CalWind Resources Inc.

September 17-18 2007

Condition Monitoring Experience

by Jon Powers

CalWind Projects: Wind Resource 1 Tehachapi, California

- 134 @ Nordtank 65/13 wind turbines installed 1984-85
- All wind turbines in current operation
- 9 Megawatt Facility

Nordtank 65/13

Wind Resource 2 – Tehachapi, California

- 200+ @ Bonus 65/13 wind turbines installed 1983 to 1985
- Purchased & Operated by CalWind since 1997
- 22 Megawatt Facility

Bonus 65/13

Condition Monitoring Turbines

- 13 @ 600+ KW wind turbines
- Operating for 4+ years
- Condition Monitoring for 1 year

600+ KW Wind Turbine

Oil Sampling and Trending

Herguth Laboratories, Inc.
People and Data You Can Count On!

101 Corporate Place, Vallejo, CA 94590

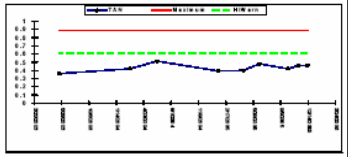
ABNORMAL

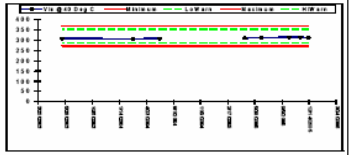
Page 1
12/14/05
08:04:59

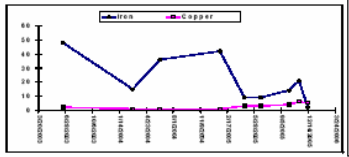
Unit Type : Gear (GN_GR001) GN_GR001
Oil Type : Texaco Meropa 320 ISO VG 320 (TE_136) TE_136 P.O. : B6248
Sampled : 12/12/05 Shipped : 12/12/05 Received: 12/13/05 Printed: 12/14/05

ABNORMAL: Abnormal results for oil are present. Equipment appears satisfactory. The particle count is higher than desirable and/or acceptable. See enclosed Ferrographic Analysis for more detail. Check vibration data and/or perform other diagnostics to investigate the severity of the wear. Recommend purifying lubricant. Resample at half your regular interval.

Tehachapi, CA 93581-0604







Lab Number Sample Date	Minimum	Maximum	Ref Oil 06/09/04	T57985 04/21/05	T72660 05/21/05	T93900 10/03/05	U11806 11/10/05	U17576 12/12/05
Unit Time				1514	2911	18015	0	0
Oil Time				0	0	4202	0	0
Vis @40 Deg C mm	272.0	368.0	299.7	310.2	313.0	313.9	315.3	312.4
TAN mg KOH/g		0.89	0.33	0.40	0.48	0.42	0.46	0.46
Metals								
Iron ppm		150	<1	9	9	14	*21	2
Aluminum ppm		10	<1	<1	<1	<1	<1	<1
Chromium ppm		5	<1	<1	<1	<1	<1	<1
Copper ppm		50	<1	3	3	4	6	5
Lead ppm		75	<1	<1	1	<1	<1	<1
Tin ppm		5	<1	<1	<1	<1	<1	<1
Nickel ppm		5	<1	<1	<1	<1	<1	<1
Silver ppm		5.0	<1	<0.4	<0.4	<0.4	<0.4	<0.4
Silicon ppm		20	4	5	1	6	3	5
Sodium ppm			<3	<4	<4	<4	<4	<4
Boron ppm			<6	<3	<3	3	<3	15
Zinc ppm			2	6	8	12	11	4
Phosphorus ppm			324	339	298	368	238	264
Calcium ppm			1	<1	1	<1	1	24
Magnesium ppm			<1	<1	<1	<1	<1	1
Barium ppm			<1	<1	<1	<1	<1	9
Molybdenum ppm			<1	<1	<1	<1	<1	1
Potassium ppm			<5	<3	<3	<3	<3	4
Particle Count								
4-6 um /100 mL			28453	152432	142282	191111	2695135	3553724
6-10 um /100 mL			19955	20360	25105	50811	3408378	361111
10-14 um /100 mL			4970	2042	3694	7117	349219	7447
14-25 um /100 mL			2402	1201	2012	2553	8686	1952
25-50 um /100 mL			300	300	420	541	390	270
50-100 um /100 m			15	90	120	120	30	90
> 100 um /100 mL			0	90	90	60	0	30
ISO Contam Code		17/15/12	16/15/12	*18/15/11	*18/15/12	*19/16/12	*23/22/14	*22/19/12
Water by KF ppm		250	18	13	17	<10	25	16
DR Ferrography								

Evaluated By: David F. Frycki, CLS - Certified LS - For questions about this report, please call 888-437-4884. Code :CALWIN Calwind Inc. Phone :(661) 822-7640 Fax :(661) 822-3262
These results are submitted pursuant to our current Terms, Conditions and Limitations and Laboratory Pricing Policy. No responsibility or liability is assumed for the manner in which these results are used or interpreted.

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ABNORMAL

Page 3
02/02/06
15:54:57

ID: '
Unit Type:GN_GR001 Gear (GN_GR001)
Oil Type :TE_136 Texaco Meropa ISO VG 320 -(Mineral) P.O. # B6286
Sampled :01/23/06 Shipped : 01/30/06 Received:01/31/06 Printed: 02/02/06

Lab Number :

Comments: The ferrous debris consists of a few cutting, sliding/scuffing, and normal rubbing wear particles. Approximately 2% of the wear particles are of a copper alloy origin. The foreign contaminants are inorganic crystalline and fibers. This sample is rated normal, however the ratio of large to small particles (DI:Ds) and non-ferrous debris observed warrants monitoring.

