About PdMA

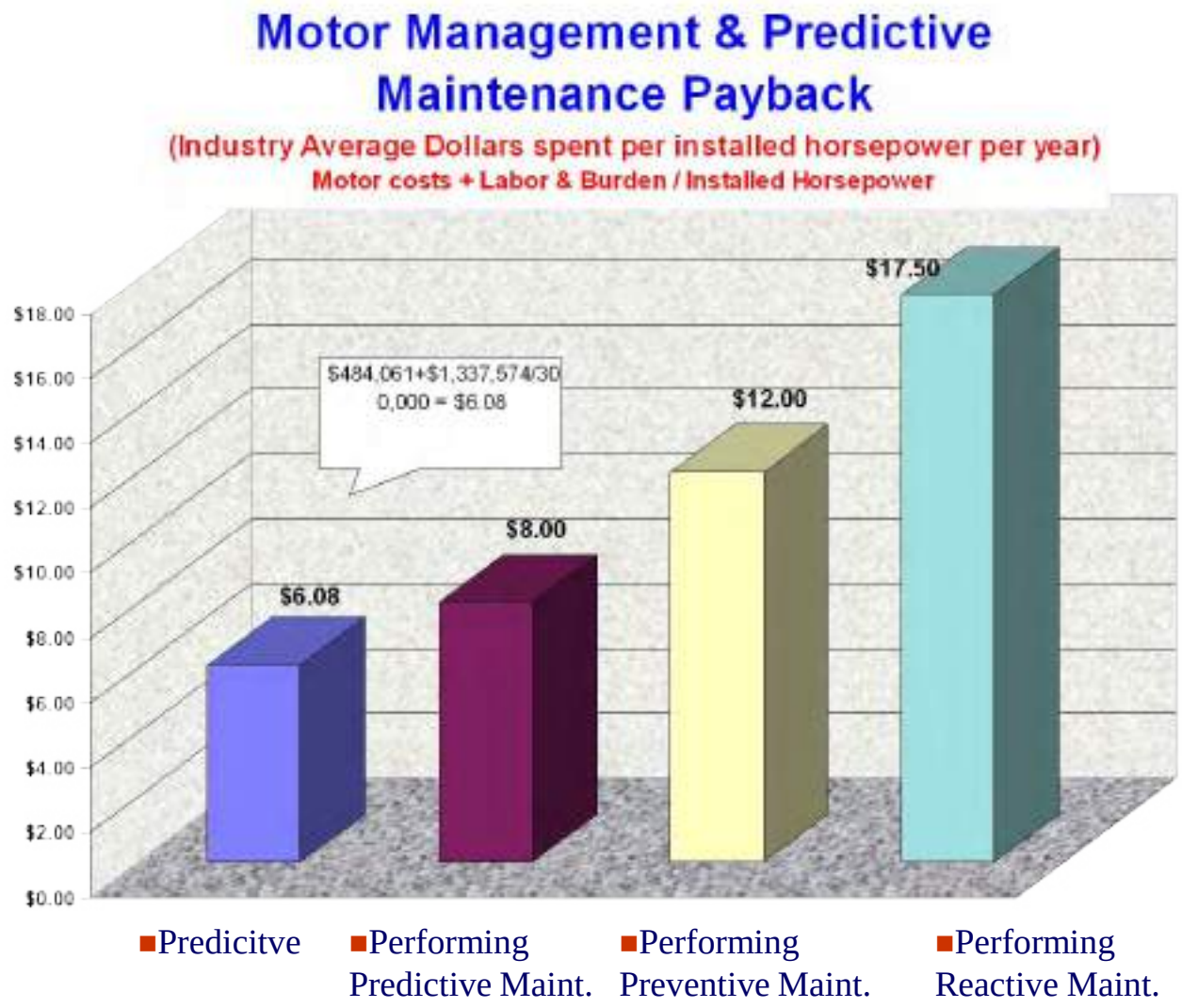
- Privately held company located in Tampa, Florida
- Active in predictive maintenance since 1983
- Motor Testers
  - EMAX (Dynamic Testing)
  - MCE (Static Testing)
  - MCEMAX (Combination)

MCEMAX

PdMA Client List

- Aerospace – NASA Langley Research Center, The Boeing Company
- Automotive – General Motors, Ford
- Petro-chemical – Chevron, Syncrude Canada, LG Chemical (Korea), Bharat Petroleum (India), PEMEX (Mexico), Caltex (Korea, Philippines, Bahrain), Coastal Regining (Philippines)
- Pulp & Paper – Mead Paper Corp., Bowater Inc.
- Steel & Aluminum – Commonwealth Aluminum, Dofasco Inc.(Canada), Alcoa, POSCO (Korea)
- Utilities – Cinergy, Ameren UE, KEPCO (Korea), KPS (Korea – Utility Service)

Predictive Maintenance Benefits



Aluminum facility

Why Motor Testing?

- **Quality Assurance** testing on new or reworked motors (Baseline Test)
- **Trending** through periodic testing of motor condition
- **Diagnostic** testing to evaluate / troubleshoot circuit faults

The Most Important Benefit of the MCEMAX

- FINANCIAL SAVINGS
  - Reduction in unexpected motor failures
    - Improved production
    - Less downtime
    - Less scrap materials
    - Better inventory control
  - Reduction in new and repaired motor costs
    - Improved quality assurance
    - Root cause analysis

Average Return on Investment

Industry	Avg. ROI	Avg. Reduction in Downtime
Overall	5.5 Months	9.48%
Automotive	3 Months	12.50%
Manufacturing	3.5 Months	20%
Mining	1 Month	10%
Petro/Chemical	3.5 Months	2.50%
Pulp and Paper	6.6 Months	6.70%
Service	9 Months	12.50%
Metal Fabrication	2 Months	5%
Utility	5.9 Months	5.80%

- Based on survey results from PdMA equipment users - PdMA Corporation, 1999

Other Benefits of the MCEMAX

- User Friendly
- Equipment Versatility
- Unparalleled Vendor Support

Downtime Reduction at GM Plant

- GM's Defiance, Ohio Plant
- MCE motor circuit evaluator.
- 1996 Annual downtime figure decreased 85%.

Downtime Reduction at Miller Steam Plant

- Major producer of electricity for Alabama Power.
- 10-12 Critical motors selected for reconditioning (old method).
- Purchased MCE at 1995
- Before 1995: $500,000/Year for scheduled motor repair.
- By 1998: $172,000/Year

User Friendly

- **Multiple Technologies in one tester**
  - Dynamic and Static technologies in one case
- **Equipment Portability**
  - Less than 20 lbs
  - Battery or AC Power
  - Laptop interface includes historical data
- **Automatic Data Analysis**
  - Operator alerted of alarming or changing conditions
- **Equipment Safety**
  - Non-destructive testing

Unparalleled Vendor Support

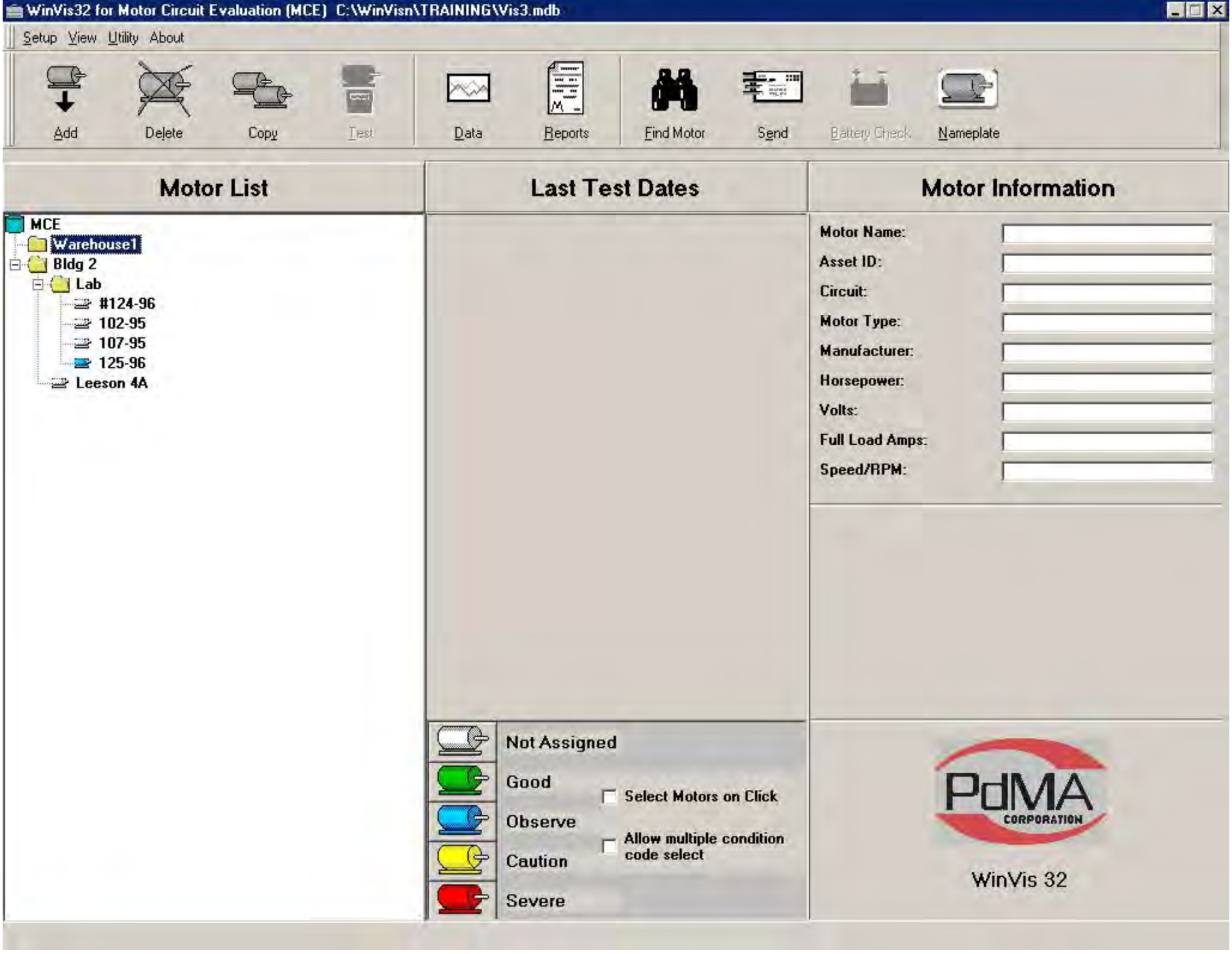
- **Technical support for life of equipment**
- **Quarterly Newsletter**

Equipment Versatility

- **Convenient in all plant conditions**
  - EMAX tests while the motor is running
  - MCE tests while the motor is shut down
- **Effective in all applications**
  - Can be used for quality assurance, trending, or fault diagnosis
- **Tests all variety of motors**
  - Not limited by size or type of motor
- **Effective in all potential fault zones**

