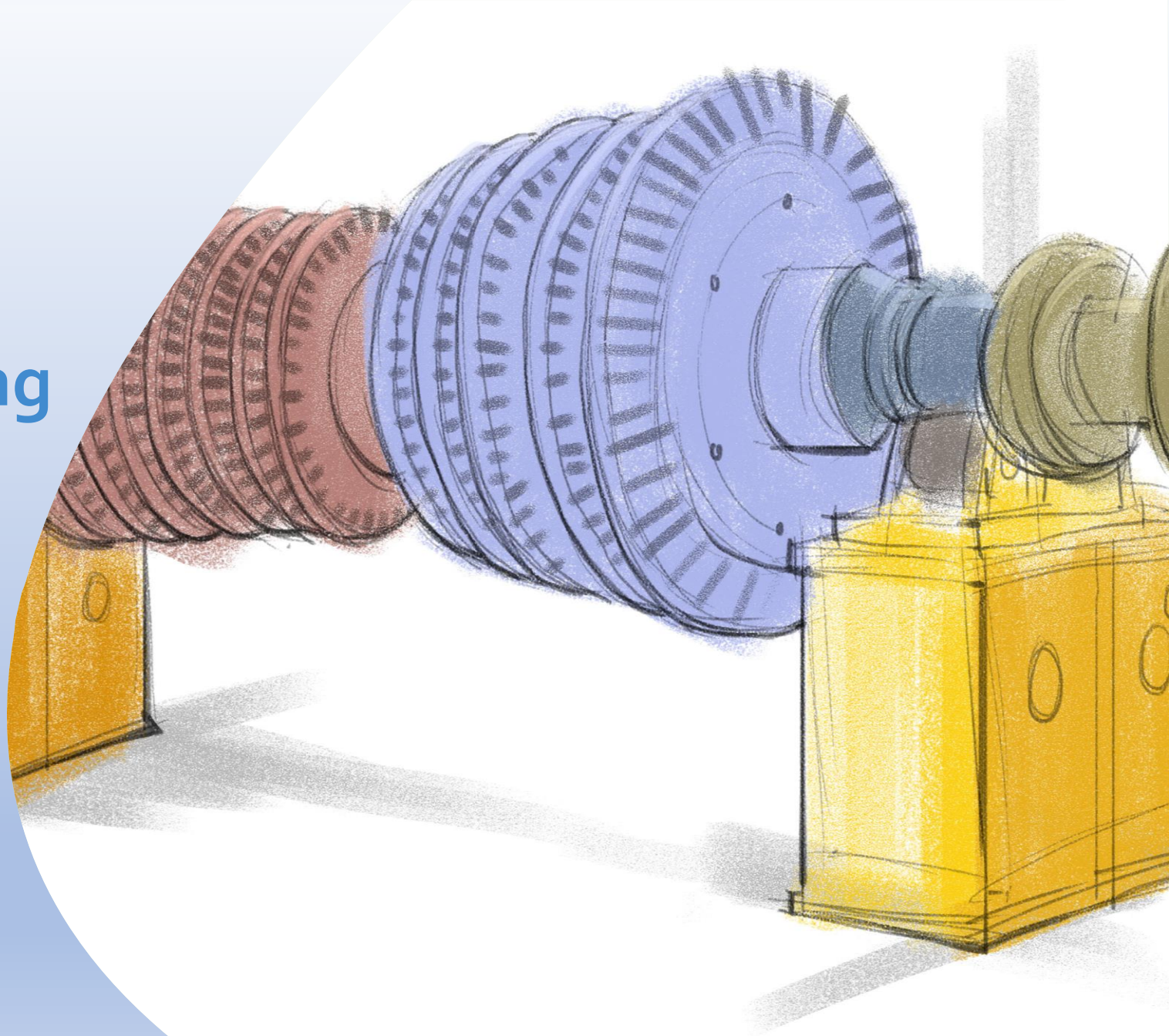
MCS Machinery Consultation Services

Steam Turbine On-site Balancing Using Emerson CSI 2140

By
Salah Attia



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Brotherhood Steam Turbine 25MW

The turbine bearings vibration spectrum shows high amplitude vibration at the running speed of 1X (5478 CPM) at both turbine drive end and non-drive end bearings, especially in the horizontal (X) direction, 1X Vibration appears in the vertical(Y) direction too, but with lower amplitude.

Turbine Speed = 5478 Rpm
Generator Speed = 1500 Rpm
Number of holes on the right side = 16
Number of holes on the left side = 12
The angle between holes for the right side = 22.5
The angle between holes for the left side = 30
Balancing Type = Two Plane Balancing

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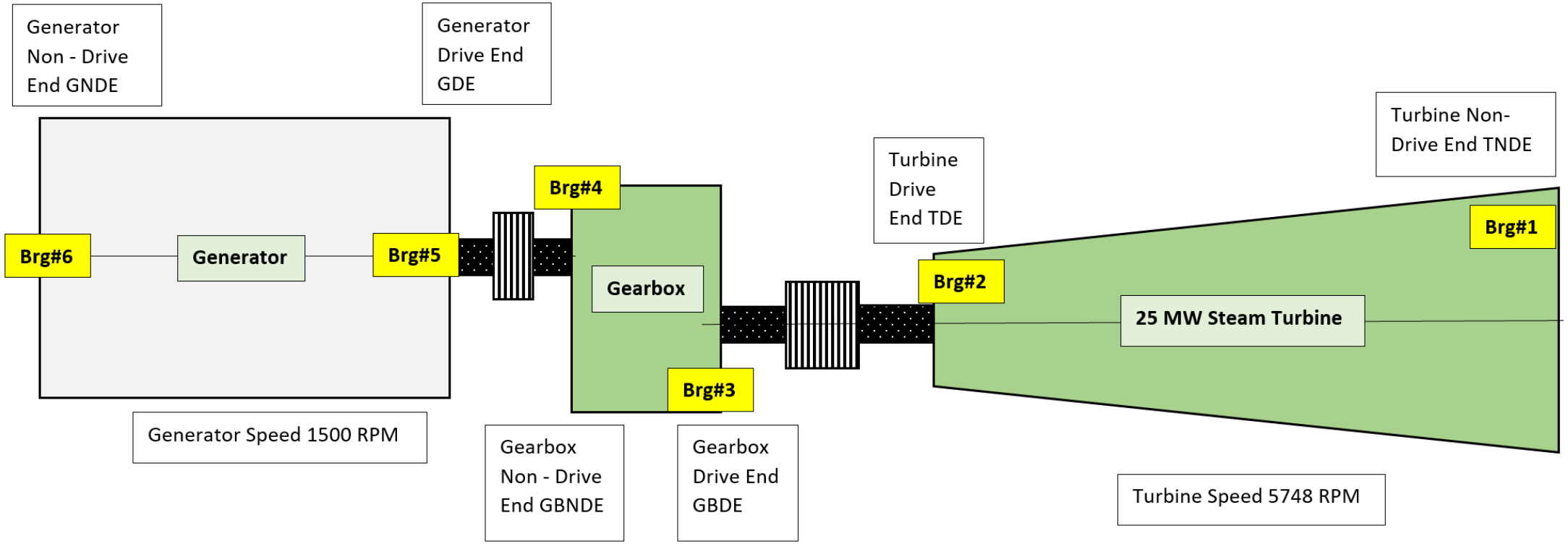
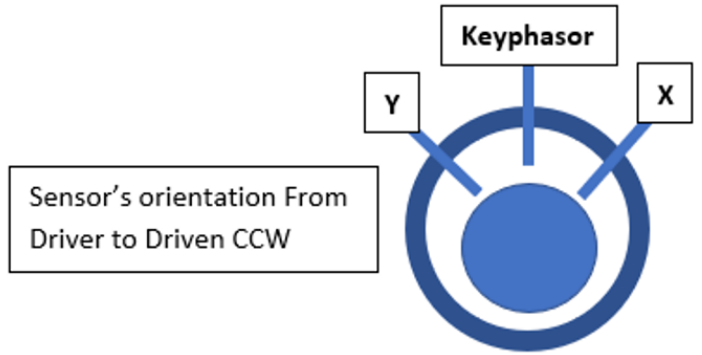
Machine Layout





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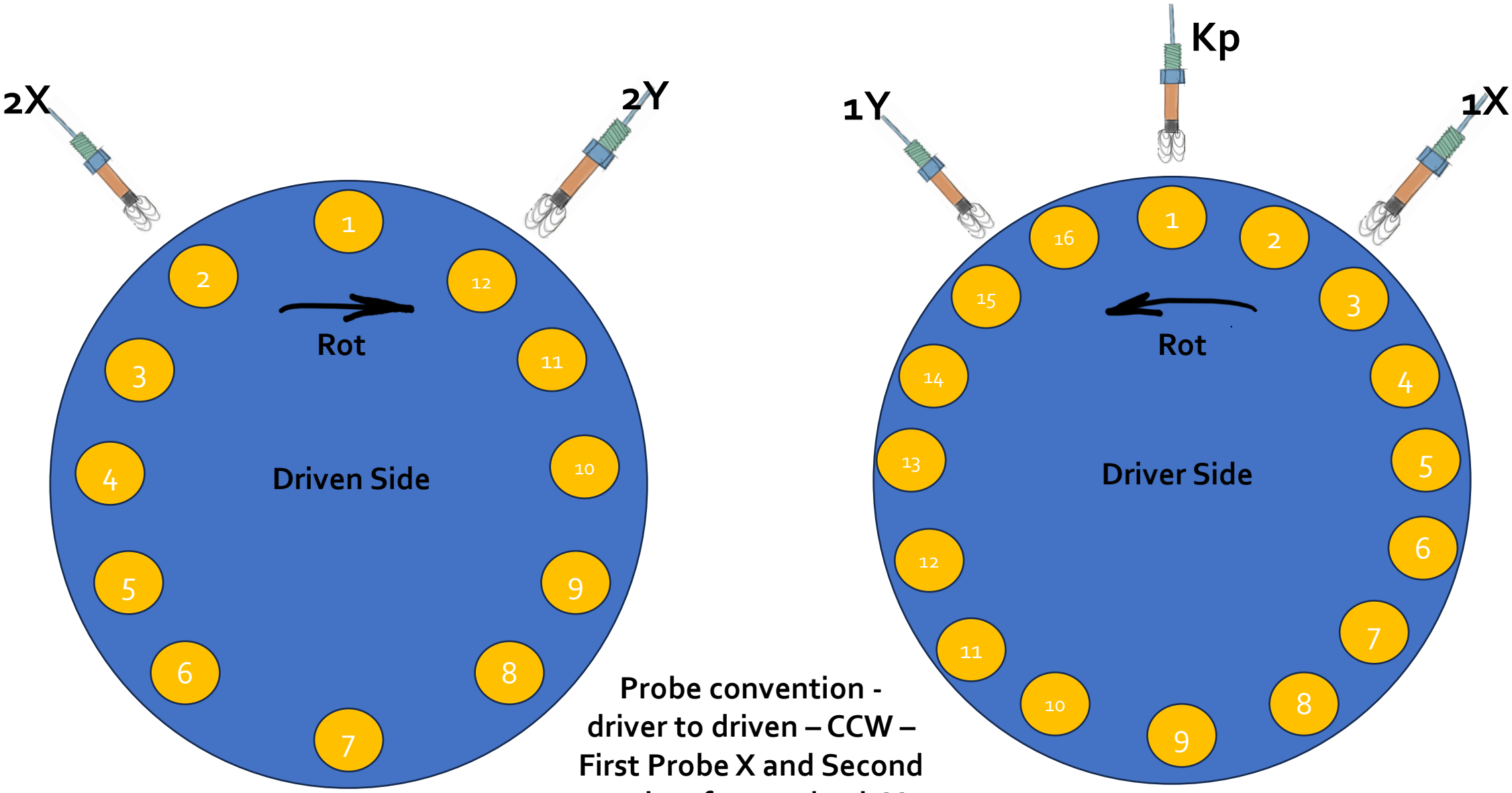