Analytical Ferrography

Density Large	8.8
Density Small	2.1
Wear Particle	10.9
Caution	59.6
Alarm	79.7
Percent Large	61
Severity Index	73
Dilution Factor	1
	Wear Particles
Rubbing Wear	65 %
Sliding Wear	1 %
Cutting Wear	2 %
Fatigue Wear	0 %
Laminar Wear	2 %
Spherical Wear	0 %
	Ferrous Oxides
Red Oxide	0 %
Dark Metallo-ox	0 %
Black Oxide	1 %
Corrosion	0 %
	Contaminants
Friction Polymr	0 %
Sand, Dirt	25 %
Fibers	3 %
Spheres	0 %
Other	1 %

Photo 1: 100X shows the concentration of particles at the entry region.

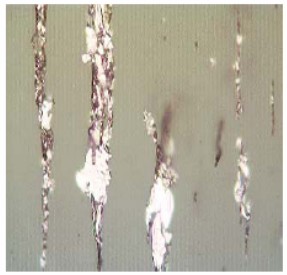

Photo 2: 500X shows some of the larger wear particles at the entry region. The largest one seen here is approximately 22 x 20 microns.

For questions about this report, please call 888 HER-GUTH (437-4884) between 8:00 am and 5:00 pm PST. A Technical Support Representitive will be glad to help you.
Code :CALWIN Calwind Inc. Phone :(661) 822-7640 Fax :(661) 822-3262 Infend2 Rv. 01/23/06
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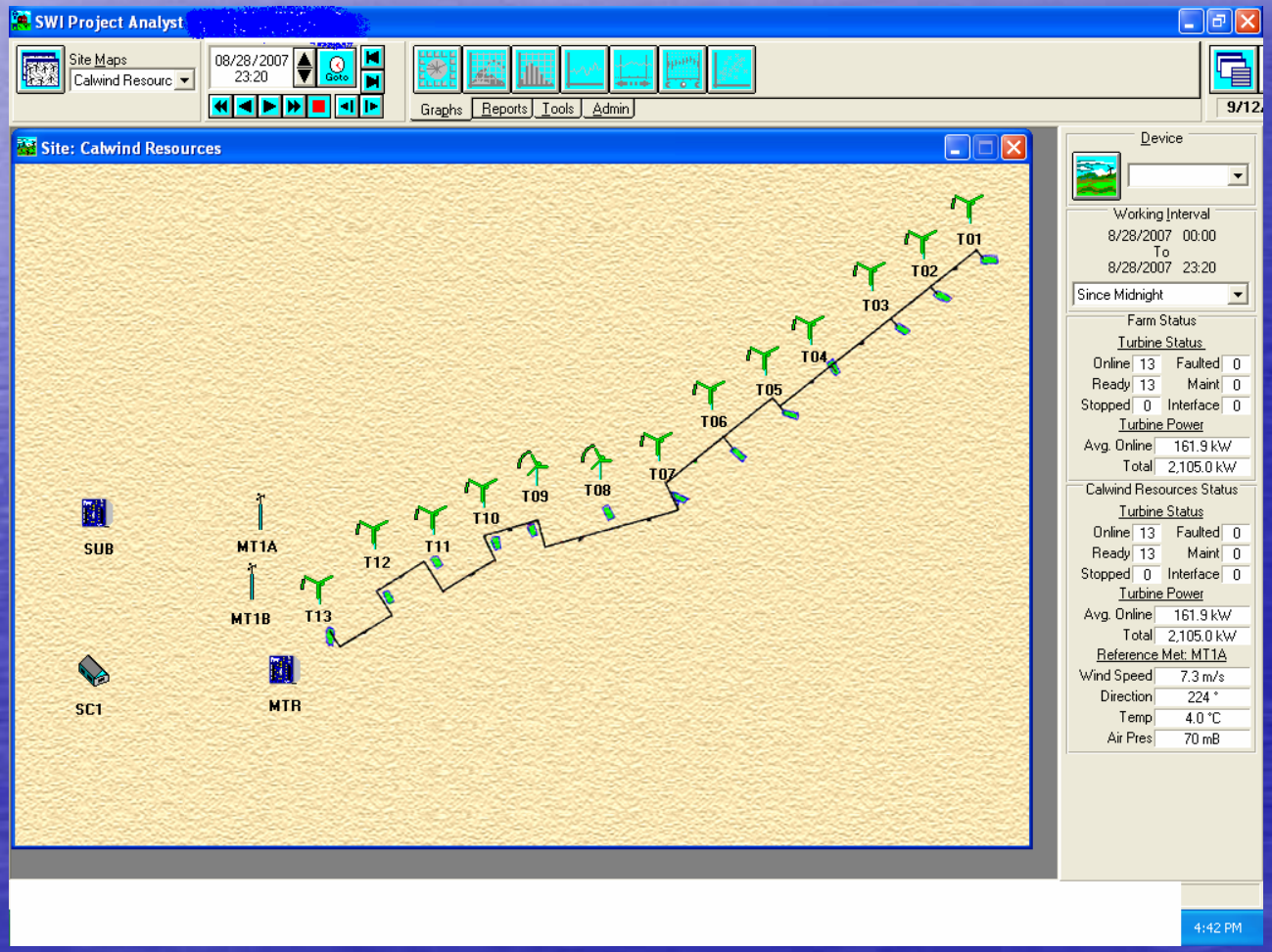
Second Wind Advanced Distributed Monitoring System



CTM Installed on Turbine Controller

- VMP Controller

Second Wind CTM

Components of the Swantech System:

- Base Unit
- Base Radio Antenna
- Swan Guard
- Sensors on Gearbox
- Sensors on Generator
- Sensors on Yaw Drive & Main Shaft

Base Unit

Base Radio Antenna

13 @600+KW Wind Turbines 1 mile

Swan Guard in Turbine

Sensors on Gearbox

Planet sensor

Helical sensor

Sensors on Generator

Drive end

Non drive end

Sensors on Yaw Drive & Main Shaft

Yaw sensor

Main shaft sensor

Stress Wave Analysis

- Stress Wave Analysis (SWAN) is a patented technology that provides measurement of overall machine health SWAN detects Stress Wave Energy that is created by shock and friction events SWAN enables the separation of these high frequency stress waves from the much lower range of operating machinery dynamics and audible noise, providing a clear indication of machine health.