MCEmax

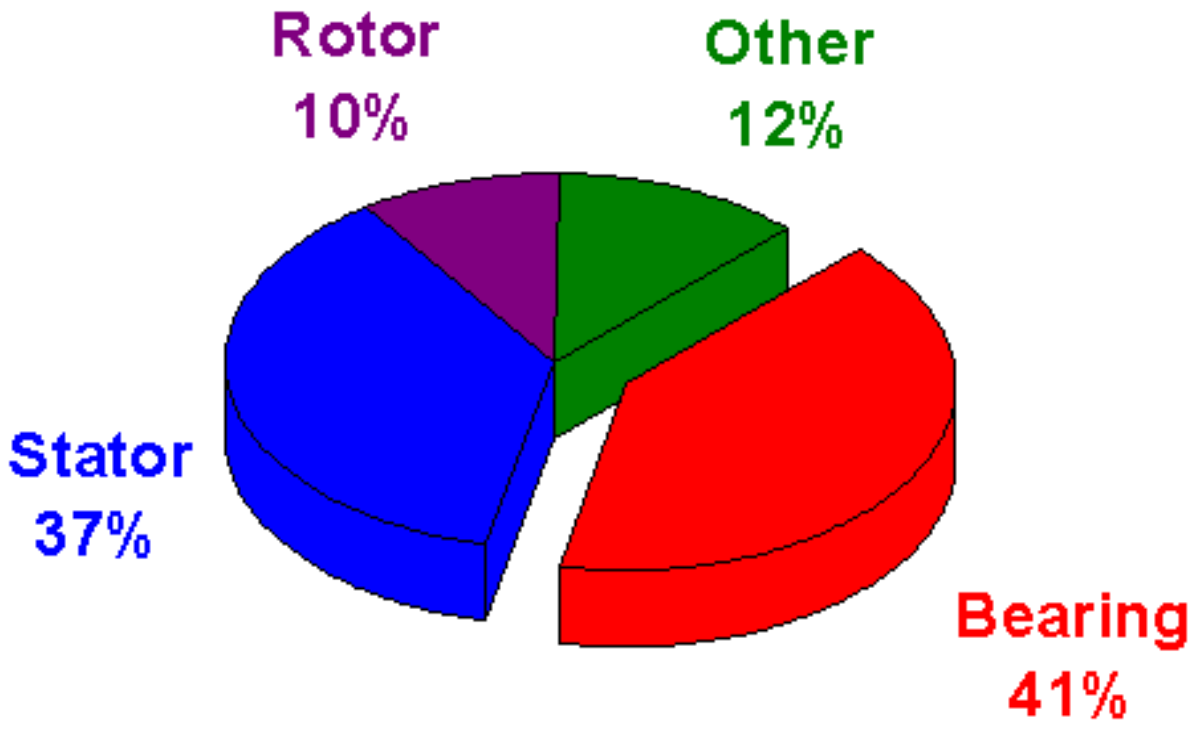
SOFTWARE


WinVis32 for Motor Circuit Evaluation (MCE) C:\WinVisn\TRAINING\Vis3.mdb
Setup View Utility About
Add
Delete
Copy
Test
Data
Reports
Find Motor
Send
Battery Check
Nameplate
Motor List
Last Test Dates
Motor Information
MCE
Warehouse1
Bldg 2
Lab
#124-96
102-95
107-95
125-96
Leeson 4A
Motor Name:
Asset ID:
Circuit:
Motor Type:
Manufacturer:
Horsepower:
Volts:
Full Load Amps:
Speed/RPM:
Not Assigned
Good
Observe
Caution
Severe
Select Motors on Click
Allow multiple condition code select
PdMA CORPORATION
WinVis 32

WinVis Features

- Keeps track of all motors
- Stores nameplate information
- Controls motor testing
- Provides immediate results
- Allows comparison of test results
- Develops/prints reports

Summary of Motor Failures



1985 EPRI/GE STUDY

Fault Zones

- **Power Quality**
- **Power Circuit**
- **Insulation**
- **Stator**
- **Rotor**
- **Air Gap**

Application to Fault Zones

	MCE	EMAX
Power Quality	*N/A*	*Power Analysis*
Power Circuit	*Standard Test*	*Power Analysis*
Insulation	*Standard Test* *PI,DA, SVT*	*N/A*
Stator	*Standard Test* *RIC*	*Power Analysis* *In- Rush/Start up*
Rotor	*Standard Test* *RIC*	*MCSA* *In- Rush/Start up*
Air Gap	*Standard Test* *RIC*	*Eccentricity*

Standard Test: RTG, CTG, Phase Resistance, Phase Inductance

SVT: Step Voltage Test

MCE

HARDWARE

Hardware

- Shipping Case
- Tester
- Laptop
- Accessory Bag

Shipping Case

MCE Tester

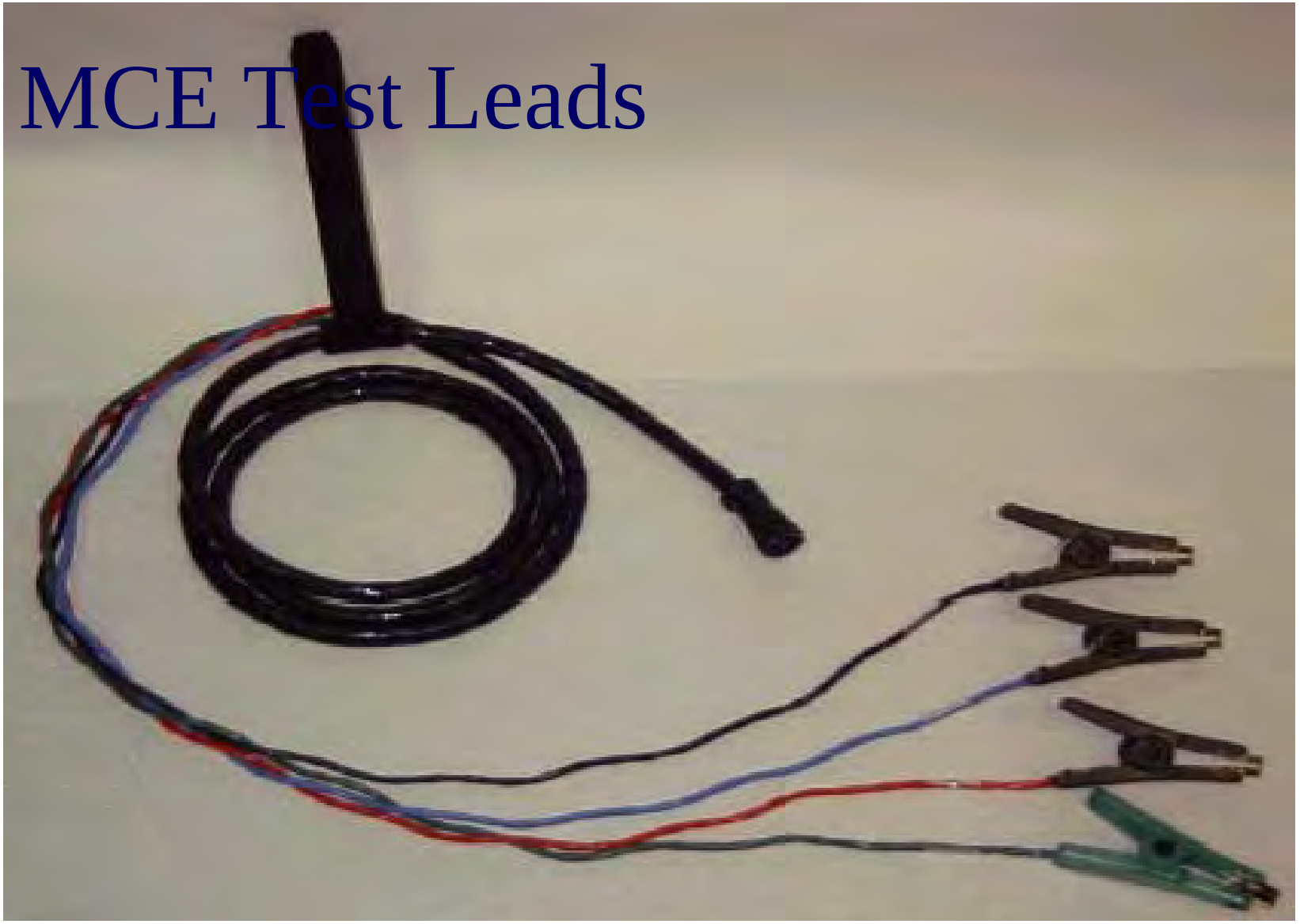
MCE Accessory

- Laptop computer
- RJ-45/serial port cable - Interface cable
- Test lead connector - Multi-pin plug
- Tester battery - Camcorder battery
- Battery status display
- Tester board - Located under mold
- Power supply board - Located under mold
- Battery monitoring board - Located under mold

Accessory Bag

- **Test leads**
  - Standard
  - Commutator Bar-to-Bar
- **Dial (Position) indicator**
- **Computer power cord/battery charger**
- **Tester batteries and charger**
- **Computer spare battery (CD ROM and/or floppy drive)**

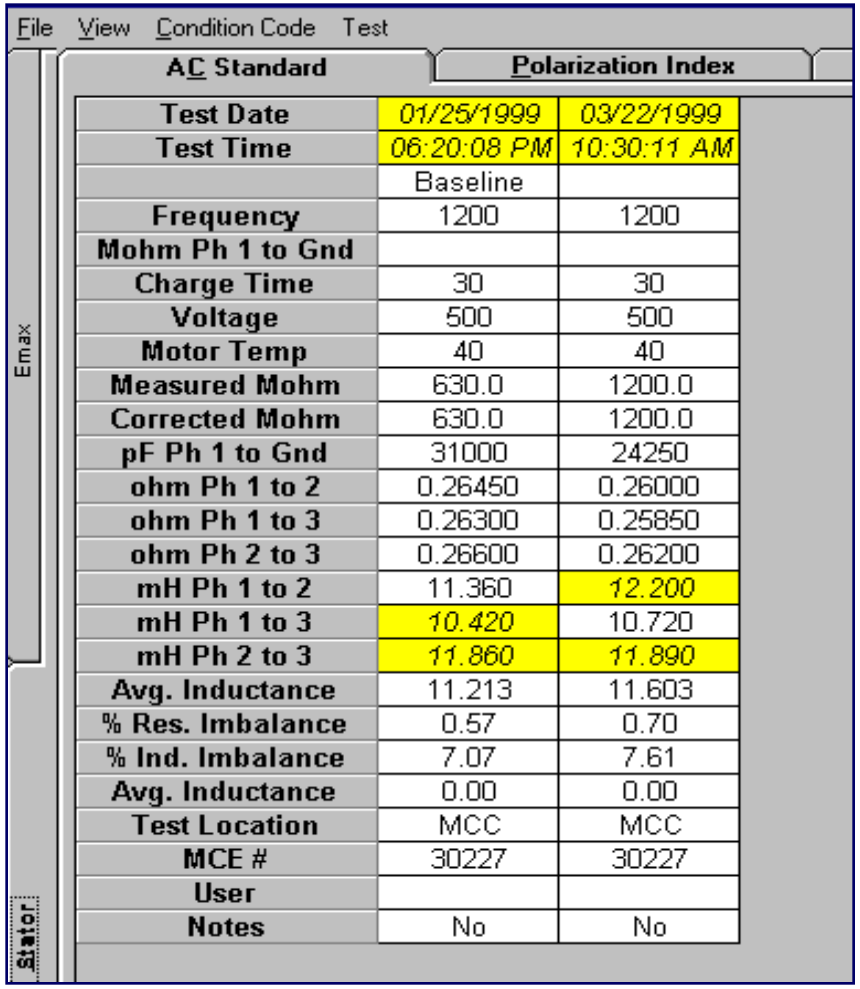
MCE Test Leads



DC Commutator Bar-to-Bar Test Leads

MCE Standard Test

- Resistance to ground
  - Measured in Mohms
  - Temperature corrected
  - Trended over time
  - Potential choices of 500 - 1000V
    - Selections of 250V - 5000V available with 5kV
- Capacitance to ground
  - Measured in picofarads
  - Trendable parameter
  - Used to measure the dirt or moisture build-up on the insulation