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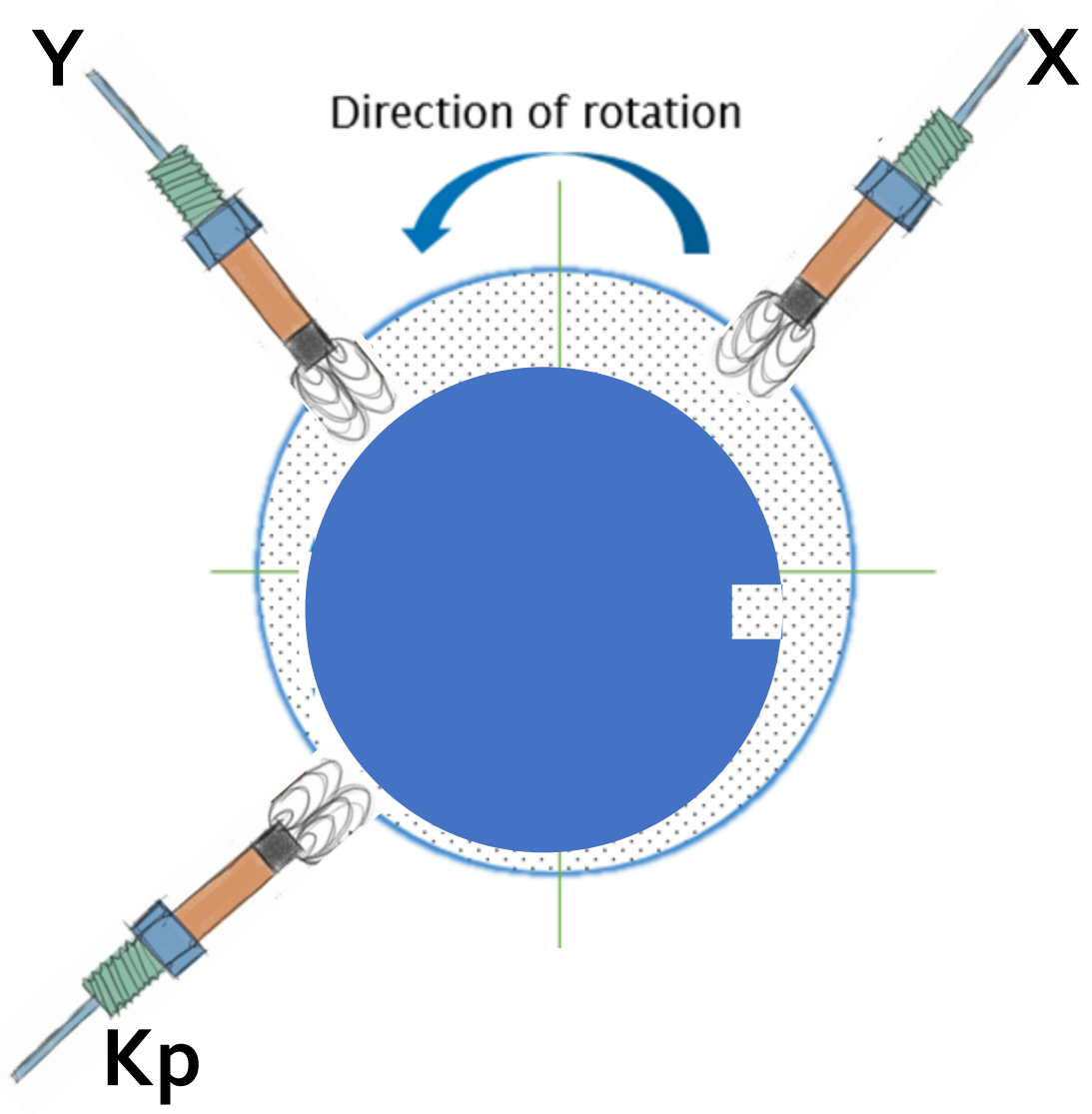
Transducer Convention

- The Common convention used which describes the transducers' locations on a machine is done by viewing the machine from the diver to the driven side and the Y probe will be 90 90-degree counter-clockwise X probe.

- The X probe represents the horizontal direction, and the Y probe represents the vertical direction.



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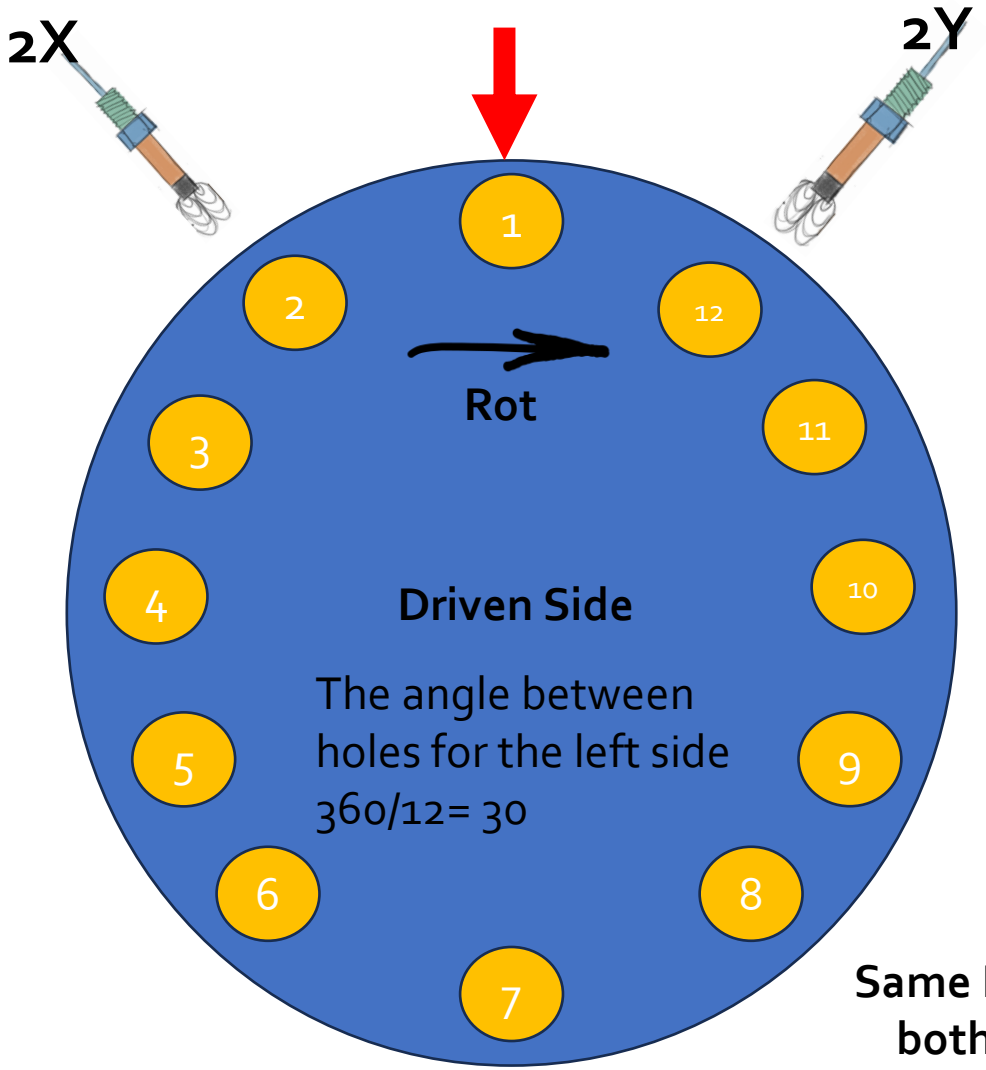
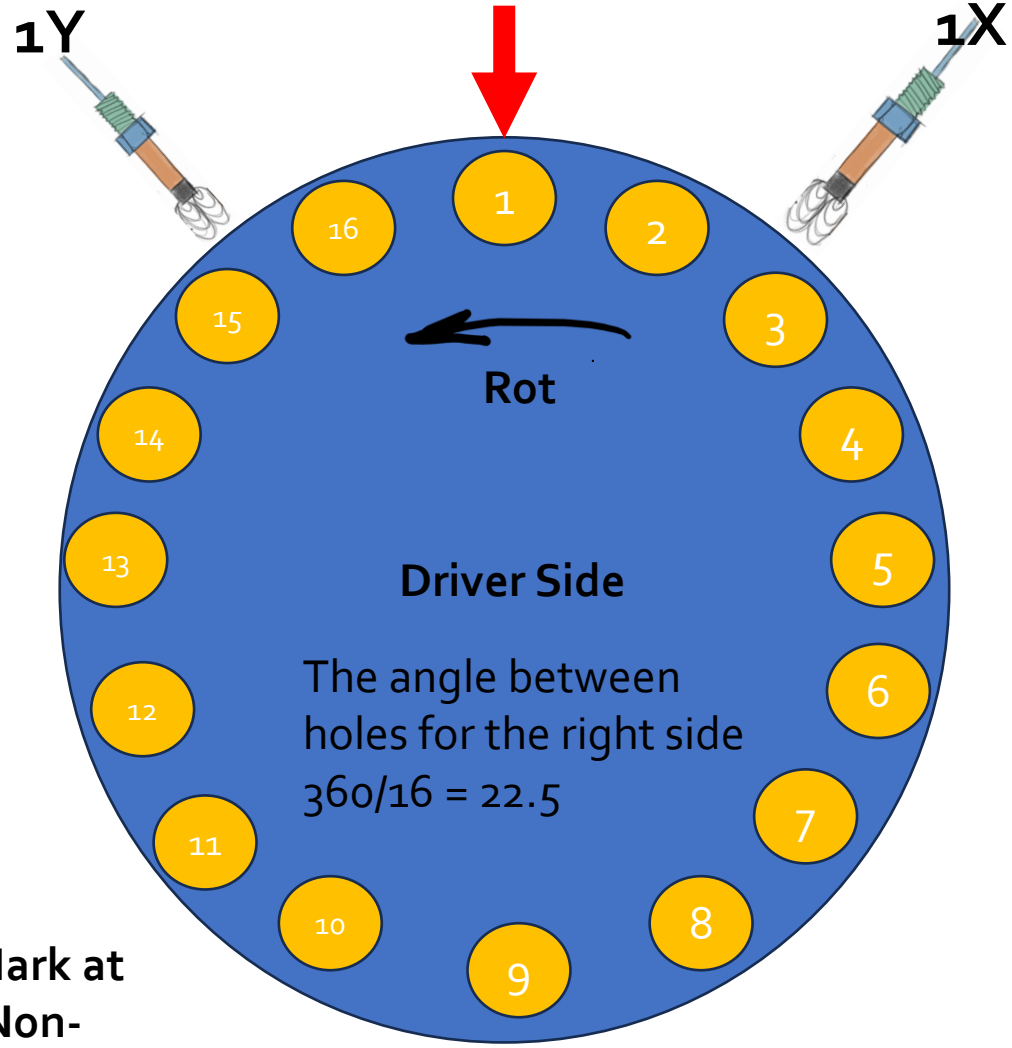