Swan Stress Energy Screen

http://[redacted] - RT Stress Levels - Microsoft Internet Explorer

Current Stress Levels - Wed, Sep 12 2007 23:57:49

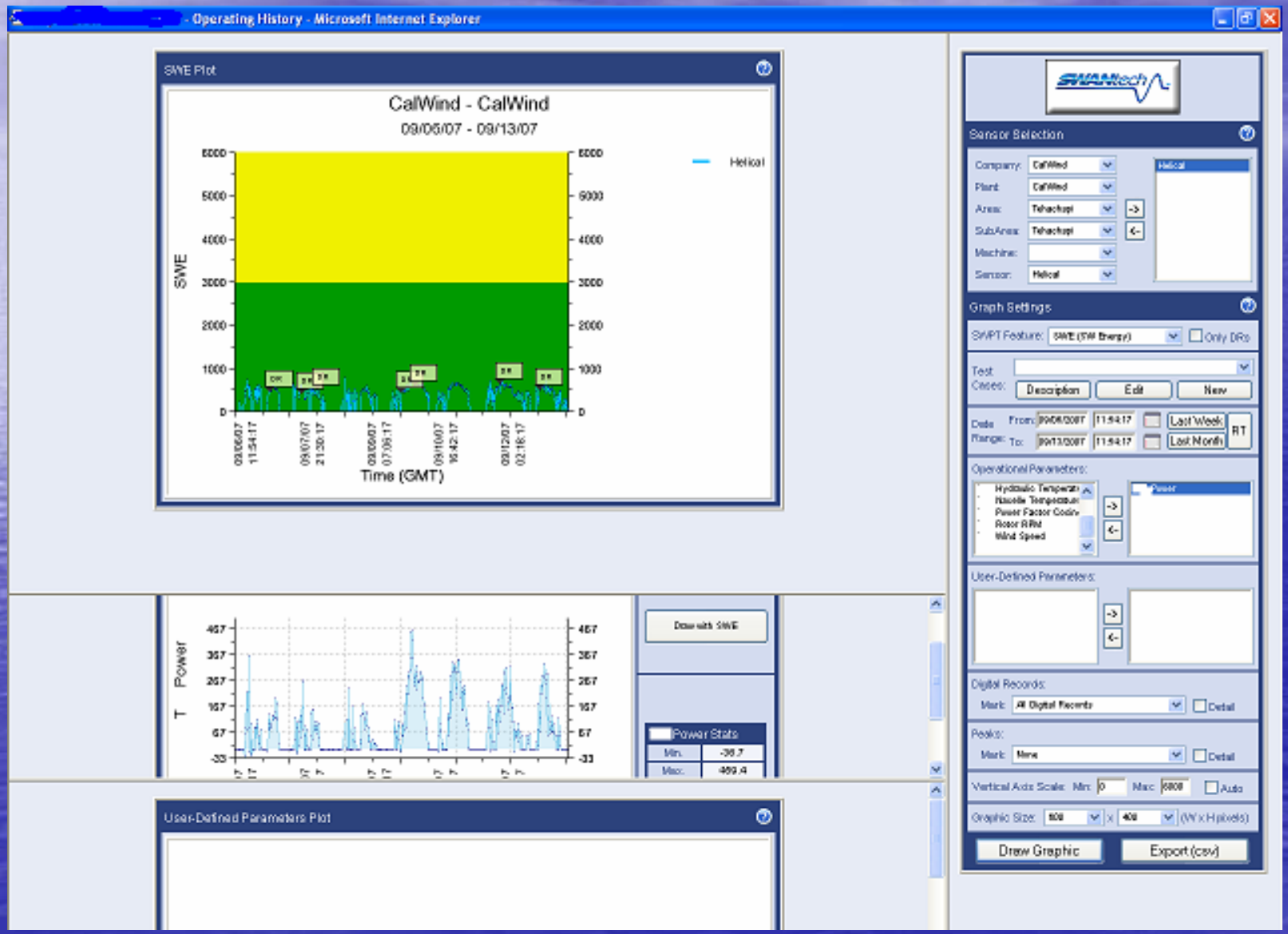
V1	Planet	SWE: 482.0000	SWPA: 0.5100V	SWMean: 0.0300V	Record	Trend
	Helical	SWE: 2867.0000	SWPA: 1.3600V	SWMean: 0.2300V	Record	Trend
	Generator DE	SWE: 650.0000	SWPA: 0.7100V	SWMean: 0.0500V	Record	Trend
	Generator NDE	SWE: 1140.0000	SWPA: 0.7500V	SWMean: 0.0900V	Record	Trend
V2	Planet	SWE: 2336.0000	SWPA: 2.2100V	SWMean: 0.1900V	Record	Trend
	Helical	SWE: 1819.0000	SWPA: 1.4600V	SWMean: 0.1400V	Record	Trend
	Generator DE	SWE: 856.0000	SWPA: 0.5400V	SWMean: 0.0600V	Record	Trend
	Generator NDE	SWE: 2659.0000	SWPA: 0.8900V	SWMean: 0.2100V	Record	Trend
V3	Planet	SWE: 909.0000	SWPA: 0.4600V	SWMean: 0.0700V	Record	Trend
	Helical	SWE: 1172.0000	SWPA: 0.9800V	SWMean: 0.0900V	Record	Trend
	Generator DE	SWE: 115.0000	SWPA: 0.0600V	SWMean: 0.0000V	Record	Trend
	Generator NDE	SWE: 1649.0000	SWPA: 0.8000V	SWMean: 0.1300V	Record	Trend
V4	Planet	SWE: 965.0000	SWPA: 1.1300V	SWMean: 0.0700V	Record	Trend
	Helical	SWE: 2335.0000	SWPA: 2.4400V	SWMean: 0.1900V	Record	Trend
	Generator DE	SWE: 310.0000	SWPA: 0.1500V	SWMean: 0.0200V	Record	Trend
	Generator NDE	SWE: 1589.0000	SWPA: 1.3800V	SWMean: 0.1200V	Record	Trend
	Planet	SWE: 2009.0000	SWPA: 2.4900V	SWMean: 0.1600V	Record	Trend