Test Date	01/25/1999	03/22/1999
Test Time	06:20:08 PM	10:30:11 AM
	Baseline	
Frequency	1200	1200
Mohm Ph 1 to Gnd		
Charge Time	30	30
Voltage	500	500
Motor Temp	40	40
Measured Mohm	630.0	1200.0
Corrected Mohm	630.0	1200.0
pF Ph 1 to Gnd	31000	24250
ohm Ph 1 to 2	0.26450	0.26000
ohm Ph 1 to 3	0.26300	0.25850
ohm Ph 2 to 3	0.26600	0.26200
mH Ph 1 to 2	11.360	12.200
mH Ph 1 to 3	10.420	10.720
mH Ph 2 to 3	11.860	11.890
Avg. Inductance	11.213	11.603
% Res. Imbalance	0.57	0.70
% Ind. Imbalance	7.07	7.61
Avg. Inductance	0.00	0.00
Test Location	MCC	MCC
MCE #	30227	30227
User		
Notes	No	No

MCE Standard Test

- Phase resistance
  - Measured in microhms
  - Highly accurate
  - Imbalance calculated
  - Indicates high resistance connections
- Phase inductance
  - Measured in mH
  - Highly sensitive parameter
  - Imbalance calculated
  - Indicates faulty capacitors

File View Condition Code Test

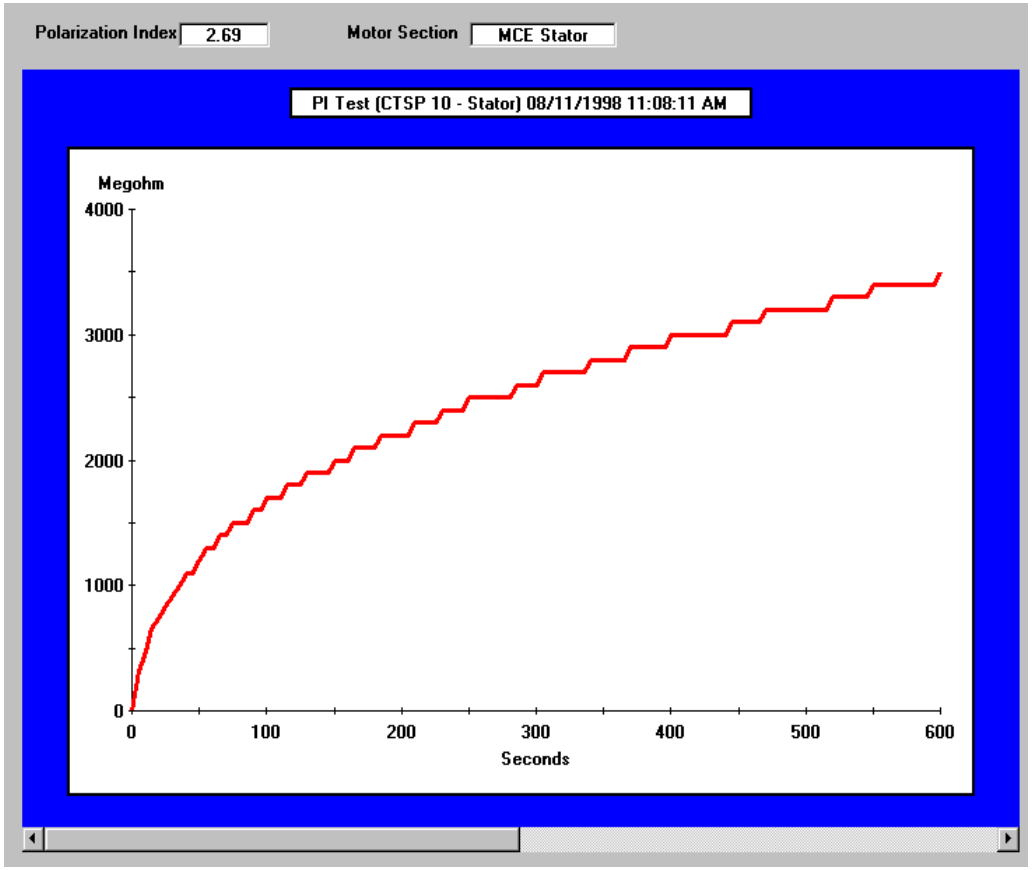
Emax / Stator

AC Standard | Polarization Index | Dielec. Absorp. | RIC

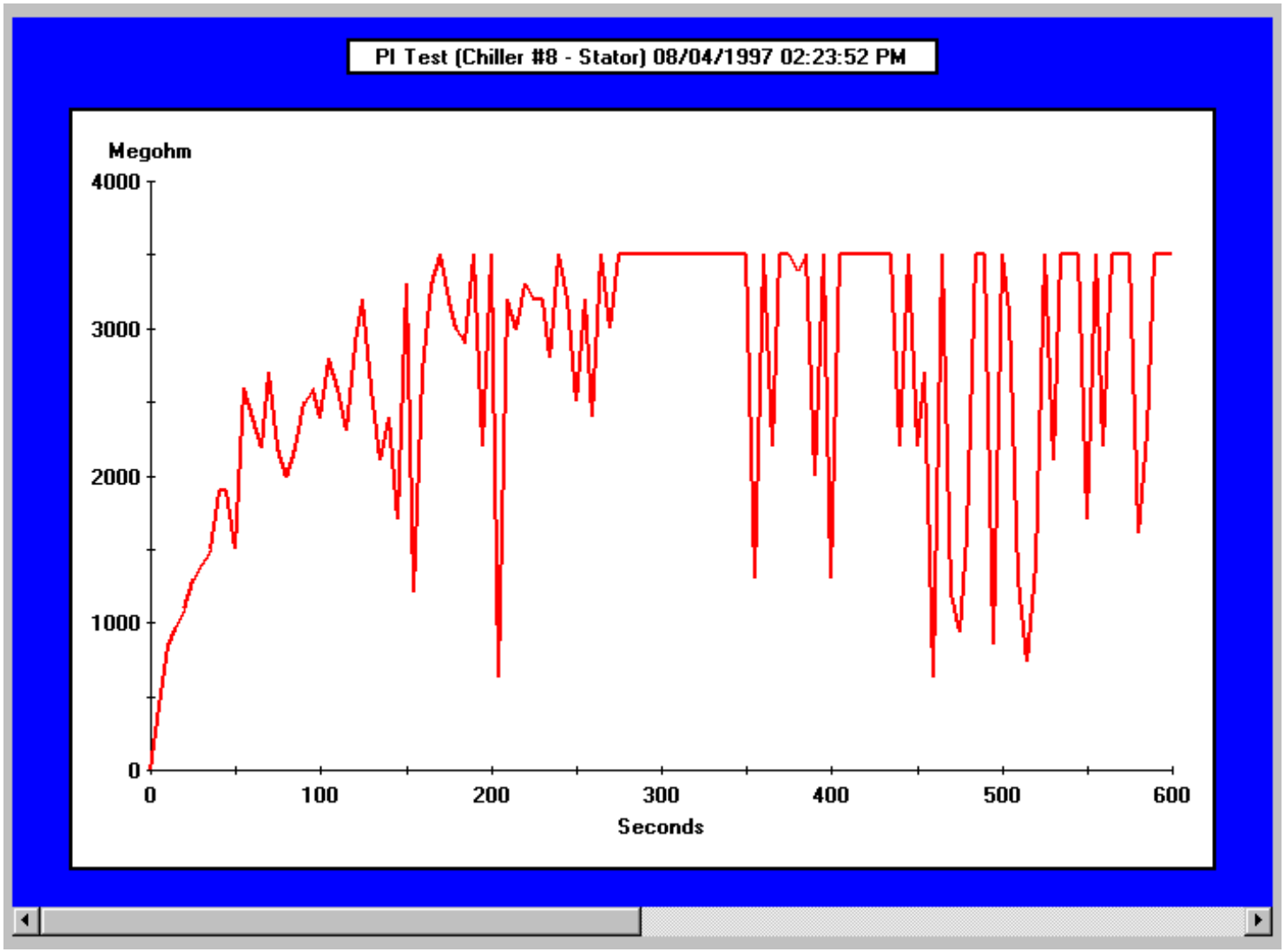
Test Date	09/16/1997	09/16/1997	09/16/1997	09/16/1997	09/16/1997	09/16/1997
Test Time	09:51:48 AM	10:53:37 AM	10:56:16 AM	10:59:38 AM	11:03:03 AM	11:47:57 AM
	Baseline					
Frequency	1200	1200	1200	1200	1200	1200
Mohm Ph 1 to Gnd						
Charge Time	30	30	30	30	30	30
Voltage	500	500	500	500	500	500
Motor Temp	20	20	20	20	20	20
Measured Mohm	>2000	>2000	>2000	>2000	>2000	>2000
Corrected Mohm	OVR	OVR	OVR	OVR	OVR	OVR
pF Ph 1 to Gnd	3000	3000	3000	3000	3000	2750
ohm Ph 1 to 2	18.04500	18.07500	18.07500	18.08000	18.08000	17.69500
ohm Ph 1 to 3	18.05500	18.06500	18.07000	18.07000	18.07500	18.08500
ohm Ph 2 to 3	18.04500	18.06500	18.06500	18.07000	18.07000	17.68500
mH Ph 1 to 2	129.800	122.500	129.800	131.600	127.200	122.600
mH Ph 1 to 3	121.300	129.800	123.800	128.700	131.700	132.000
mH Ph 2 to 3	125.200	128.700	130.400	124.700	125.800	122.900
Avg. Inductance	125.433	127.000	128.000	128.333	128.233	125.833
% Res. Imbalance	0.04	0.04	0.03	0.04	0.03	1.48
% Ind. Imbalance	3.48	3.54	3.28	2.83	2.70	4.90
Avg. Inductance	0.00	0.00	0.00	0.00	0.00	0.00
Test Location	N/A	N/A	N/A	N/A	N/A	N/A
MCE #	10147	10147	10147	10147	10147	10147
User						
Notes	No	No	No	No	No	No

MCE PI & DA

- Dielectric Absorption Ratio
  - 1 minute test
  - RTG readings graphed every 5 seconds
  - Ratio of value at 60 seconds to value at 30 seconds
- Polarization Index
  - 10 minute test
  - RTG readings graphed every 5 seconds
  - Ratio of value at 10 min. to value at 1 min.

