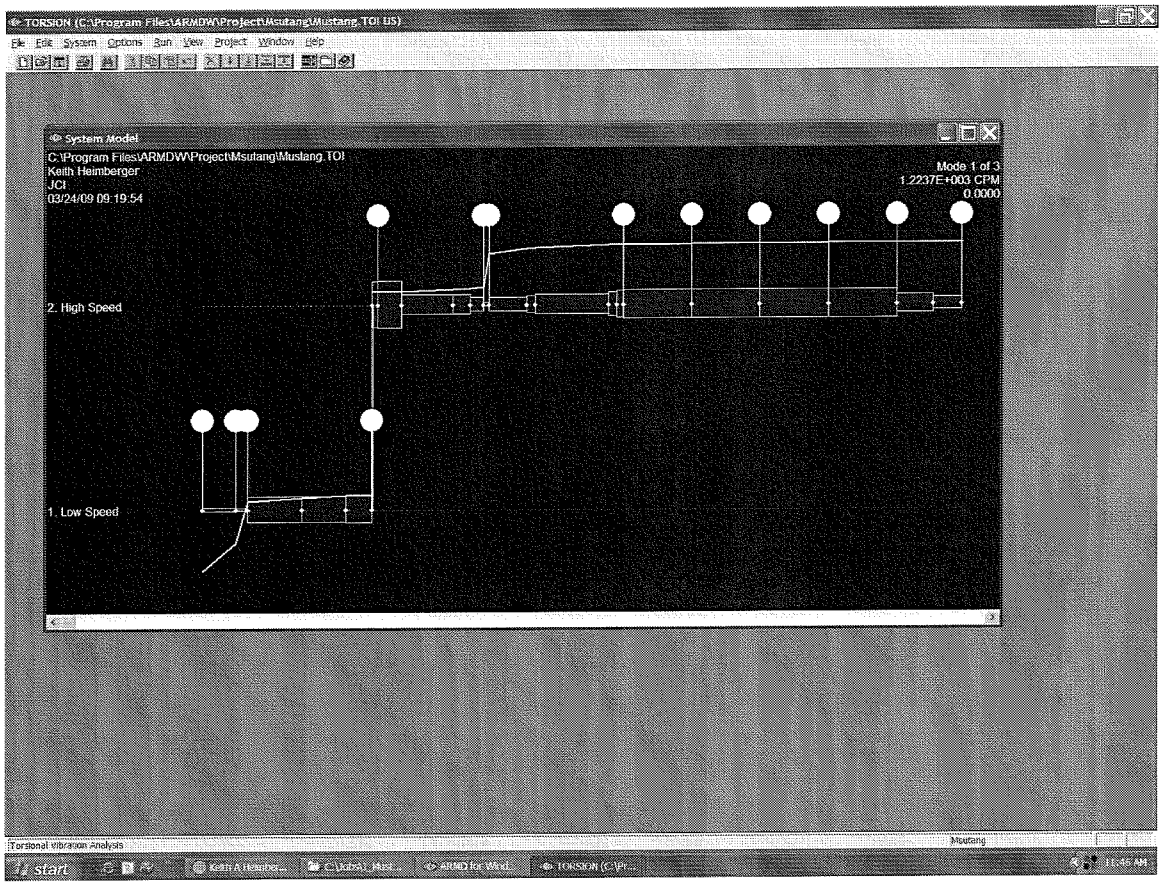
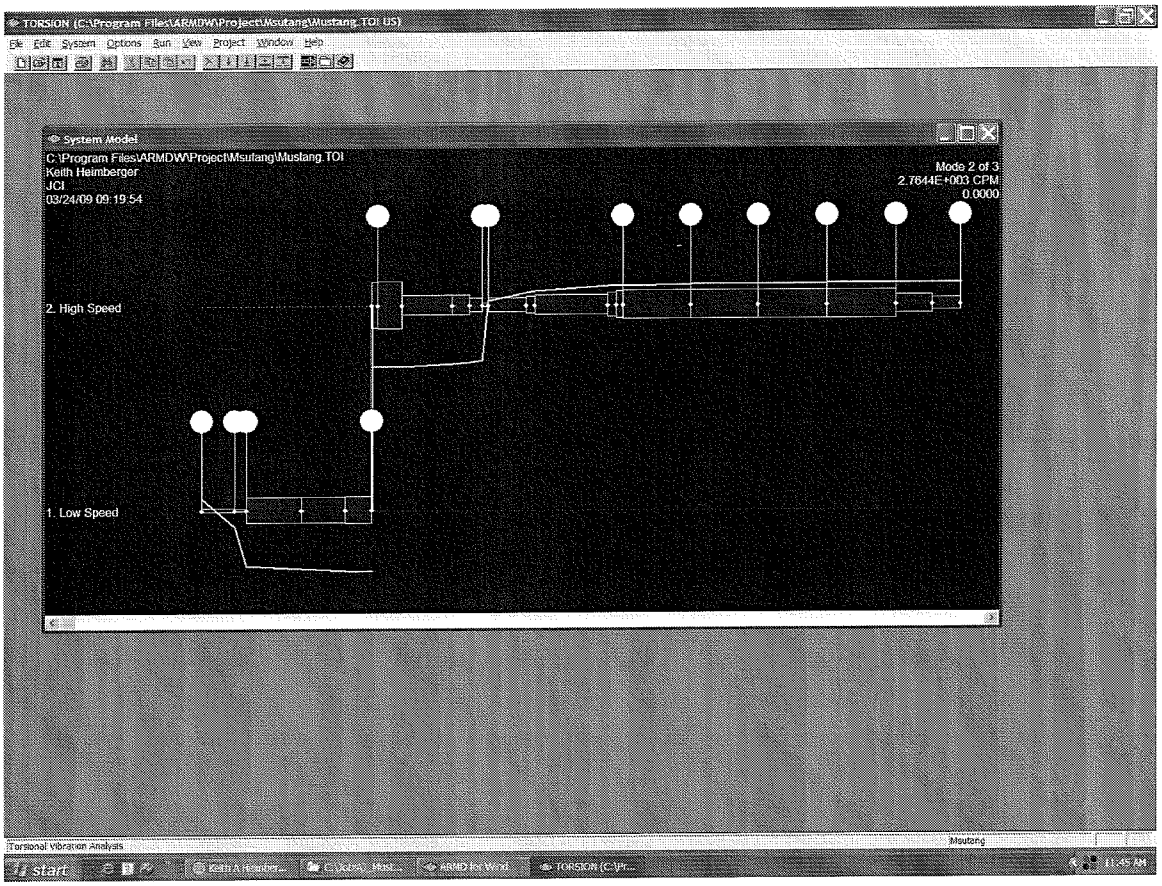