Turbine Drive End

Same Reference Mark at both Drive and Non-Drive Ends



Turbine Non - Drive End

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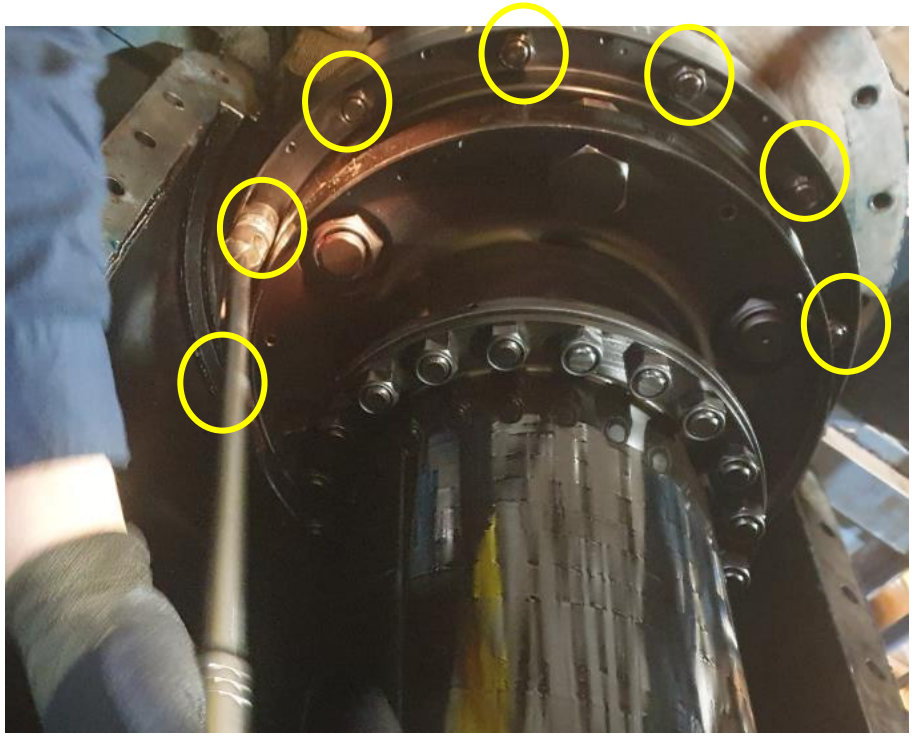
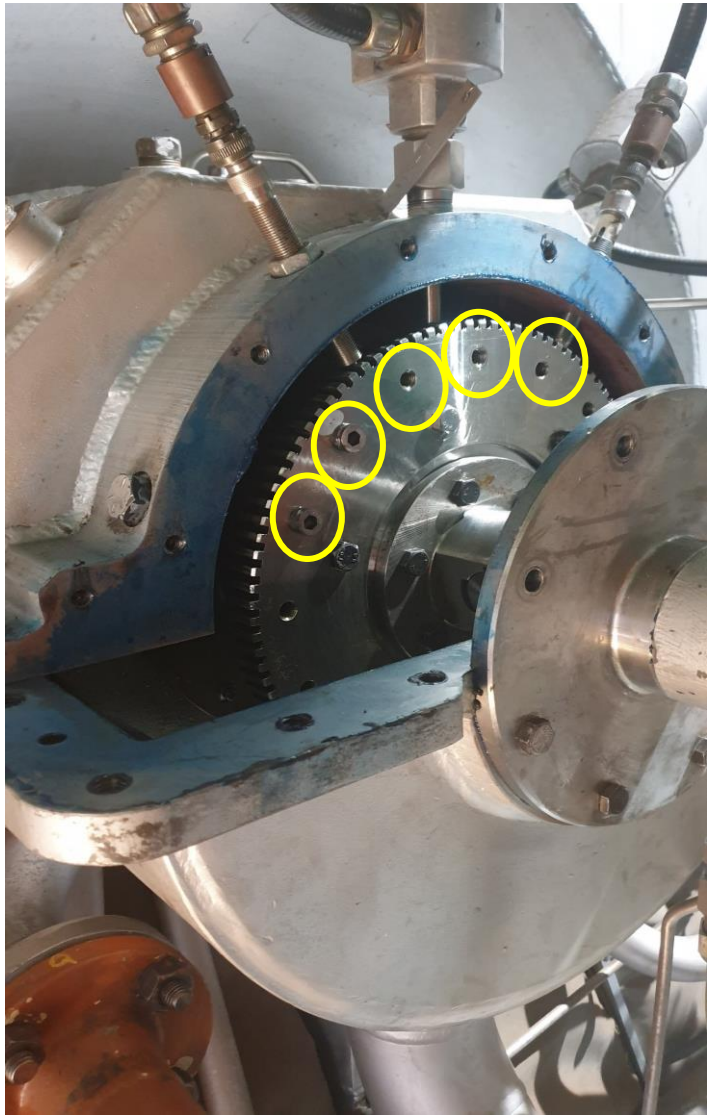


Turbine Drive End

Balancing Weight Location



Turbine Non - Drive End

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The data were collected using the CSI 2140 from the proximity probes via the BNC connection, as shown in the photo. The turbine had five proximity probes: two for the drive end, two for the non-drive end, and one key phasor for the speed reference, as seen in the photo.

Proper setup for the job is crucial to collect accurate data; without it, everything might go wrong.

- Amplitude units: Microns or mils P-P
- Sensor sensitivity: 0.0078 V/EU
- Tacho voltage should be set to -12 DCV
- Run-up data (polar plot and Bode plot) must be collected
- Checking for critical speeds is very important
- Slow roll vibration data should be collected for compensation

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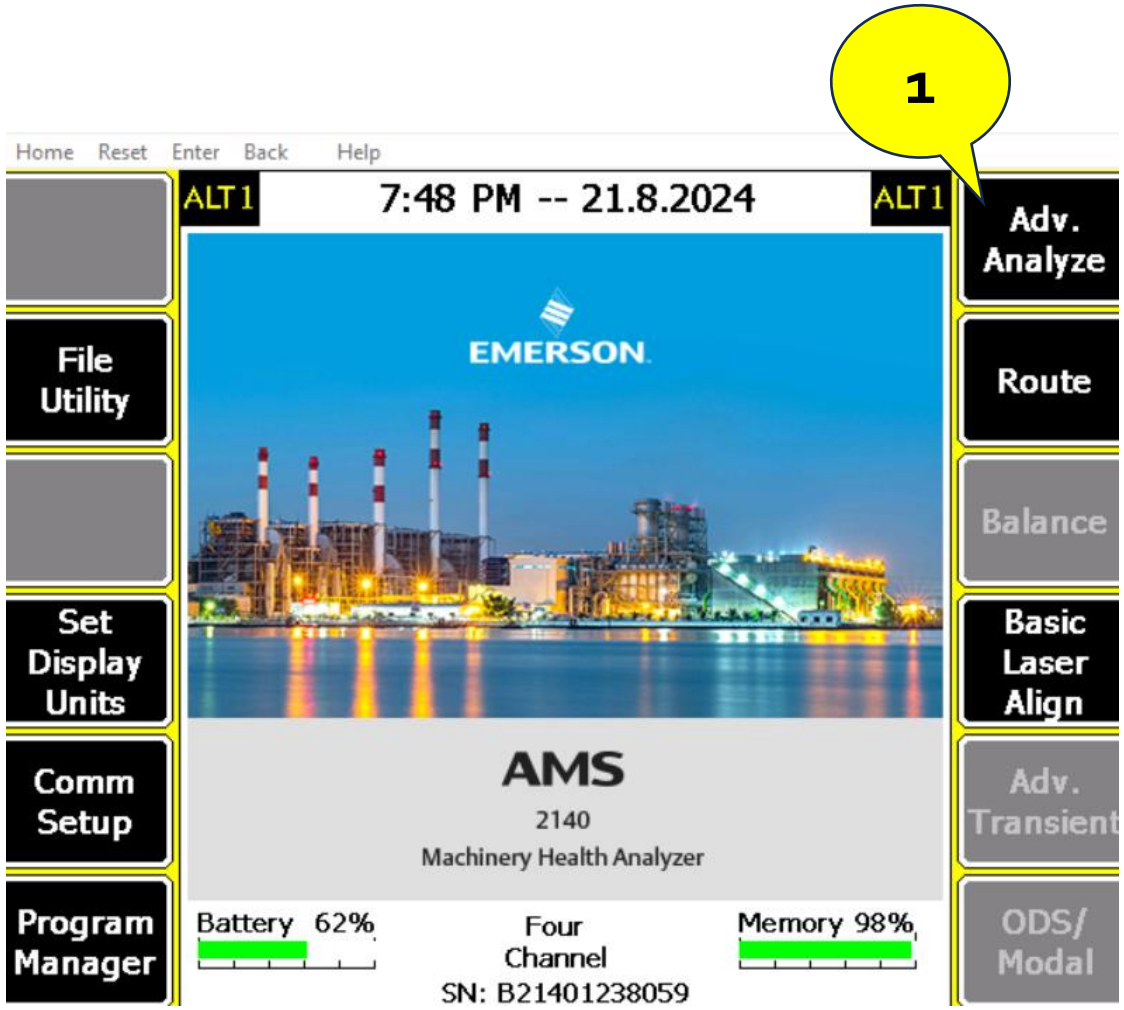