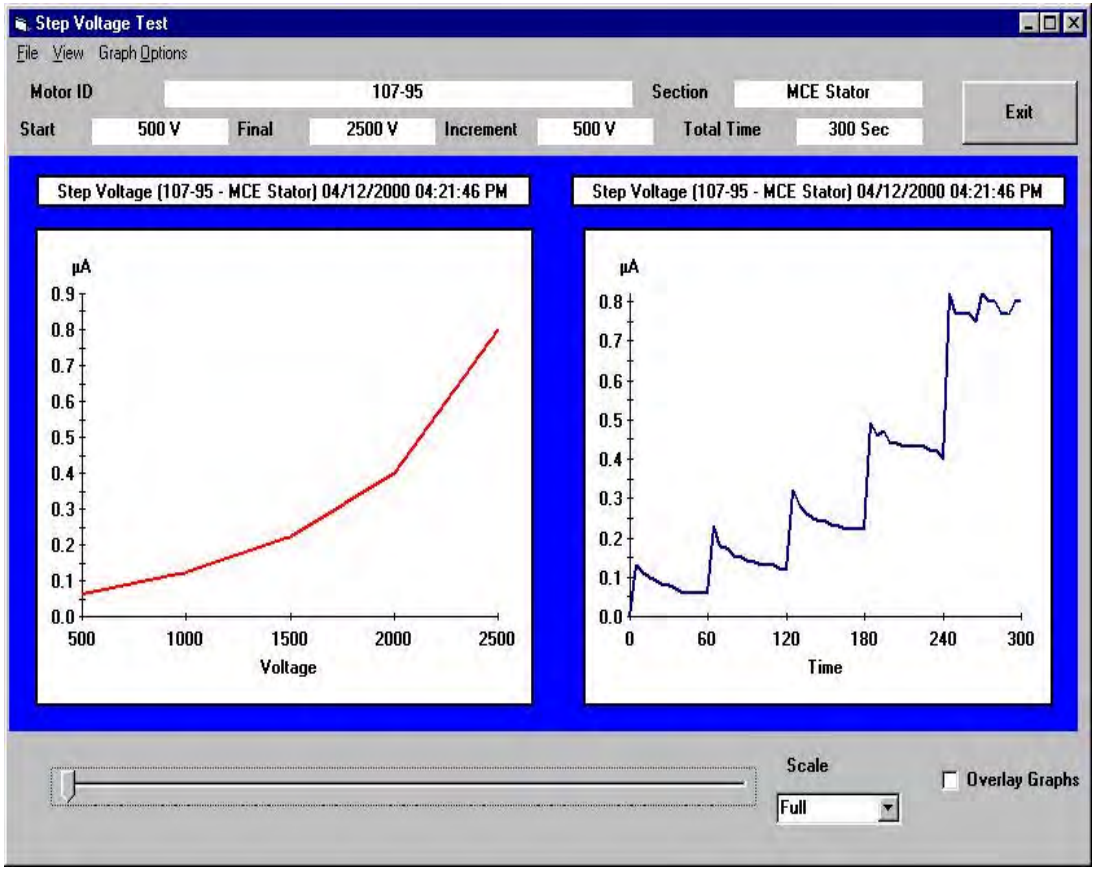


MCE PI Test


PI Test (Chiller #8 - Stator) 08/04/1997 02:23:52 PM
Megohm
4000
3000
2000
1000
0
0
100
200
300
400
500
600
Seconds

5kV Module

- Optional MCE accessory
- Offers Step Voltage Test
- Safely stresses insulation
- Less stressful than a hipot test

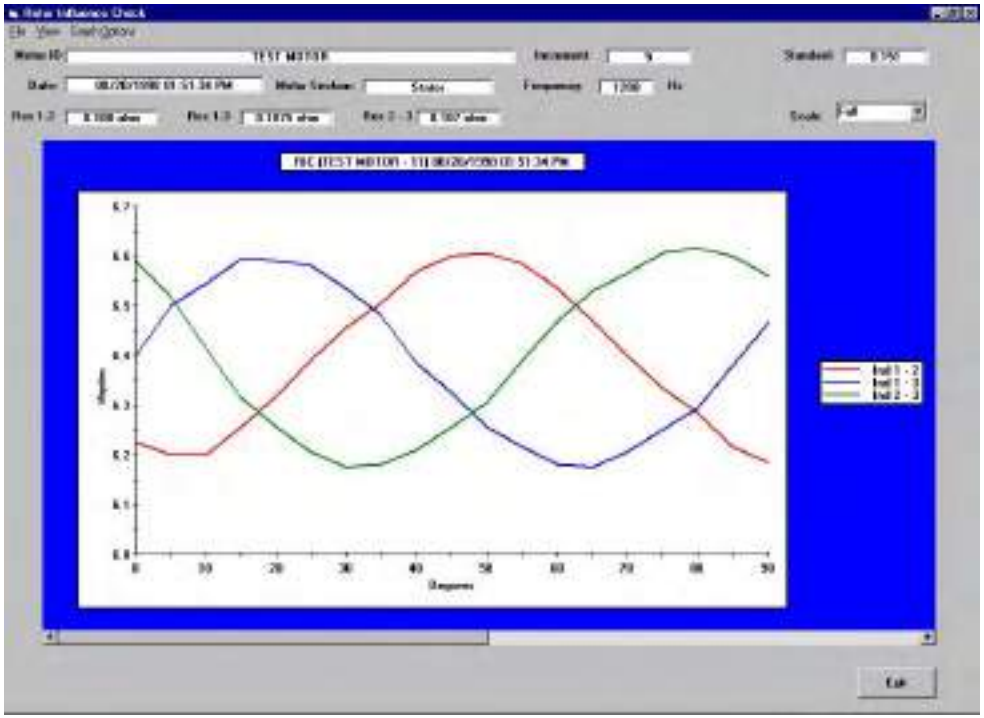


Surge Test -IEC 34-15 4xVLine + 5000 for new motor, 65% of new motor rate for in-used motor

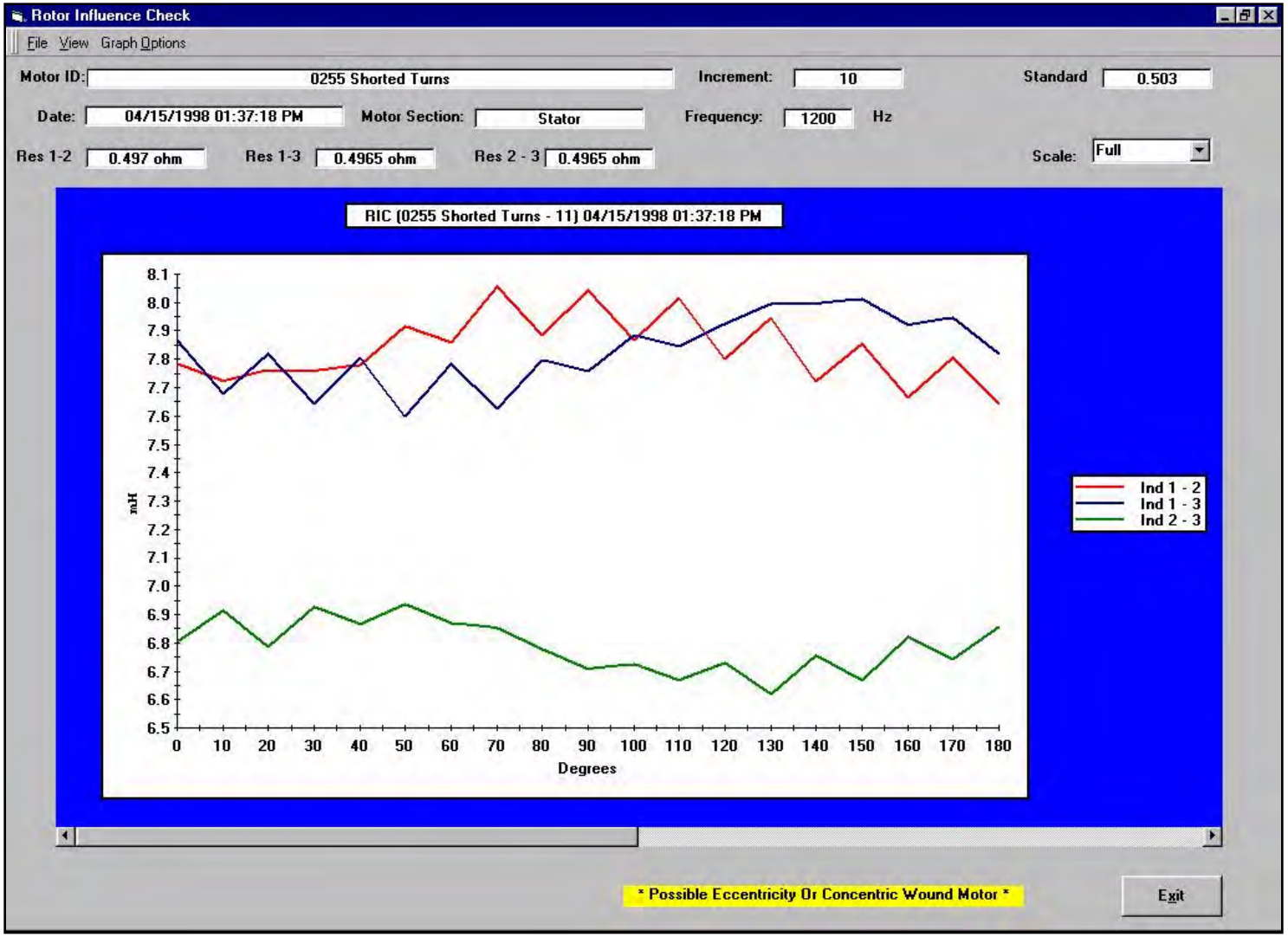
-EAFA 2xVLine + 1000 for new motor, 75% of new motor rate for in-used motor

MCE RIC Test (Rotor Influence Check)