Unknown Zone

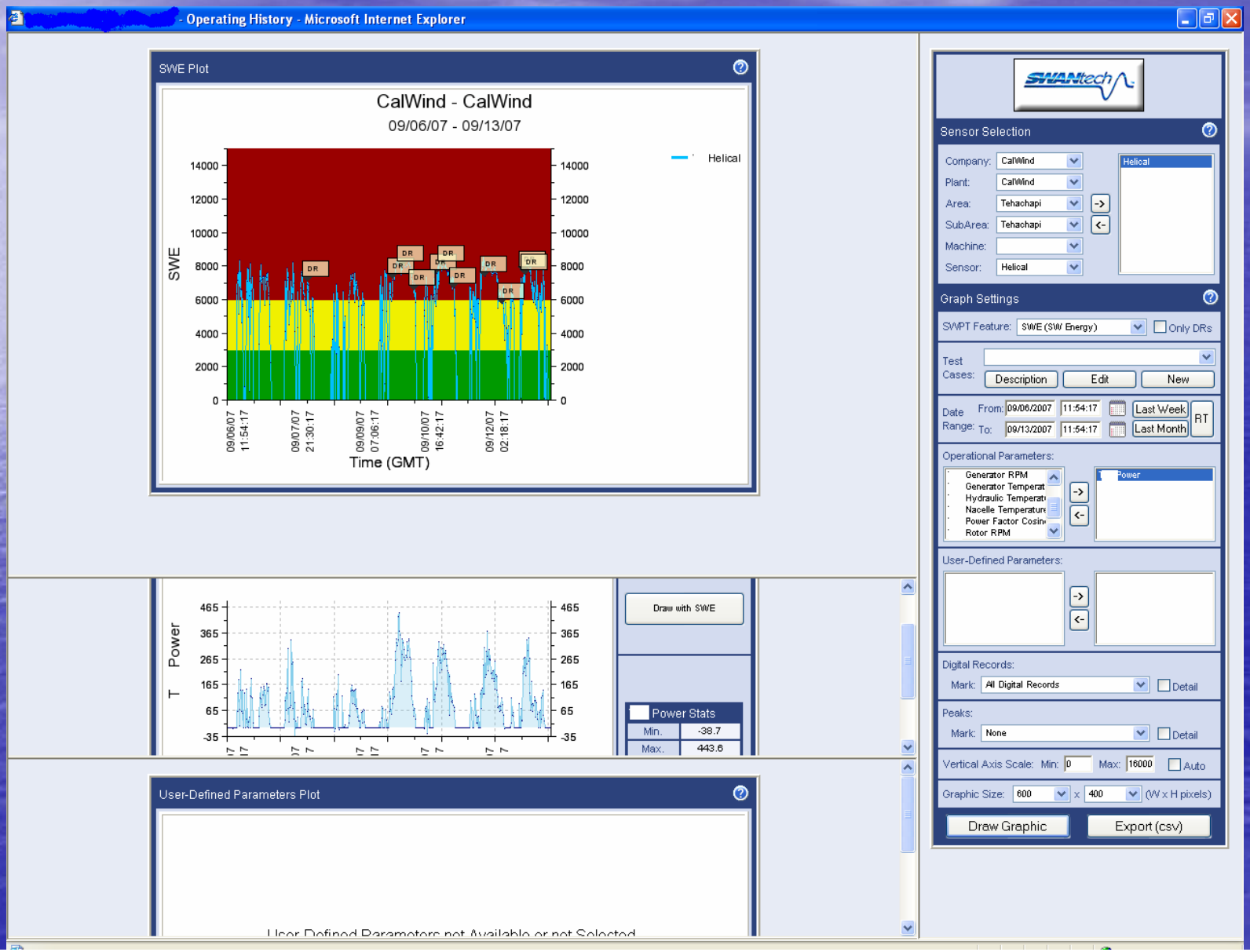
Operational Parameters for Digital Record Triggering

	Name	Description	Persist	Cease	Condition
Planetary	High Wind				
	100 KW				
	300 KW				
	660 KW				
	Oil Sump Temp				
	Gear Bearing Tmp				
	Name	**Description**	**Persist**	**Cease**	**Condition**
Helical	High Wind				
	100 KW				
	300 KW				
	660 KW				
	Oil Sump Temp				
	Gear Bearing Tmp				