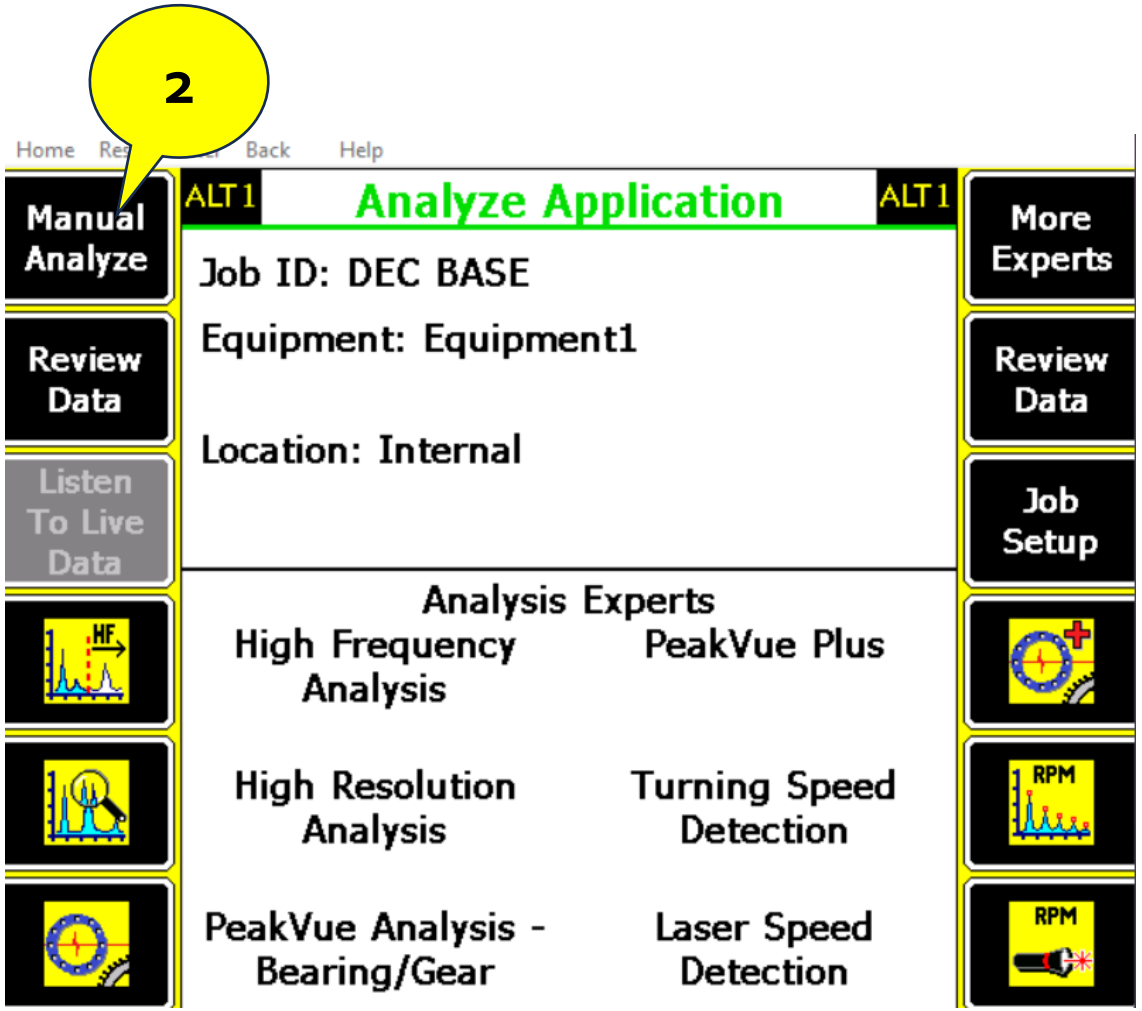

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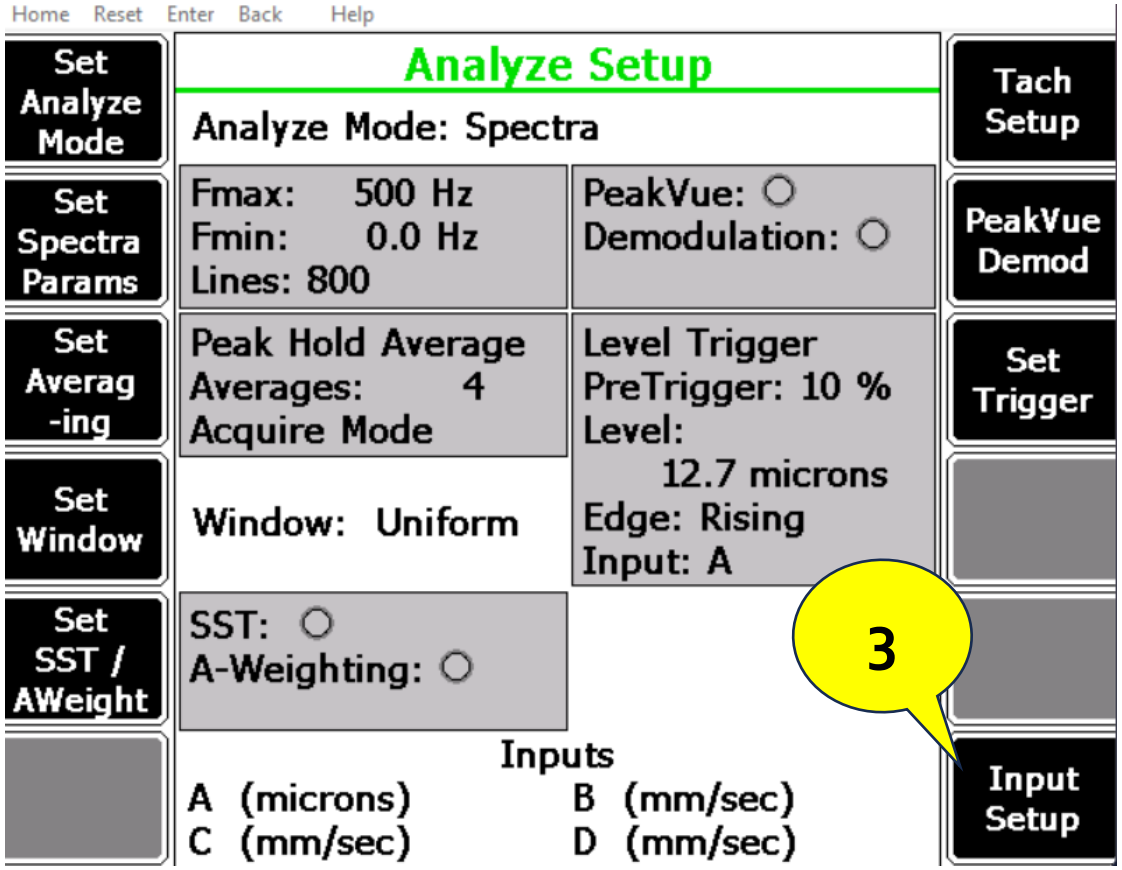