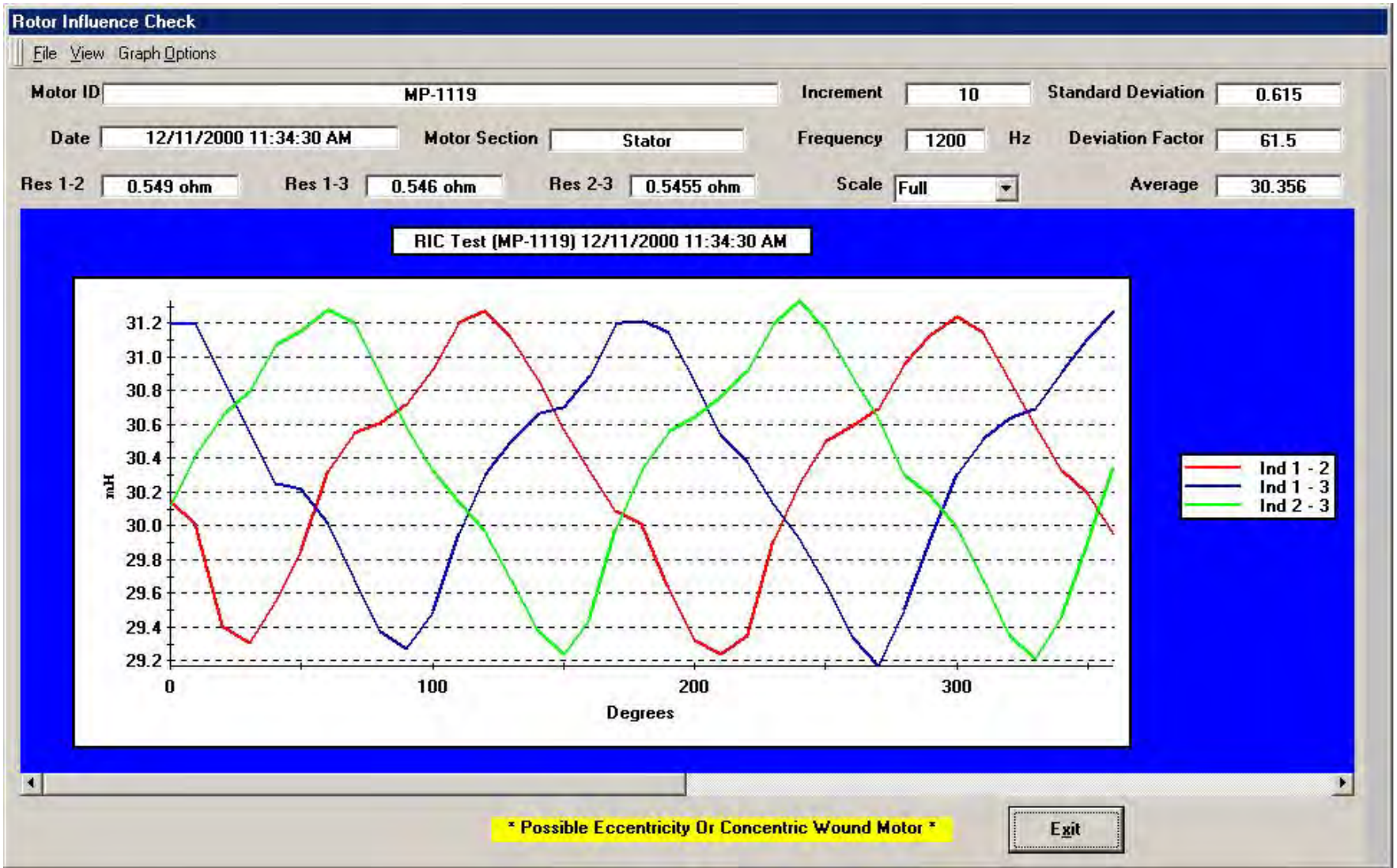
- A measurement of phase to phase inductance over rotation
- Usually through one pole face
- Confirms the presence of rotor, stator and air gap anomalies



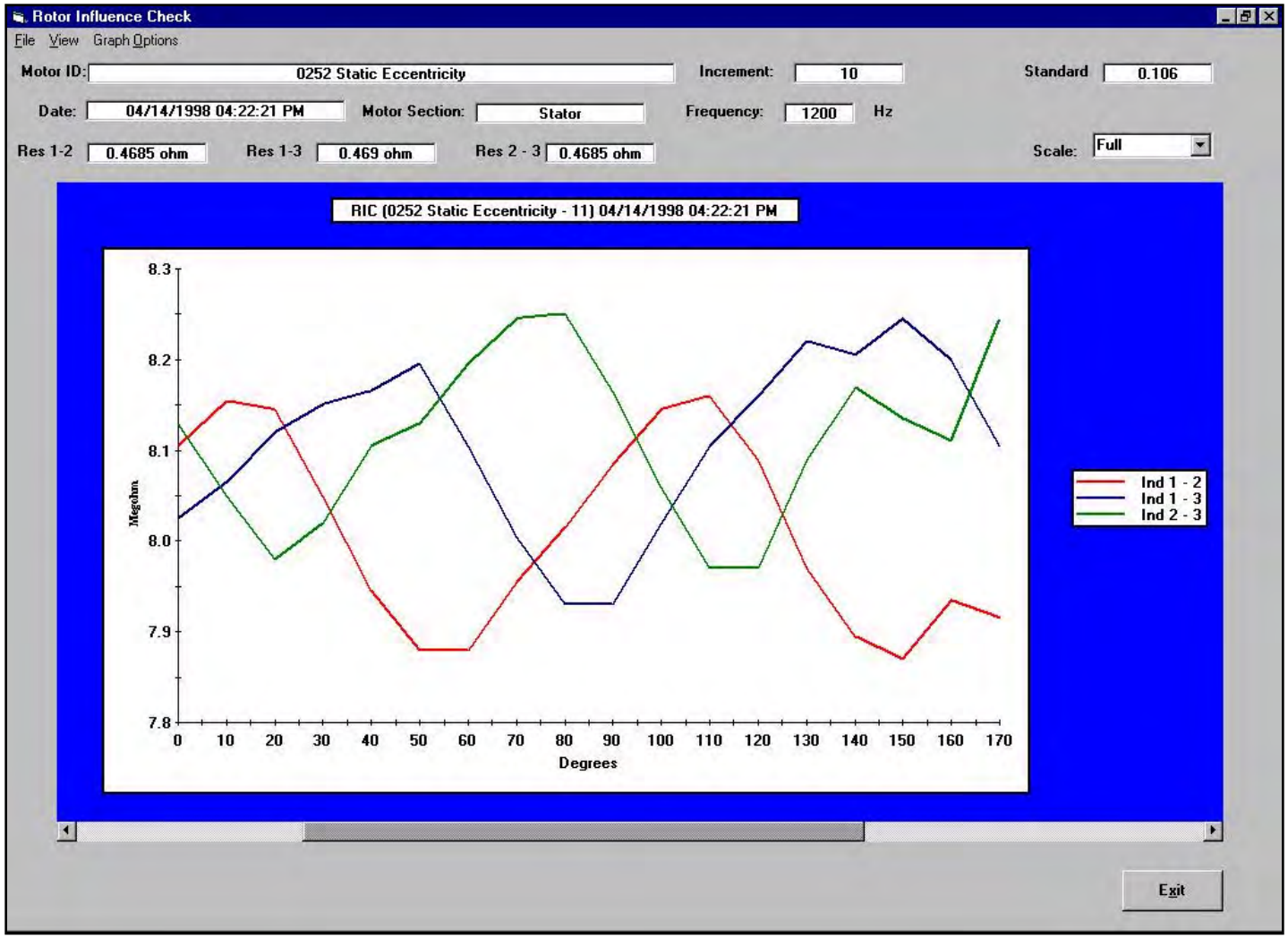
MCE Turn-to-Turn Short



MCE Broken Rotor bar



MCE Air Gap


Rotor Influence Check
File View Graph Options
Motor ID: 0252 Static Eccentricity
Increment: 10
Standard 0.106
Date: 04/14/1998 04:22:21 PM
Motor Section: Stator
Frequency: 1200 Hz
Res 1-2 0.4685 ohm
Res 1-3 0.469 ohm
Res 2 - 3 0.4685 ohm
Scale: Full
RIC (0252 Static Eccentricity - 11) 04/14/1998 04:22:21 PM
Megohm
8.3
8.2
8.1
8.0
7.9
7.8
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Degrees
Ind 1 - 2
Ind 1 - 3
Ind 2 - 3
Exit

MCE Detailed Report

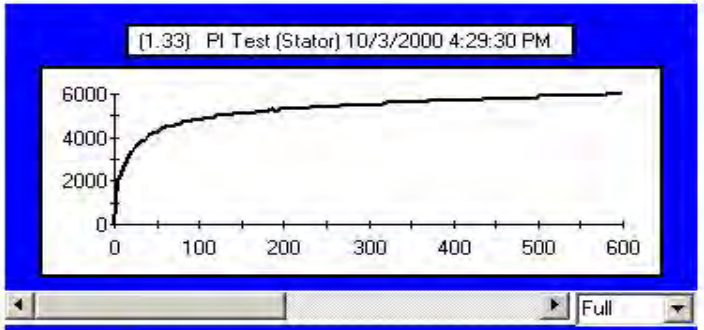
Default

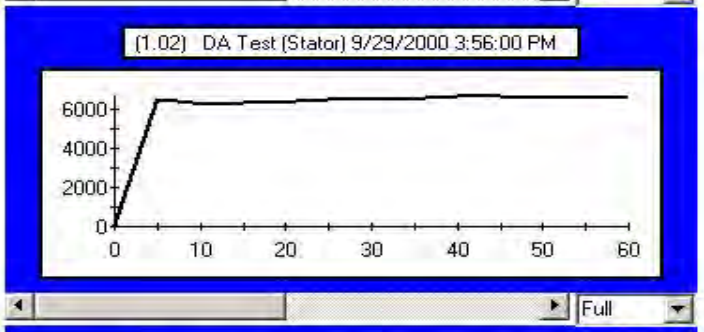
File Template Notes View

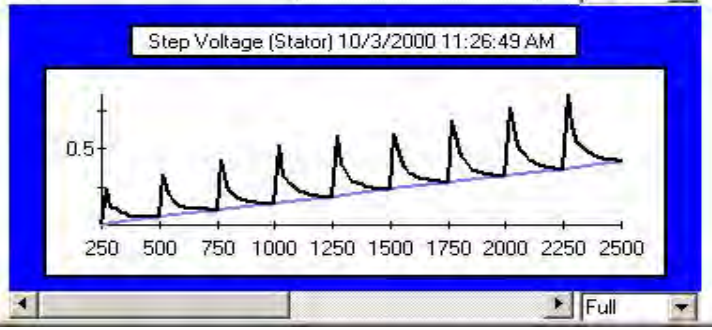
Report Title:		Motor ID:	125-96	Frame #:	XXX
Date:	12/26/2000	Voltage:	480	Stator Slots:	N/A
Submitted By:		HP:	5	Rotor Bars:	0
Chart Section	MCE Stator	FLA:	6.5		
Condition Code:	Good	Manufacturer:	MARATHON ELECTRIC		

Test Date	09/26/2000	09/26/2000	09/29/2000	09/29/2000	09/29/2000	10/03/2000	10/03/2000
Test Time	02:00:06 PM	11:31:21 AM	04:36:50 PM	03:53:01 PM	04:27:24 PM	02:54:41 AM	04:11:29 PM
	Baseline						
Frequency	1200	1200	1200	1200	1200	1200	1200
Mohm Ph 1 to Gnd							
Charge Time	60	60	60	60	60	60	60
Voltage	1000	500	500	5000	5000	5000	2500
Motor Temp	22	22	22	22	22	22	22
Measured Mohm	OVR (MCE)	OVR (MS)	5900.0	1720000.0	4500.0	3300.0	4000.0
Corrected Mohm	OVR (MCE)	86100.0	1500.0	439900.0	1300.0	950.0	1100.0
pF Ph 1 to Gnd	6750	6750	6750	6750	6750	6750	6750
ohm Ph 1 to 2	2.54500	2.53500	2.54000	2.55900	2.55900	2.54000	2.54500
ohm Ph 1 to 3	2.54000	2.53500	2.54000	2.55500	2.55500	2.54000	2.54500
ohm Ph 2 to 3	2.54000	2.53600	2.54000	2.55900	2.55900	2.54000	2.54900
mH Ph 1 to 2	23.740	23.500	23.480	23.740	23.730	23.670	23.570
mH Ph 1 to 3	23.500	23.490	23.430	23.440	23.430	23.370	23.530
mH Ph 2 to 3	23.510	23.830	23.810	23.810	23.600	23.540	23.650
Avg. Inductance	23.583	23.607	23.573	23.607	23.587	23.527	23.600
% Res. Imbalance	0.13	0.00	0.00	0.00	0.00	0.00	0.00
% Ind. Imbalance	0.66	0.99	1.00	0.66	0.66	0.67	0.21
$ Power Loss	0.22	0.00	0.00	0.00	0.00	0.00	0.00
Test Location	Motor Leads	N / A	Motor Leads	Main Disc	Main Disc	Main Disc	Motor Leads
MCE #	030395	030395HV	030395HV	030395HV	030395HV	030395HV	030395HV
User	PHIL	PHIL	PHIL	PHIL	PHIL	PHIL	PHIL
Notes	No	No	No	No	No	No	No