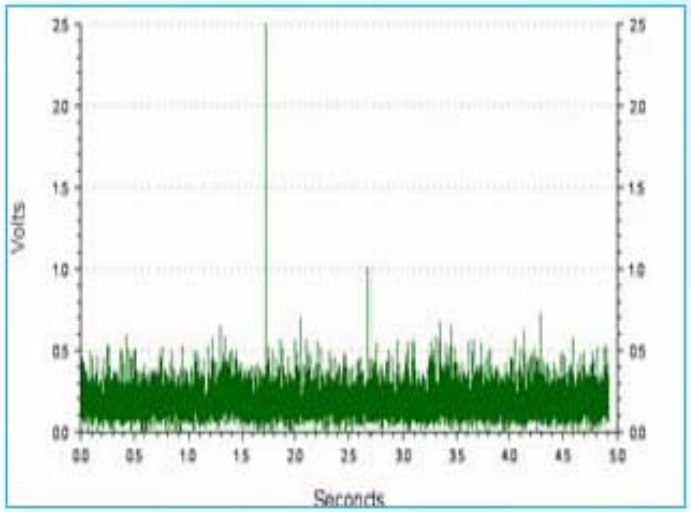
SWE Plot - Normal



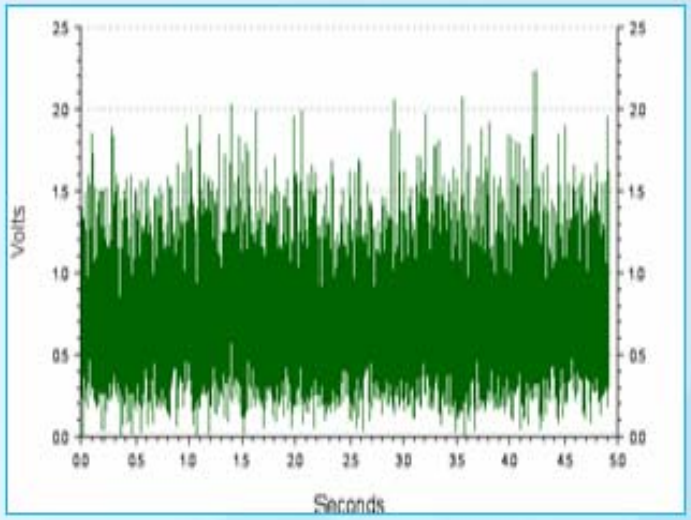
SWE Plot - Abnormal



Generic Domain Time Series



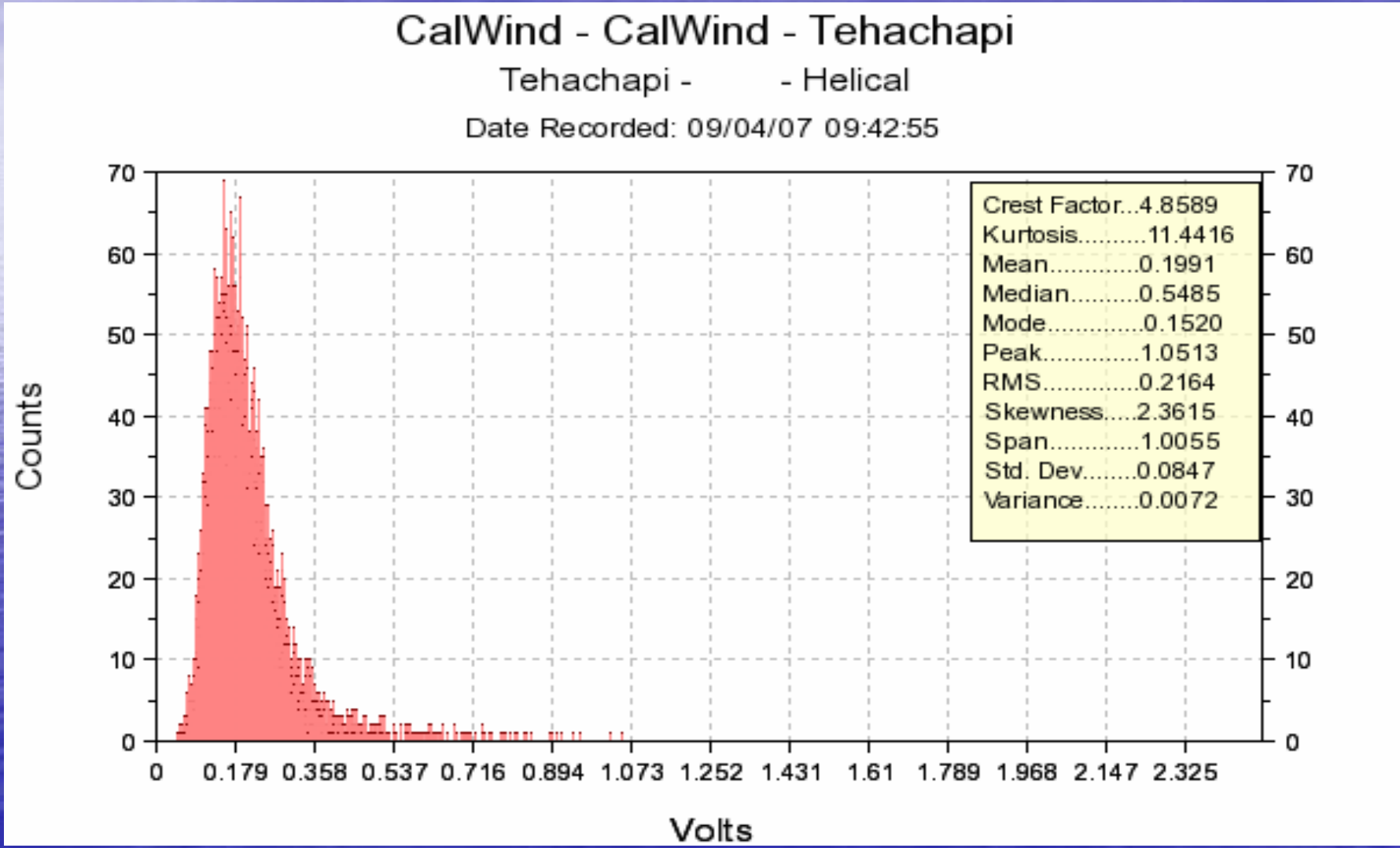
Healthy



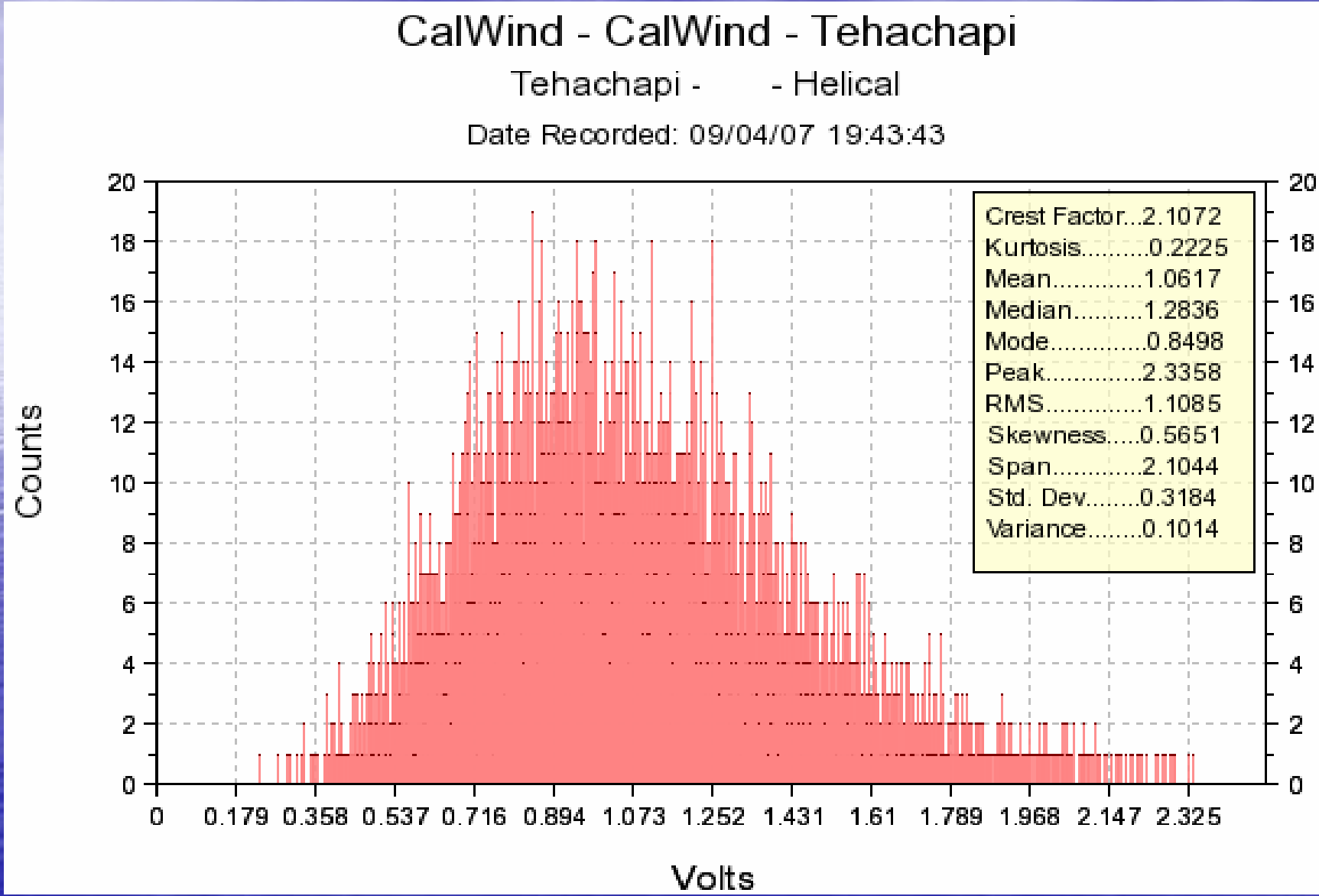
Random Friction

- Demodulated sensor signal
- Shows random friction and shock events