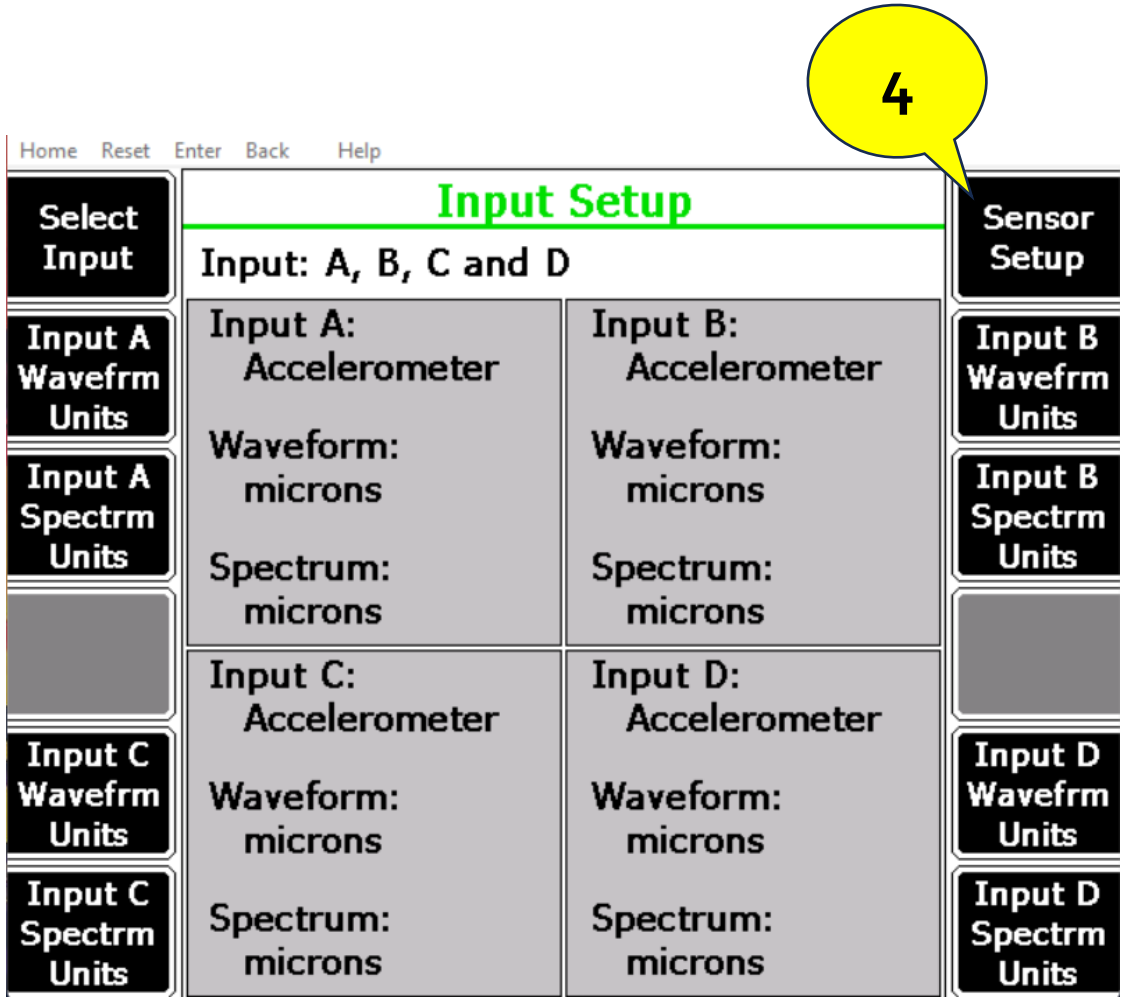

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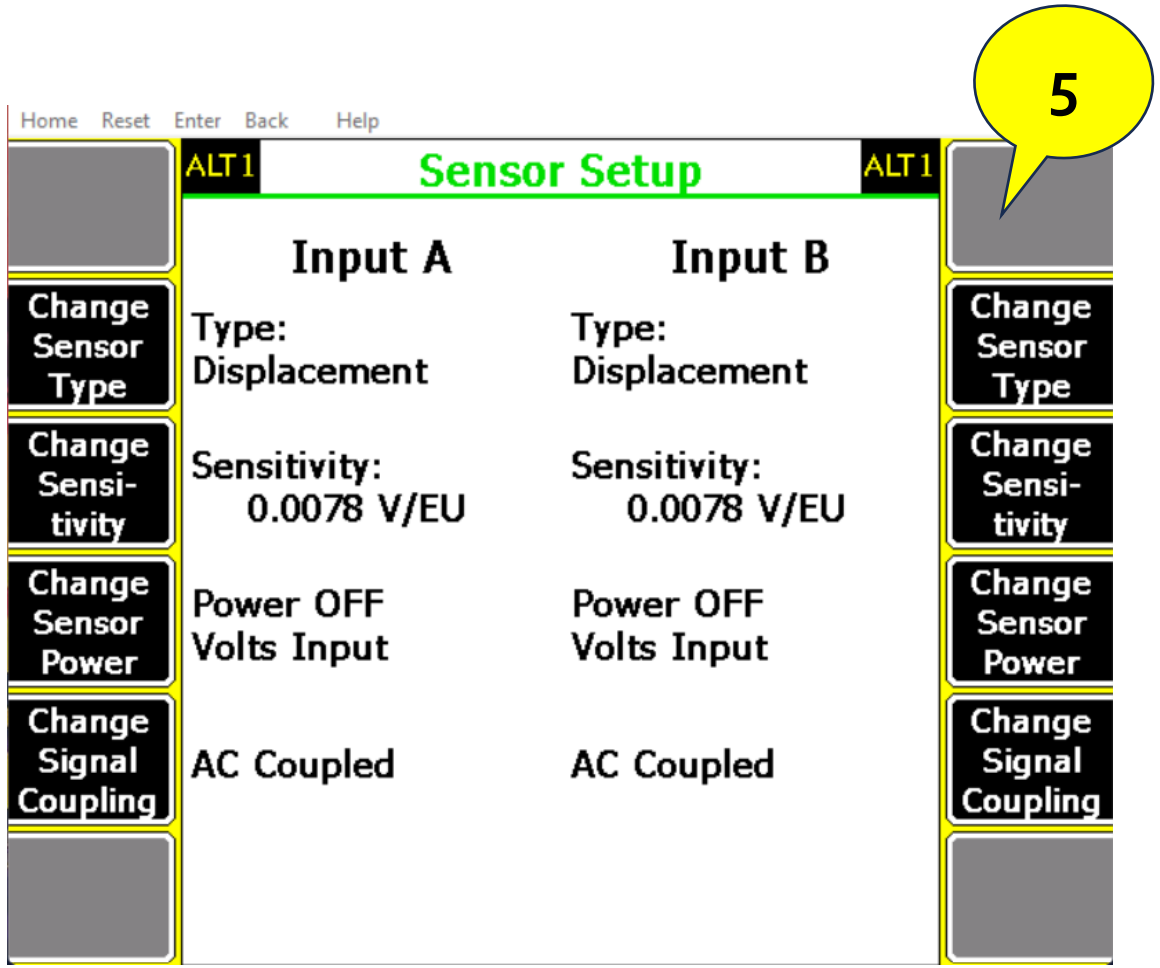

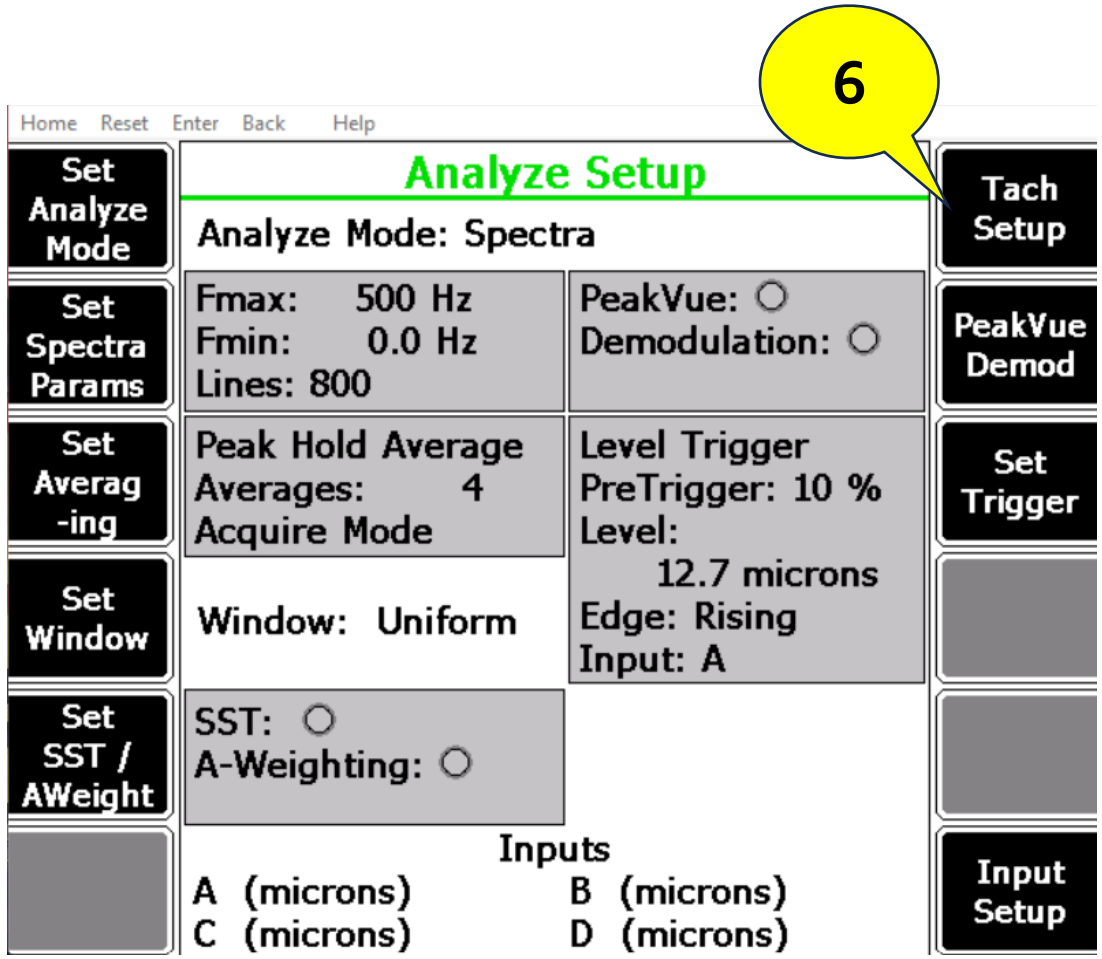

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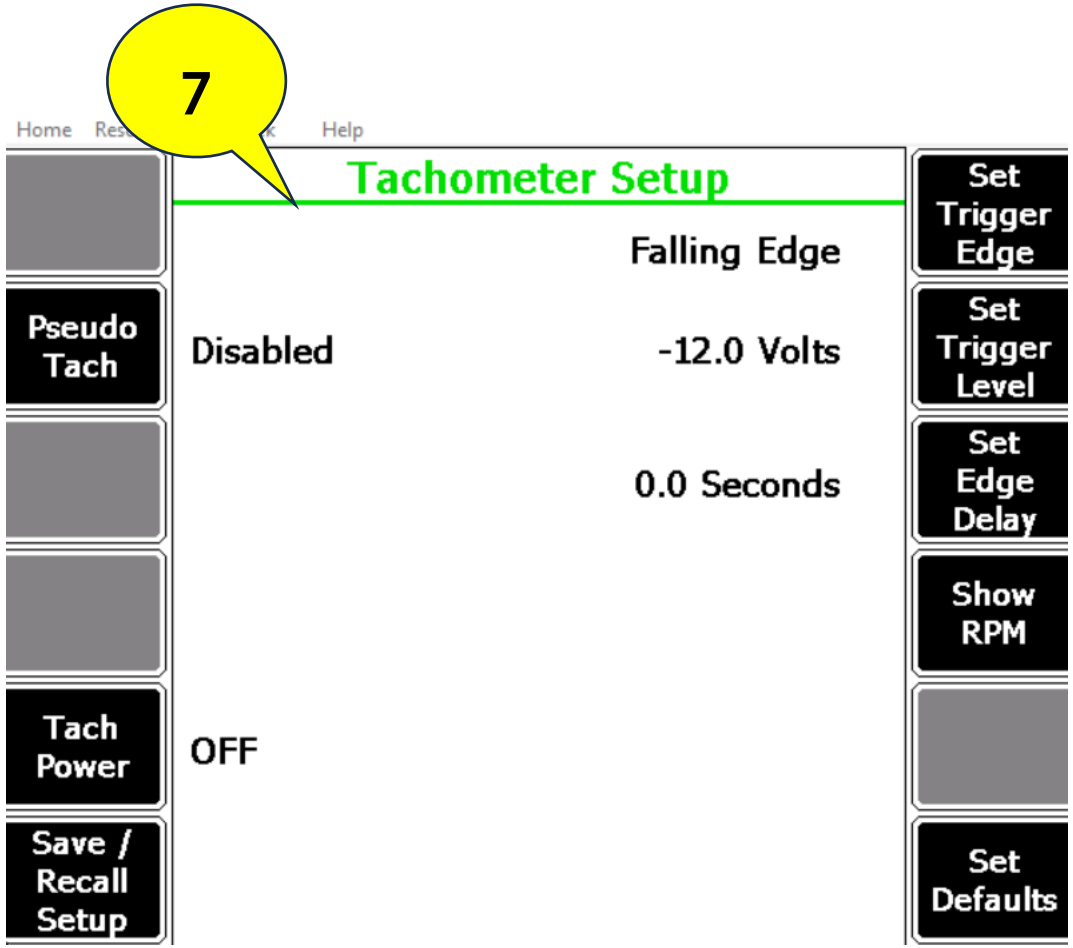