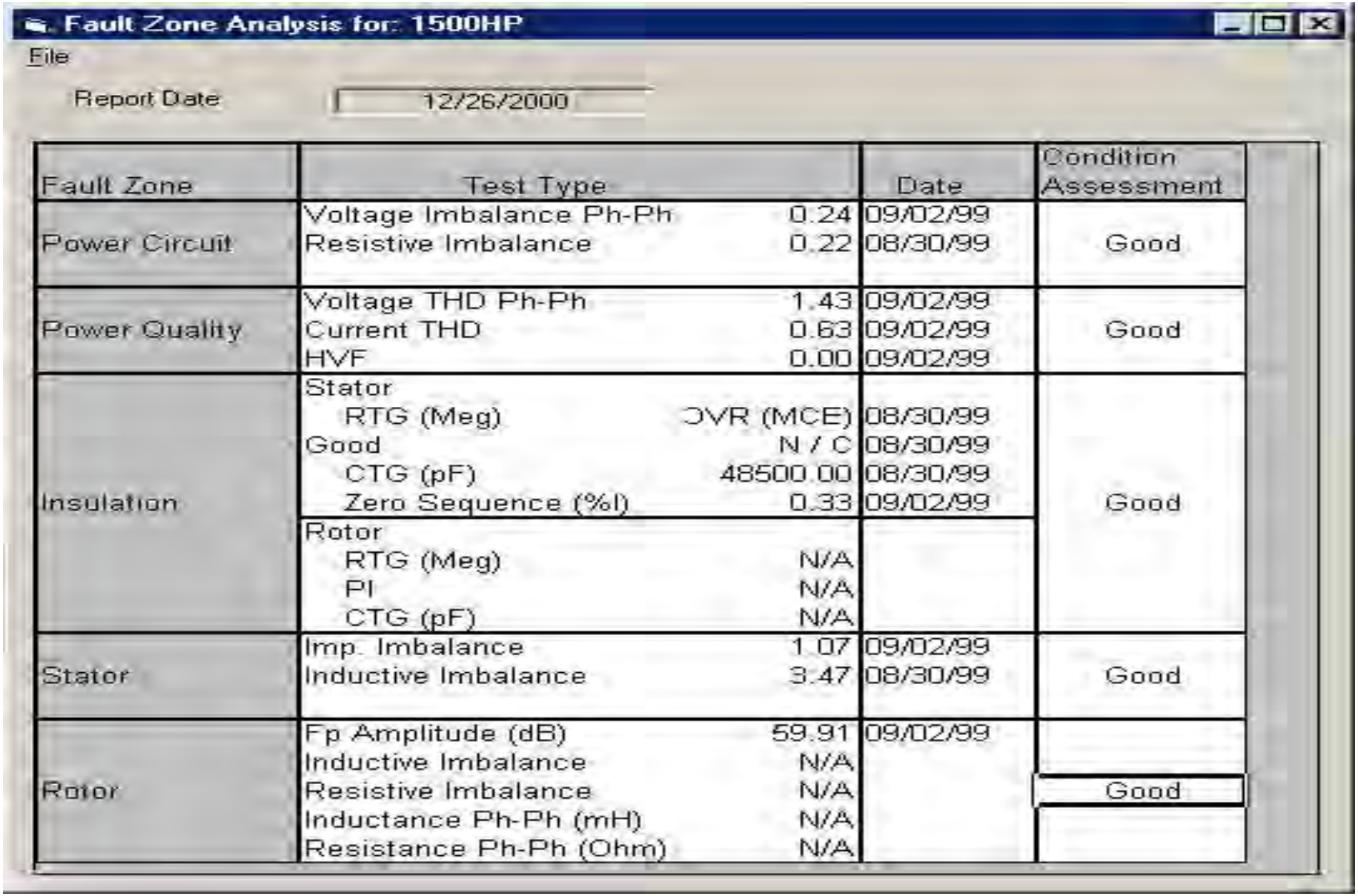
One example of how customizable the Detailed Report is.







Fault Zone Analysis Report



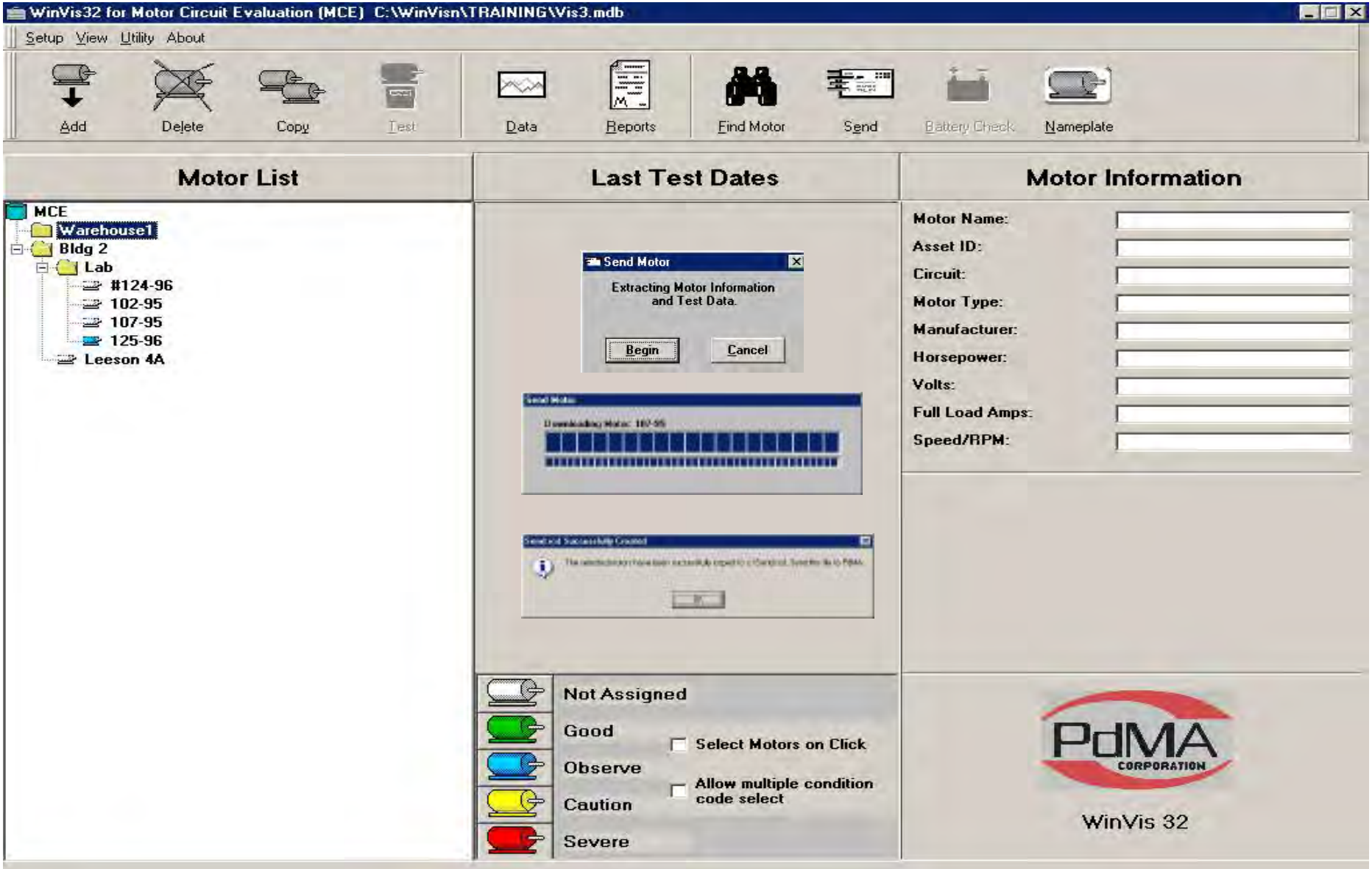
Fault Zone Analysis for: 1500HP

File

Report Date: 12/26/2000

Fault Zone	Test Type		Date	Condition Assessment
Power Circuit	Voltage Imbalance Ph-Ph	0.24	09/02/99	Good
	Resistive Imbalance	0.22	08/30/99	
Power Quality	Voltage THD Ph-Ph	1.43	09/02/99	Good
	Current THD	0.63	09/02/99	
	HVF	0.00	09/02/99	
Insulation	Stator			Good
	RTG (Meg)	OVR (MCE)	08/30/99	
	Good	N / C	08/30/99	
	CTG (pF)	48500.00	08/30/99	
	Zero Sequence (%I)	0.33	09/02/99	
	Rotor			
	RTG (Meg)	N/A		
	PI	N/A		
	CTG (pF)	N/A		
Stator	Imp. Imbalance	1.07	09/02/99	Good
	Inductive Imbalance	3.47	08/30/99	
Rotor	Fp Amplitude (dB)	59.91	09/02/99	Good
	Inductive Imbalance	N/A		
	Resistive Imbalance	N/A		
	Inductance Ph-Ph (mH)	N/A		
	Resistance Ph-Ph (Ohm)	N/A		

Send Feature



Motor Cleared

MCE testing shows that many times the motor is not the problem; possible sources include:

- Power circuit
- Faulty load
- Improper application

Case Study

- Motor would trip on start-up (soft start)
- Decision made to replace starter at close to $50,000
- After starter replacement, the motor continued to trip
- MCE testing performed

Read-Only Nameplate	
Motor ID:	High Flow Pum
Circuit:	P-4
Location:	MCE\Ottawa R
Motor Type:	AC Induction
Mfg Name: U.S. ELECTRIC	
Volts:	575
HP:	125
KW:	93.25
FLA:	119
Operating Speed:	1775
Min./Base Speed:	
Installed:	
Efficiency:	.9
Frame #:	405T DP
Ins Type:	B
Svc Factor:	1.15
Pwr Factor:	.85
Field Volts:	
Field Current:	
# Poles:	