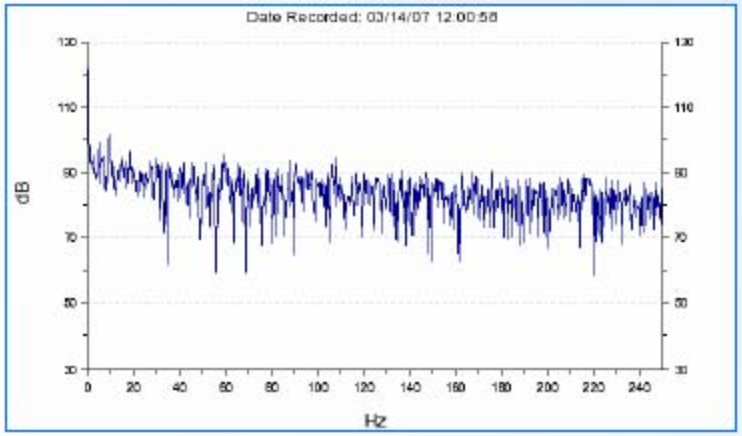
Histogram Plot - Normal



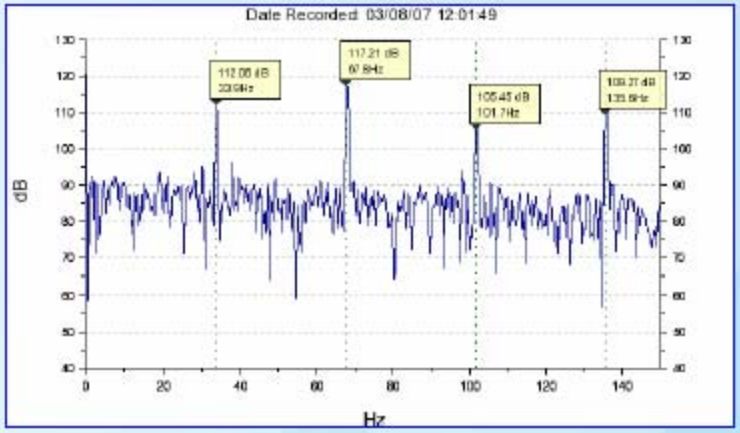
Histogram Plot - Abnormal



Generic FFT Spectral Analysis



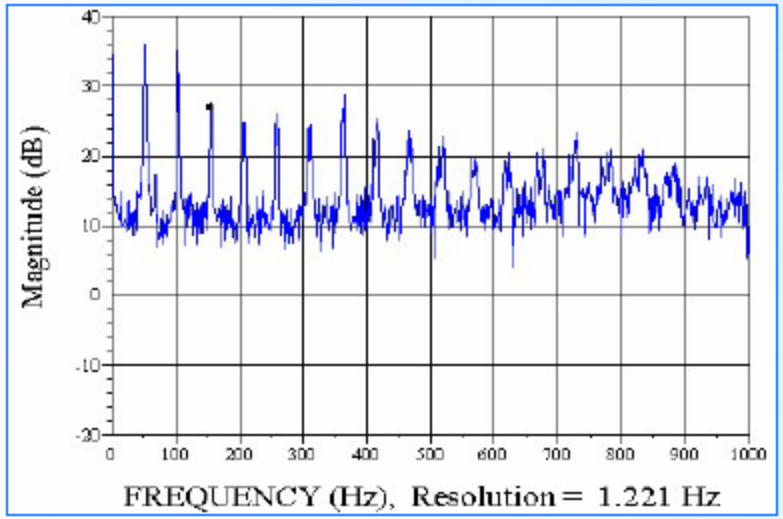
Healthy



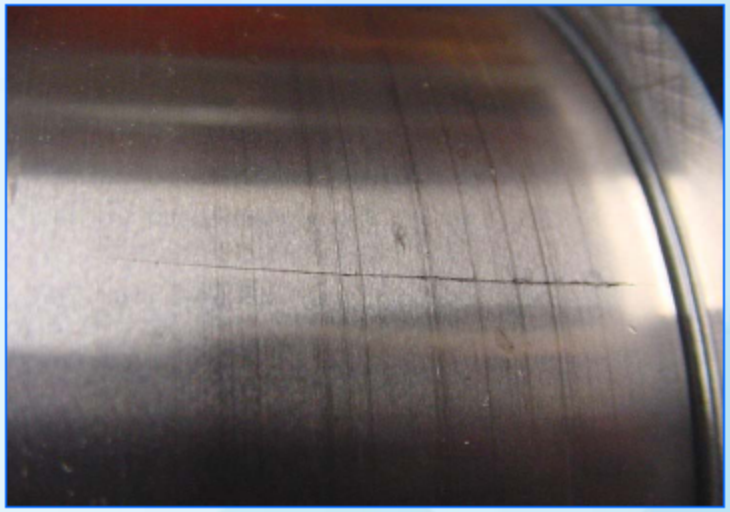
Repetitive Shock

- Spectrum only contains friction and shock events