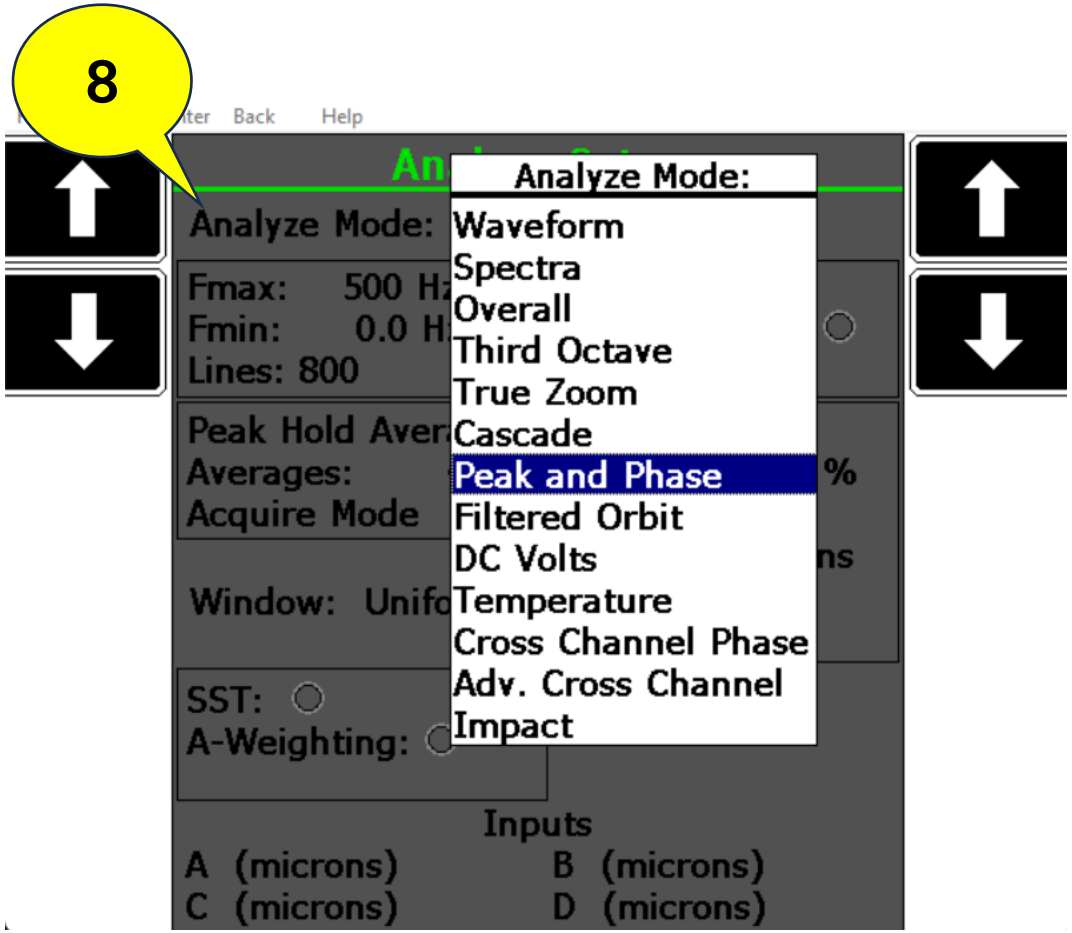

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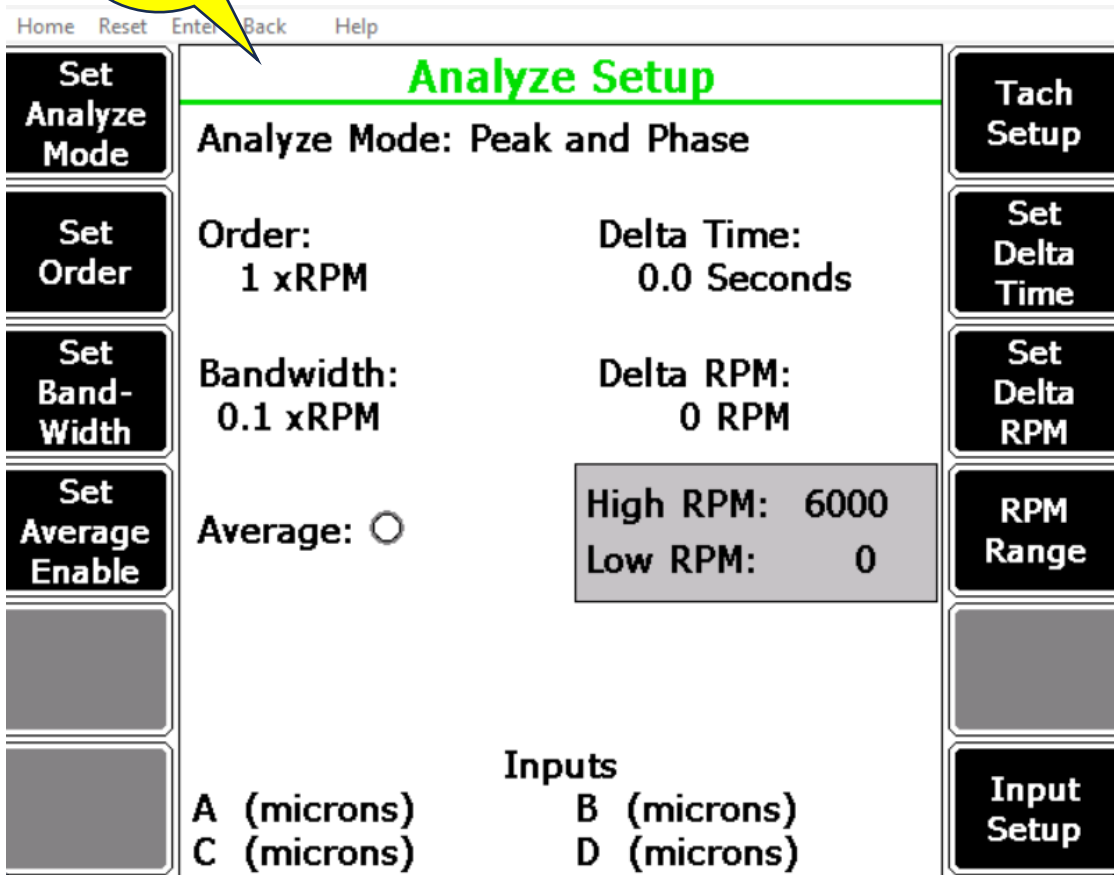

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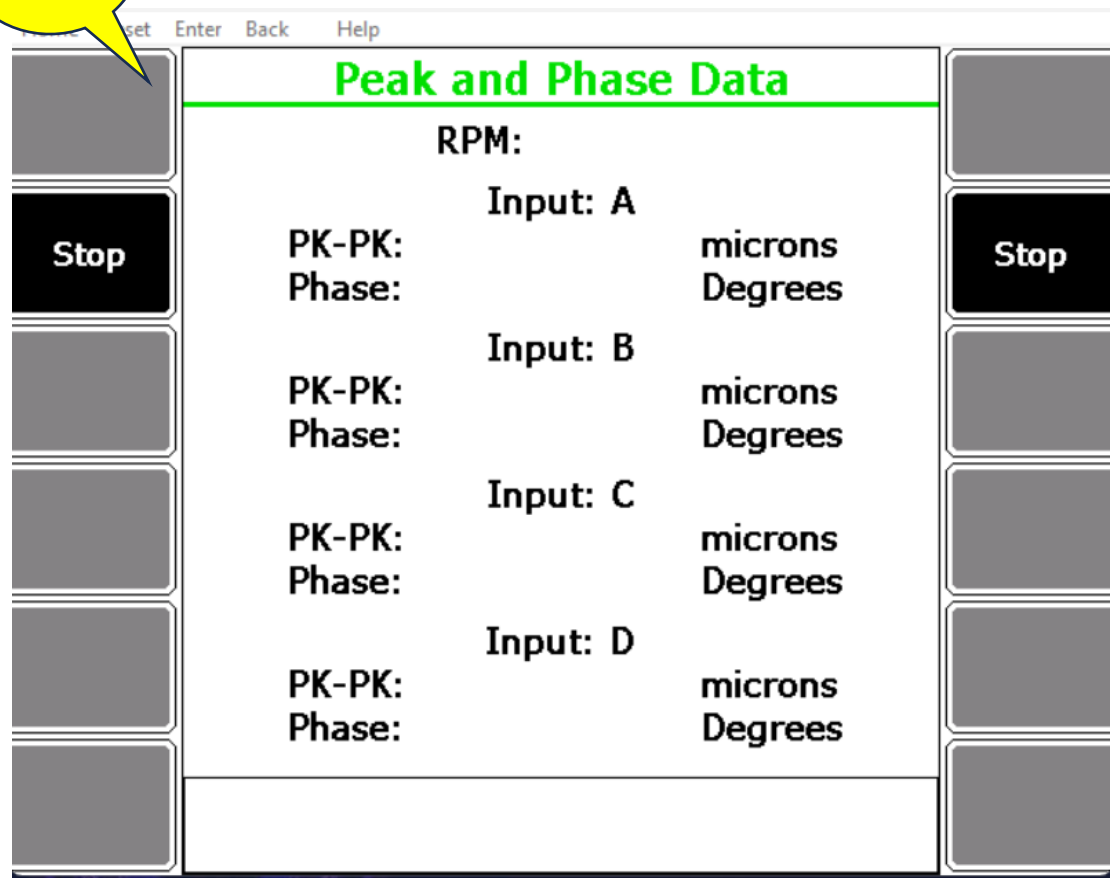