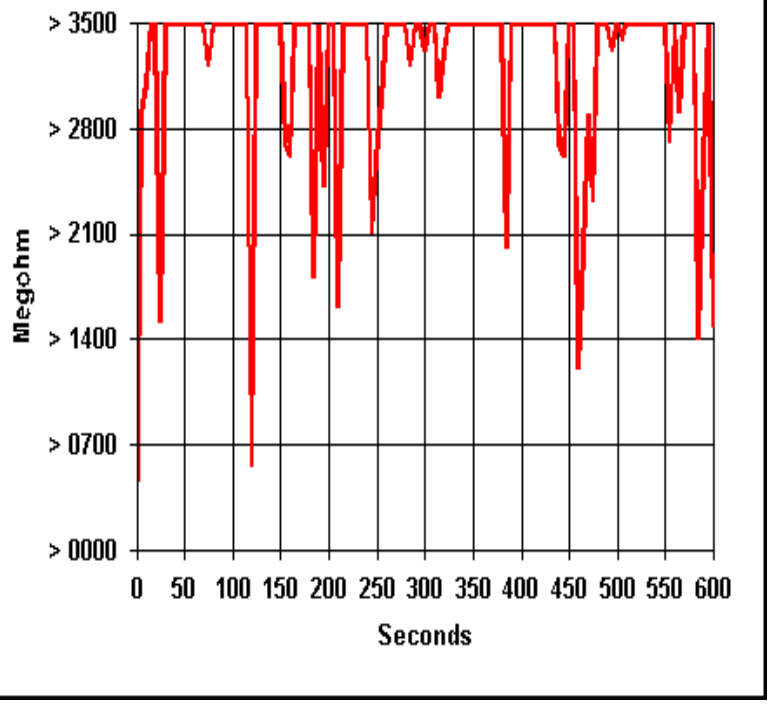
MCE Results

Test Date	10/15/1997
Test ID:	579
Frequency	1200
	BASELINE
Mohm Ph 1 to Gnd	
Charge Time	30
Voltage	1000
Motor Temp	20
Measured Mohm	>2000
Corrected Mohm	OVR
pF Ph 1 to Gnd	14500
ohm Ph 1 to 2	0.12300
ohm Ph 1 to 3	0.12400
ohm Ph 2 to 3	0.12500
mH Ph 1 to 2	6.275
mH Ph 1 to 3	5.290
mH Ph 2 to 3	4.430
% Res. Imbalance	0.81
% Ind. Imbalance	17.69
$ Power Loss	32.22

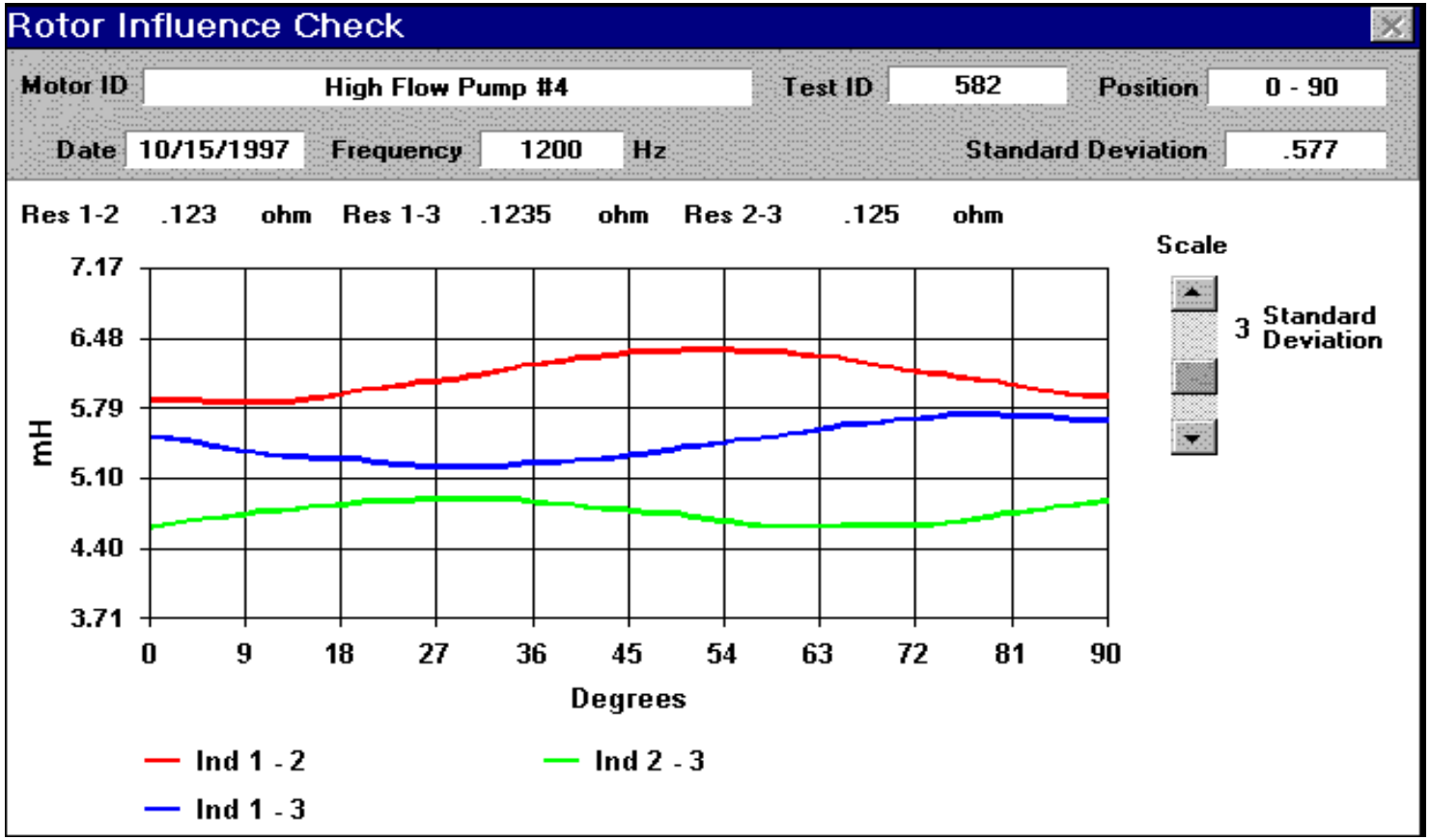
PI Test for Motor ID: High Flow Pump #4, Test ID: 578

Dielectric Absorption: N/C | Polarization Index: .15 | Motor Section: Stator

Time	Megohm
5	2900.00
10	3100.00
15	>3500
20	>3500
25	1500.00
30	>3500
35	>3500
40	>3500
45	>3500
50	>3500
55	>3500
60	>3500
65	>3500
70	>3500
75	3200.00
80	>3500
85	>3500
90	>3500
95	>3500
100	>3500



MCE Results


Rotor Influence Check
Motor ID
High Flow Pump #4
Test ID
582
Position
0 - 90
Date
10/15/1997
Frequency
1200
Hz
Standard Deviation
.577
Res 1-2 .123 ohm
Res 1-3 .1235 ohm
Res 2-3 .125 ohm
Scale
3 Standard Deviation
7.17
6.48
5.79
5.10
4.40
3.71
mH
0 9 18 27 36 45 54 63 72 81 90
Degrees
Ind 1 - 2
Ind 2 - 3
Ind 1 - 3

Conclusion

- Multiple tests in one technology confirms stator problem
  - MCE
    - Polarization Index shows insulation break down, Standard test shows high inductive imbalance and RIC shows high inductive imbalance.

Emax (Dynamic Tester)

HARDWARE

Hardware

- Shipping Case
- Tester
- Accessory Bag

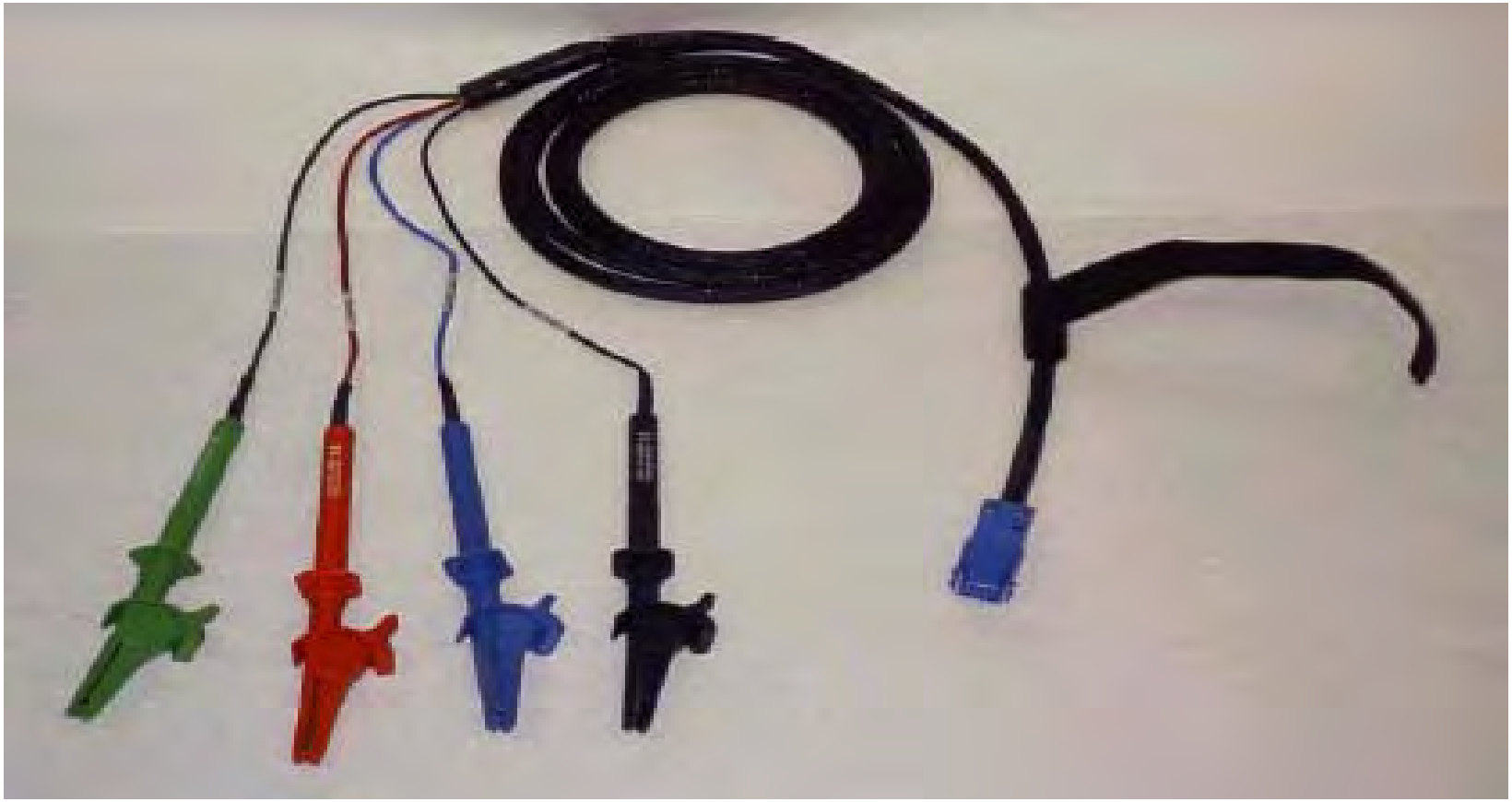
Shipping Case

Hardware

- **Component makeup**
  - Power supply
  - Battery Monitoring board
  - EMAX Tester board
  - Laptop computer
  - Durable carrying case
  - Accessory bag

EMAX Tester

Voltage Probes



Current Probes

EMAX Case

- Polymer Case
- Laptop computer
- RJ-45/serial port cable - Interface cable
- DAQ - Interface cable
- Current test leads - 3 phases
- Voltage test leads - 3 phases plus ground
- Tester battery – NiMH Camcorder battery
- Battery status display
- Tester board - Located under mold
- Power supply board - Located under mold
- Battery monitoring board - Located under mold