Mustang
Campbell Diagram
Natural Frequency (cpm)
Speed (rpm)
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
compressor
speed +/- 10%
motor
speed
+/- 10%
[f(3)= 17358 cpm]
2X
1X
f(2)= 2764 cpm
f(1)= 1224 cpm

Figure 2



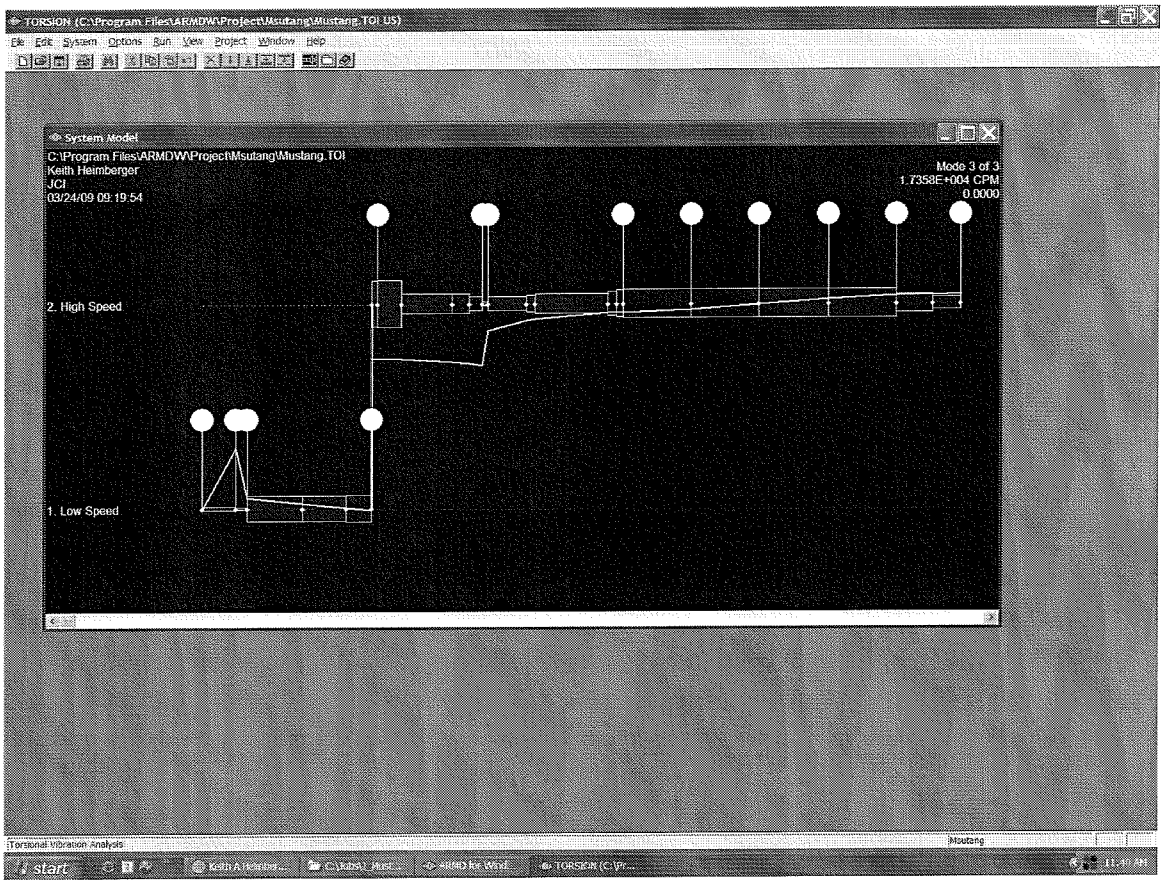
Mode 1, Natural Frequency = 1224 CPM

Figure 3



Mode 2, Natural Frequency = 2764 CPM

Figure 4



Mode 3, Natural Frequency = 17358 CPM

Figure 5