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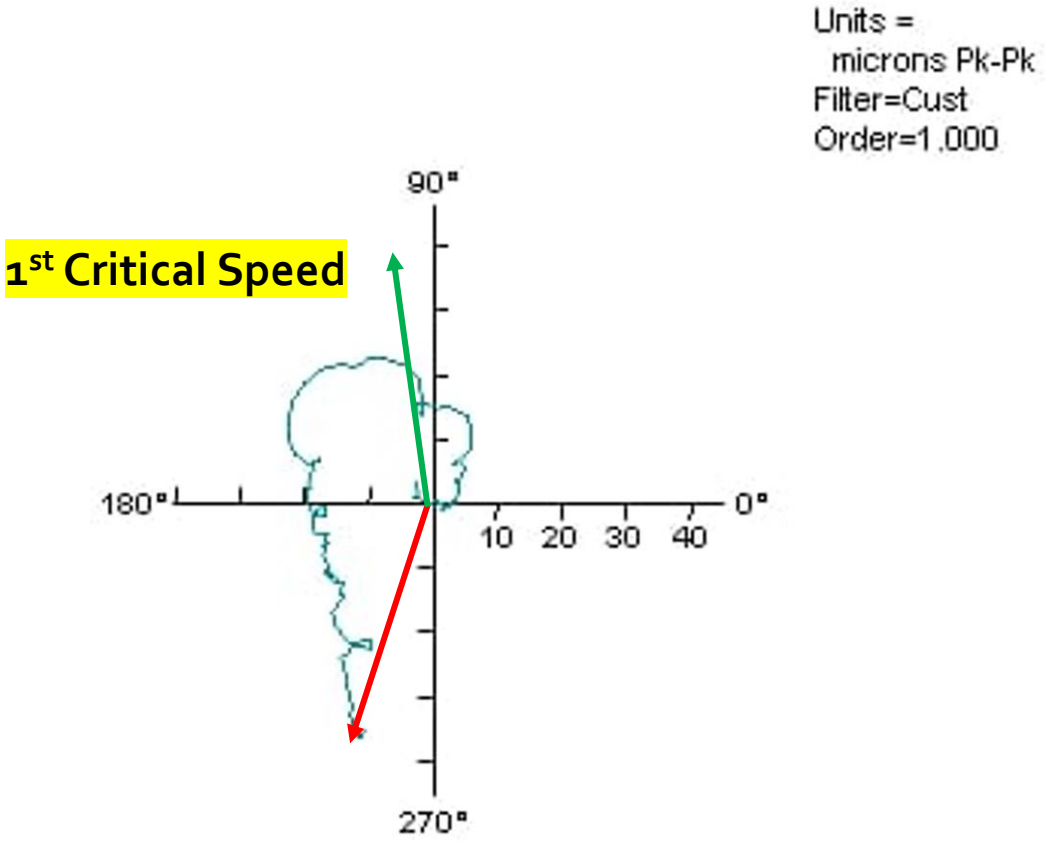
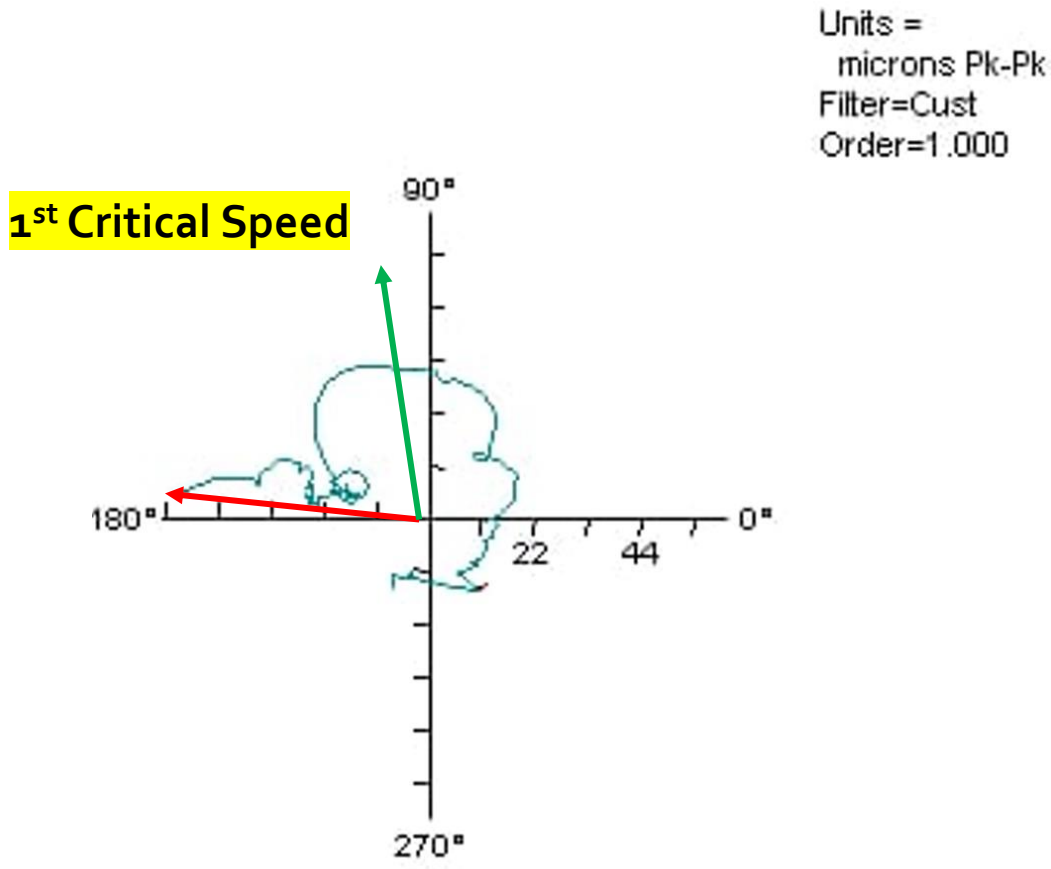
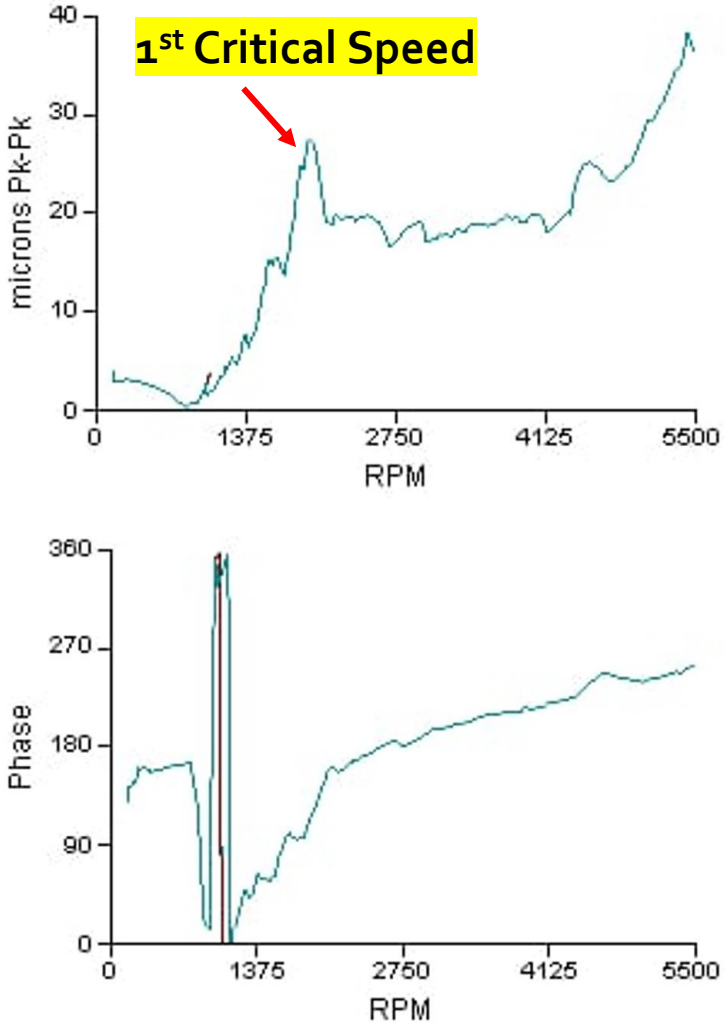


Turbine Drive End – 2X Polar Plot

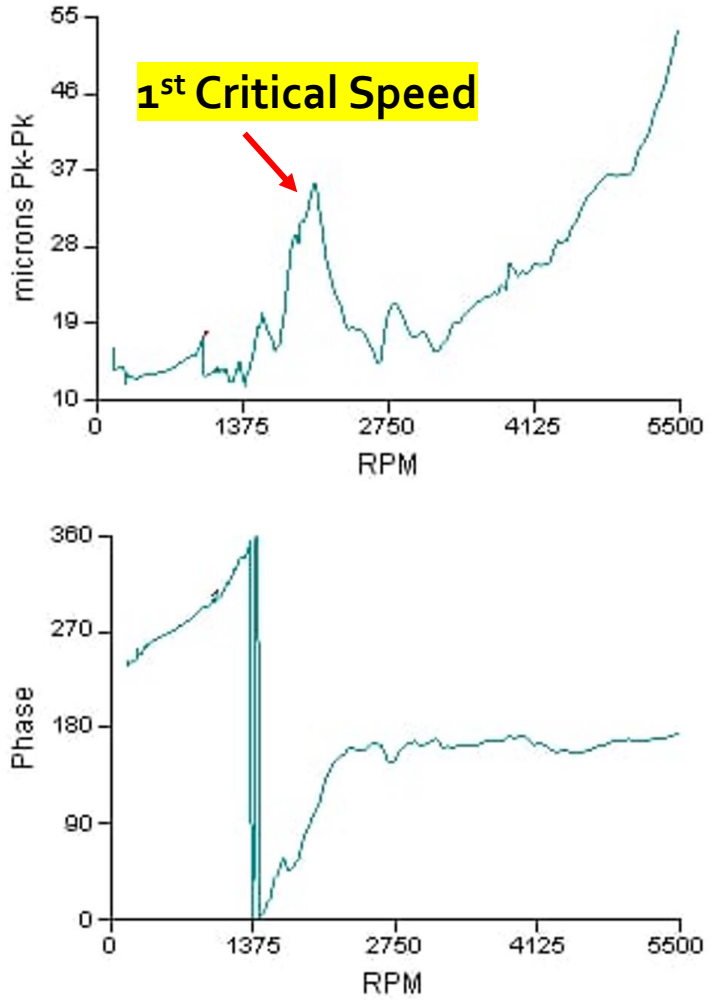


Turbine Non - Drive End – 1X Polar Plot

On-site Balancing – Steam Turbine Using Emerson CSI 2140



Turbine Drive End – Bode Plot



Turbine Non - Drive End – Bode Plot

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Initial Vibration readings

Location	1X Vibration	Phase	Speed
TNDE – 1X	65 um PP	173°	5480 rpm
TNDE – 1Y	87 um PP	299°	5480 rpm
TDE – 2X	42 um PP	261°	5480 rpm
TDE – 2Y	75 um PP	166°	5480 rpm

1st Trail Weight Readings on the right side (100 gm @ 202.5 deg)

Location	1X Vibration	Phase	Speed
TNDE – 1X	26 um PP	166°	5480 rpm
TNDE – 1Y	72 um PP	292°	5480 rpm
TDE – 2X	40 um PP	244°	5480 rpm
TDE – 2Y	26 um PP	3°	5480 rpm

Turbine Non - Drive End

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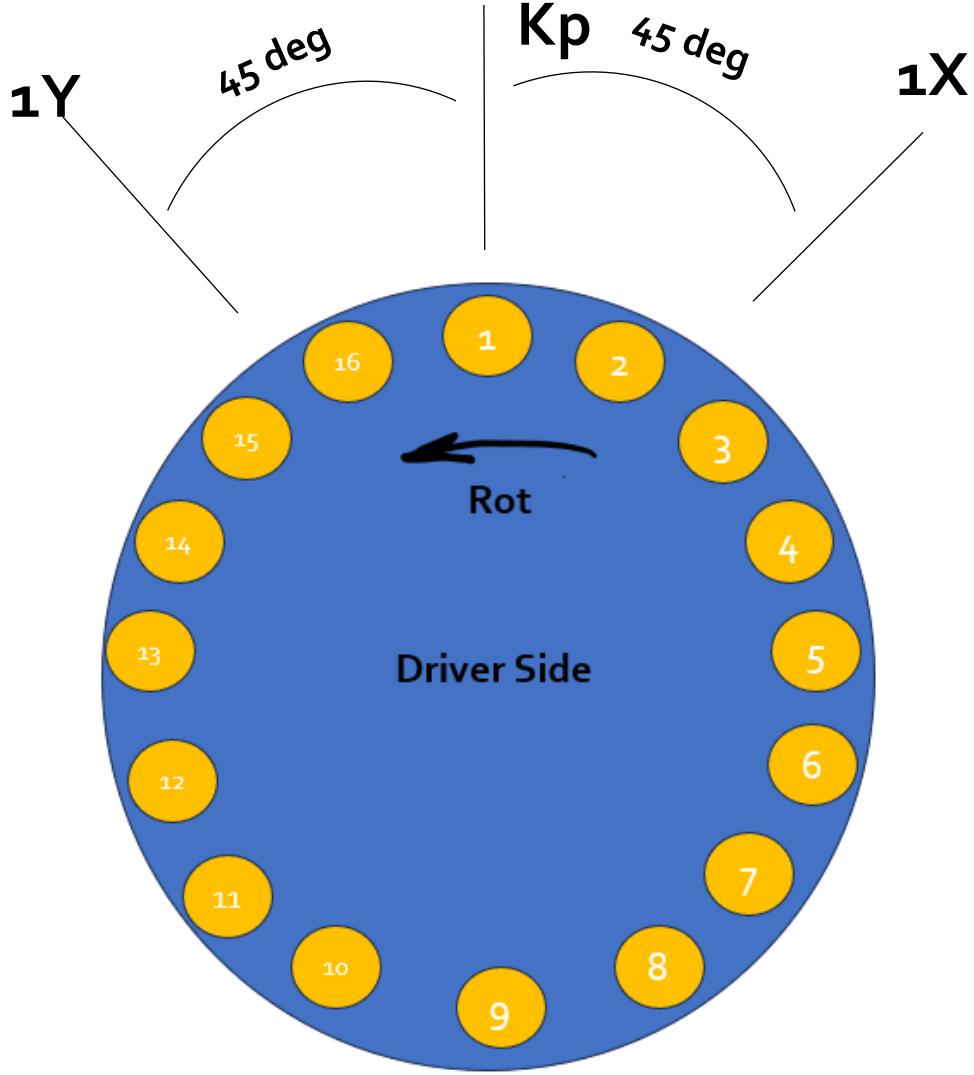
1st Trail Weight Location

Location	1X Vibration	Phase	Speed
TNDE – 1X	55 um PP	173°	5480 rpm

1st Trail Weight Readings on the right side (80gm @ 202.5 deg)

Rotate the 1X probe 45° to the left, in the same direction as the shaft rotation, to compensate for the angle difference by adding 45° to the measured phase value.