- Healthy components produce a flat spectrum
- Repetitive shock/friction events show up as significant spectral lines

Analysis Example: Inner Race Crack



Stress Wave Spectrum

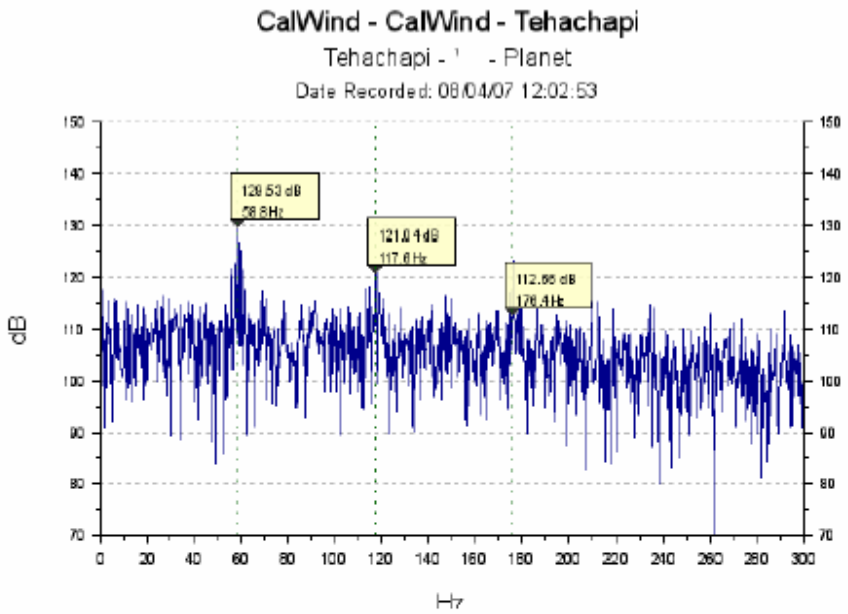


Inner Ring Crack

- Spectral lines present
- Correlated to bearing inner ring defect frequency
- Tear down and inspection verified defect

Case Study: Torque Arm Spring Replacement

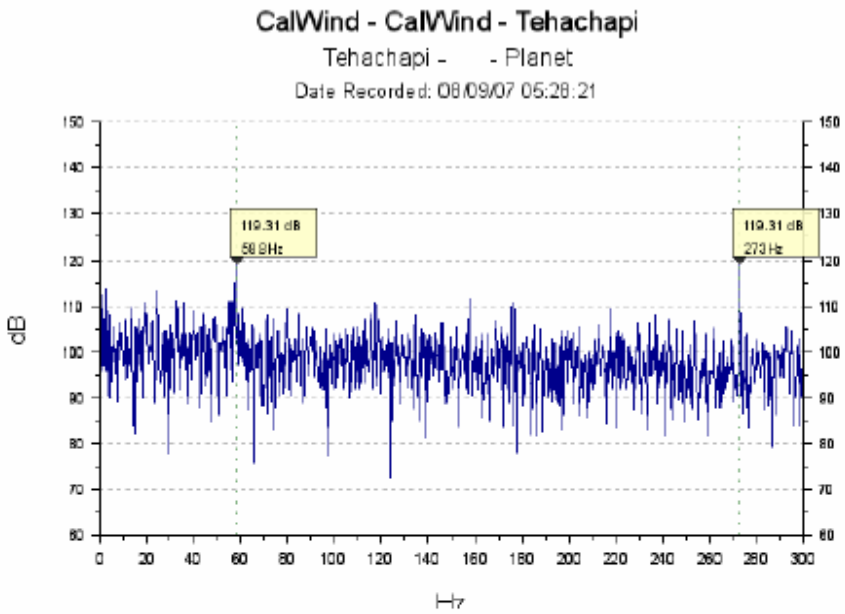
Case Study FFT: Torque Arm Spring Replacement



Before Replacement

325 KW / 1819.5 RPM

- 58.84 (1x); 117.68 (2x); 176.52 (3x)
  - Planet / Ring gear mesh (Normal)

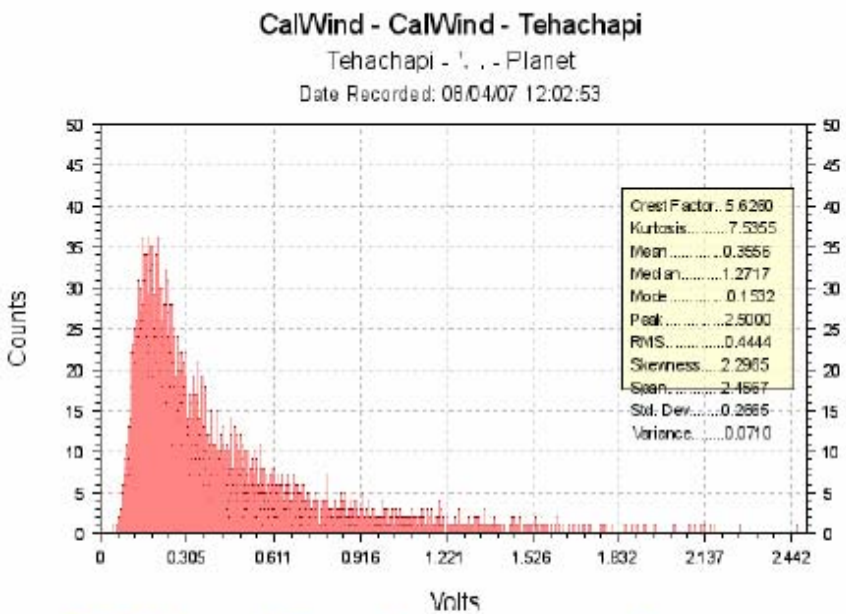


After Replacement

338 KW / 1821 RPM

- 58.89 (1x)
  - Planet / Ring gear mesh (Normal)
- 273.15
  - Oil Pump gear mesh (Normal)

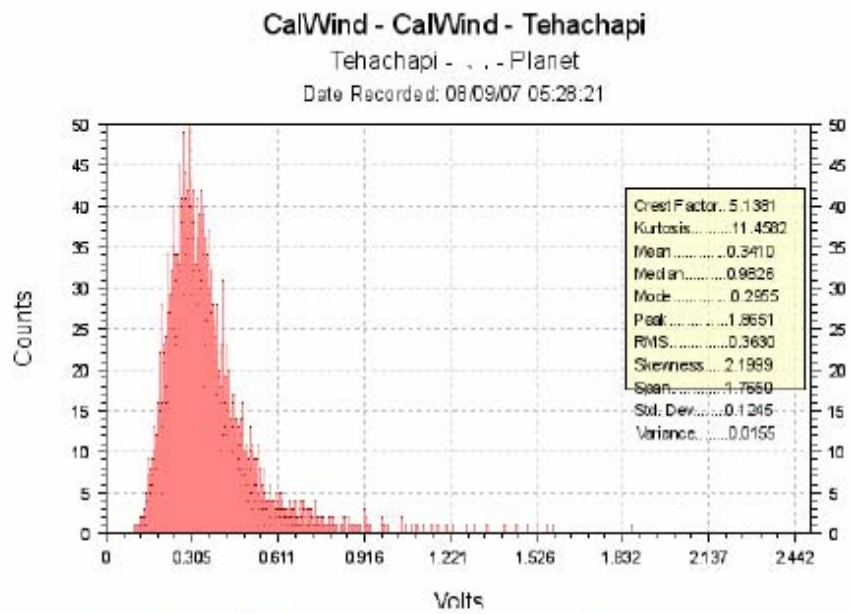
Case Study Histogram: Torque Arm Spring Replacement



Before Replacement

325 KW / 1819.5 RPM

- Skewed
  - Lubrication issues at tooth flanks of Planet / Ring gear mesh



After Replacement

338 KW / 1821 RPM

- Normal
  - Lubrication issues at tooth flank of Planet / Ring gears have been resolved

Concluding Summary:

- SCADA – Second Wind ADMS for operational data
- Oil samples with analytical ferrography
- Swantech condition monitoring system
- Warranty Compliance
- Preventative Maintenance
- Not discussed: Maintenance program and motivated talented technicians