As we run above the critical speed, so the heavy spot and high spot are out of phase approximately 180 deg, and the location of our trail weight should be very close to high spot location.



Turbine Non - Drive End

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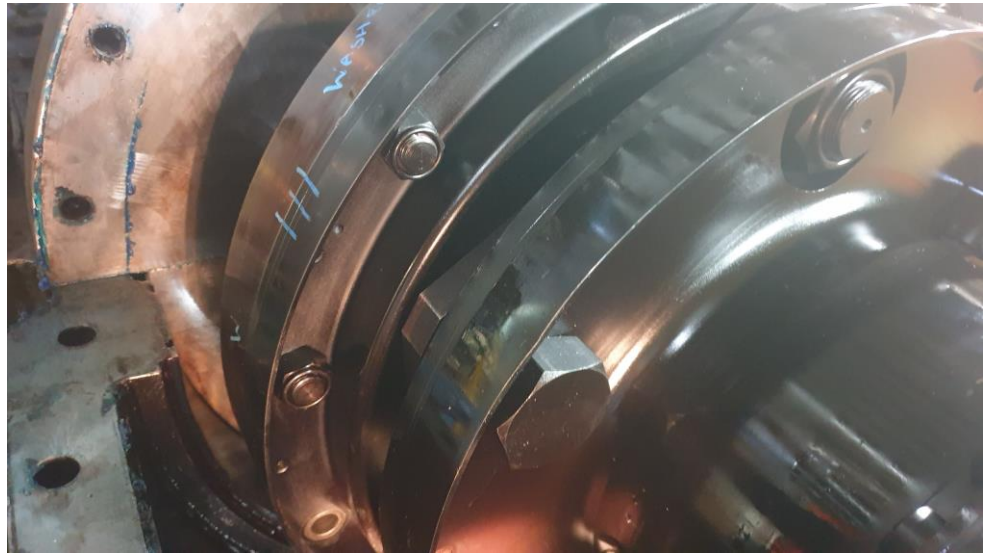
Initial Vibration readings

Location	1X Vibration	Phase	Speed
TNDE – 1X	65 um PP	173°	5480 rpm
TNDE – 1Y	87 um PP	299°	5480 rpm
TDE – 2X	42 um PP	261°	5480 rpm
TDE – 2Y	75 um PP	166°	5480 rpm

2nd Trail Weight Readings on the left side (50gm @ 300 deg)

Location	1X Vibration	Phase	Speed
TNDE – 1X	25 um PP	274°	5480 rpm
TNDE – 1Y	13 um PP	40°	5480 rpm
TDE – 2X	12 um PP	229°	5480 rpm
TDE – 2Y	73 um PP	141°	5480 rpm



Turbine Drive End

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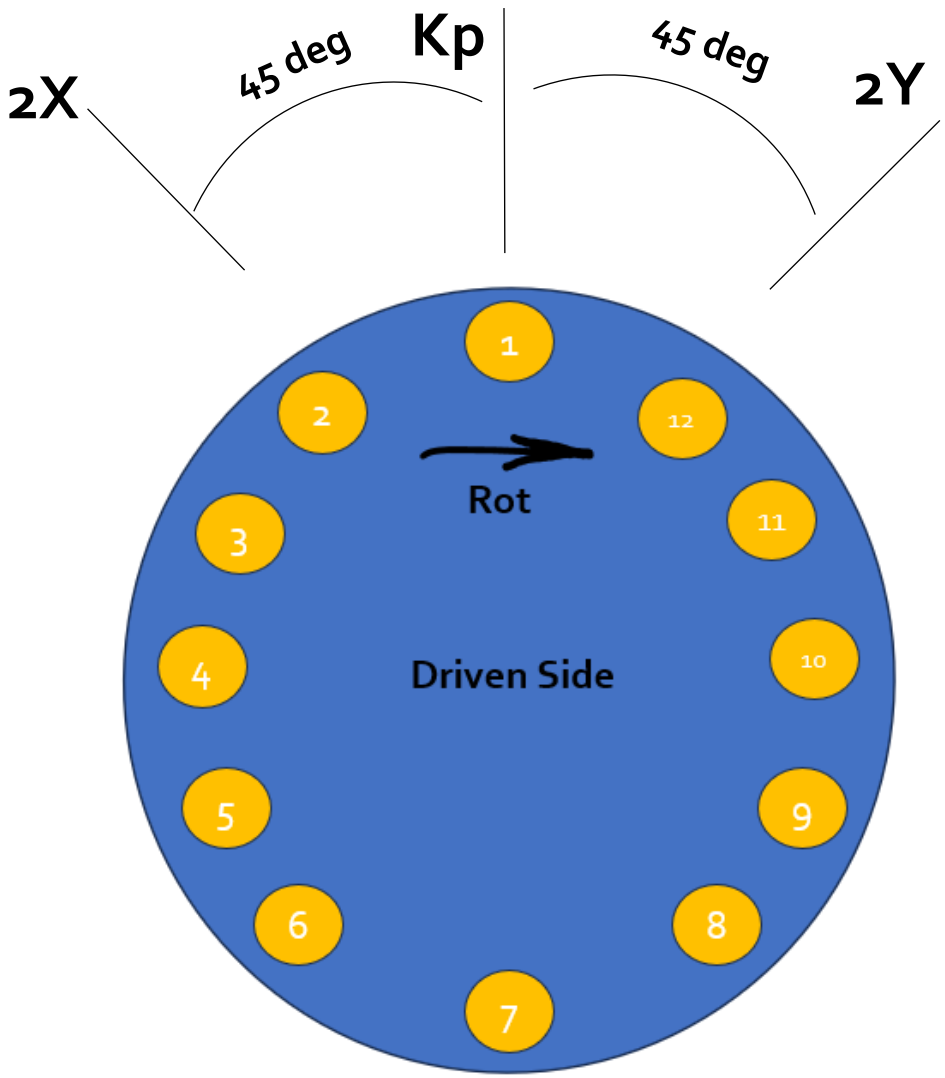

Turbine Drive End

2nd Trail Weight Location

Location	1X Vibration	Phase	Speed
TDE – 2X	42 um PP	261°	5480 rpm

2nd Trail Weight Readings on the left side (50gm @ 300 deg)

Rotate the 2X probe 45° to the right, in the same direction as the shaft rotation, to compensate for the angle difference by adding 45° to the measured phase value.

As we run above the critical speed, so the heavy spot and high spot are out of phase approximately 180 deg, and the location of our trail weight should be very close to high spot location.

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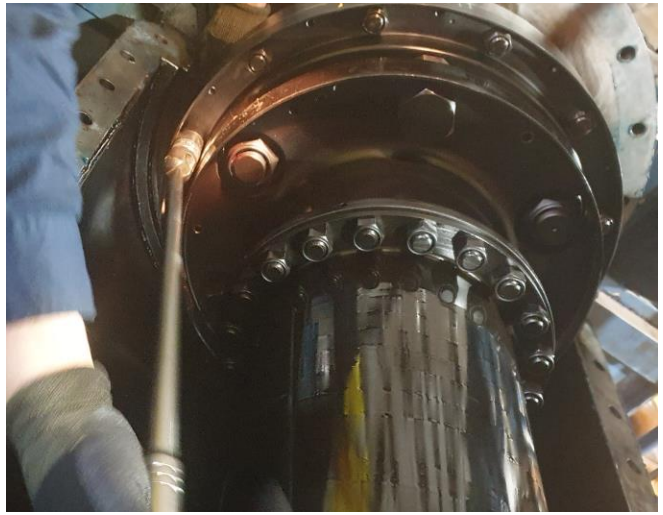
Initial Vibration readings

Location	1X Vibration	Phase	Speed
TNDE – 1X	65 um PP	173°	5480 rpm
TNDE – 1Y	87 um PP	299°	5480 rpm
TDE – 2X	42 um PP	261°	5480 rpm
TDE – 2Y	75 um PP	166°	5480 rpm

Correction weights Readings
(217 gm @ 352 deg on Right Side) – (99 gm @ 300 deg on Left Side)

Location	1X Vibration	Phase	Speed
TNDE – 1X	14 um PP	48°	5480 rpm
TNDE – 1Y	18 um PP	192°	5480 rpm
TDE – 2X	12 um PP	139°	5480 rpm
TDE – 2Y	16 um PP	264°	5480 rpm



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Metric Units		Vertical Y-Axis Probe Calculations					
		Probe # 1VD			Probe # 2VD		
		Mag.*	@	Angle	Mag.*	@	Angle
INPUT:							
Slow Roll	E1=	0.00	@	0	0.00	@	0
Initial Vibration	A1=	42.00	@	261	65.00	@	173
Calib. Wt. @ Plane	B11=	12.00	@	229	25.00	@	274
Calib. Wt. @ Plane	B12=	40.00	@	244	26.00	@	166
Calib. Weights	W1=	50.00	@	300	100.00	@	202
CALCULATED:							
Runout Compensated Vibration Vectors	A1c=	42.00	@	261	65.00	@	173
	B11c=	12.00	@	229	25.00	@	274
	B12c=	40.00	@	244	26.00	@	166
Response from Calibration Weights	C11=	32.45	@	92	73.96	@	334
	C12=	12.28	@	153	39.32	@	358
Equiv. Cal. Wt. Add	W1e=	50	@	300	100	@	202
Unbalance Sens. µMeters$_{pp}$/Gram	S11=	0.649	@	152	1.479	@	34
	S12=	0.123	@	311	0.393	@	156
Unbalance Sens. Grams/µMeters$_{pp}$	*S11=*	*1.54*	@	*208*	*0.68*	@	*326*
	S12=	*8.14*	@	*49*	*2.54*	@	*204*
INITIAL RESULTS:							
Unbalance	U1=	99	@	125	217	@	172
Weight Add	Wa1=	99	@	305	217	@	352

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Balancing Weights