Capturing Current Signals

- Utilizes clamp-on current probes to acquire signals
  - No electrical connections need to be made
  - Equipment operation is not interrupted

Capturing Current Data

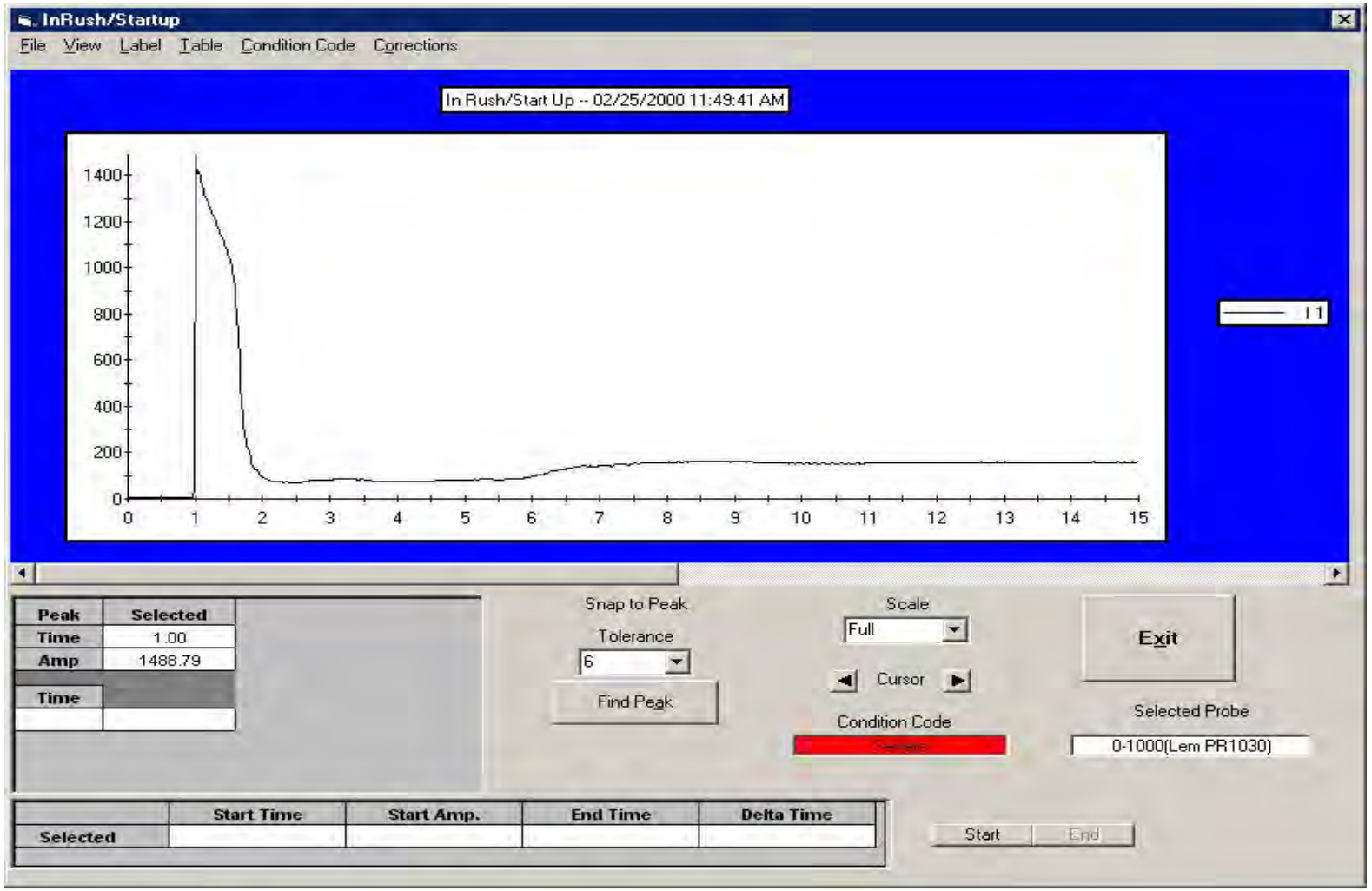
Current Analysis Fault Zones

- Rotor
  - In-Rush Startup (peak in-rush current and time to start motor)
  - Low and High Resolution (MCSA) (pole pass Frequency [F_P] sideband amplitude)
- Air Gap
  - Eccentricity (eccentricity peaks)

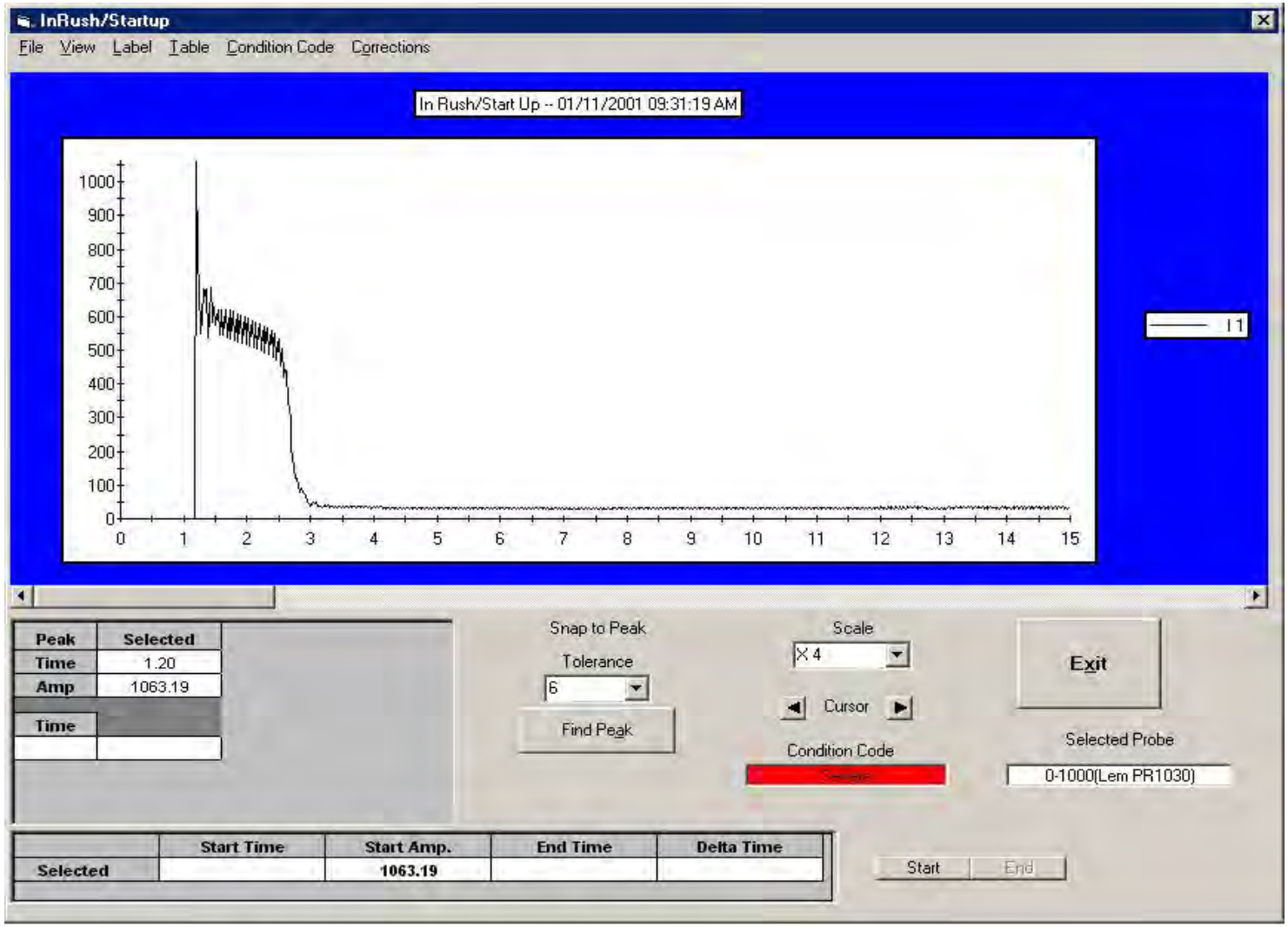
In-Rush Startup

- Perform as often as possible
- Provides valuable information when troubleshooting
- Stator and rotor problems cause changes in the In-Rush Startup profile
  - Peak current
  - Graph shape
  - Duration

In-Rush Startup Manual Capture



In-Rush Startup Auto Capture Broken Bars

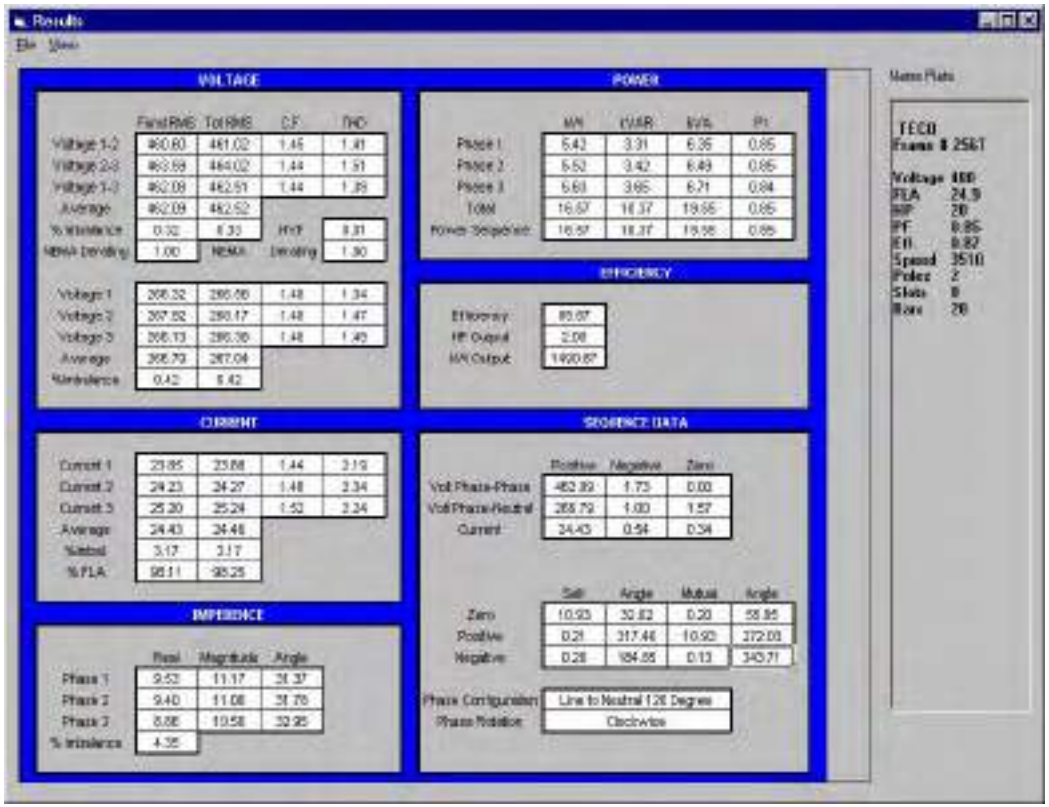


Power Quality

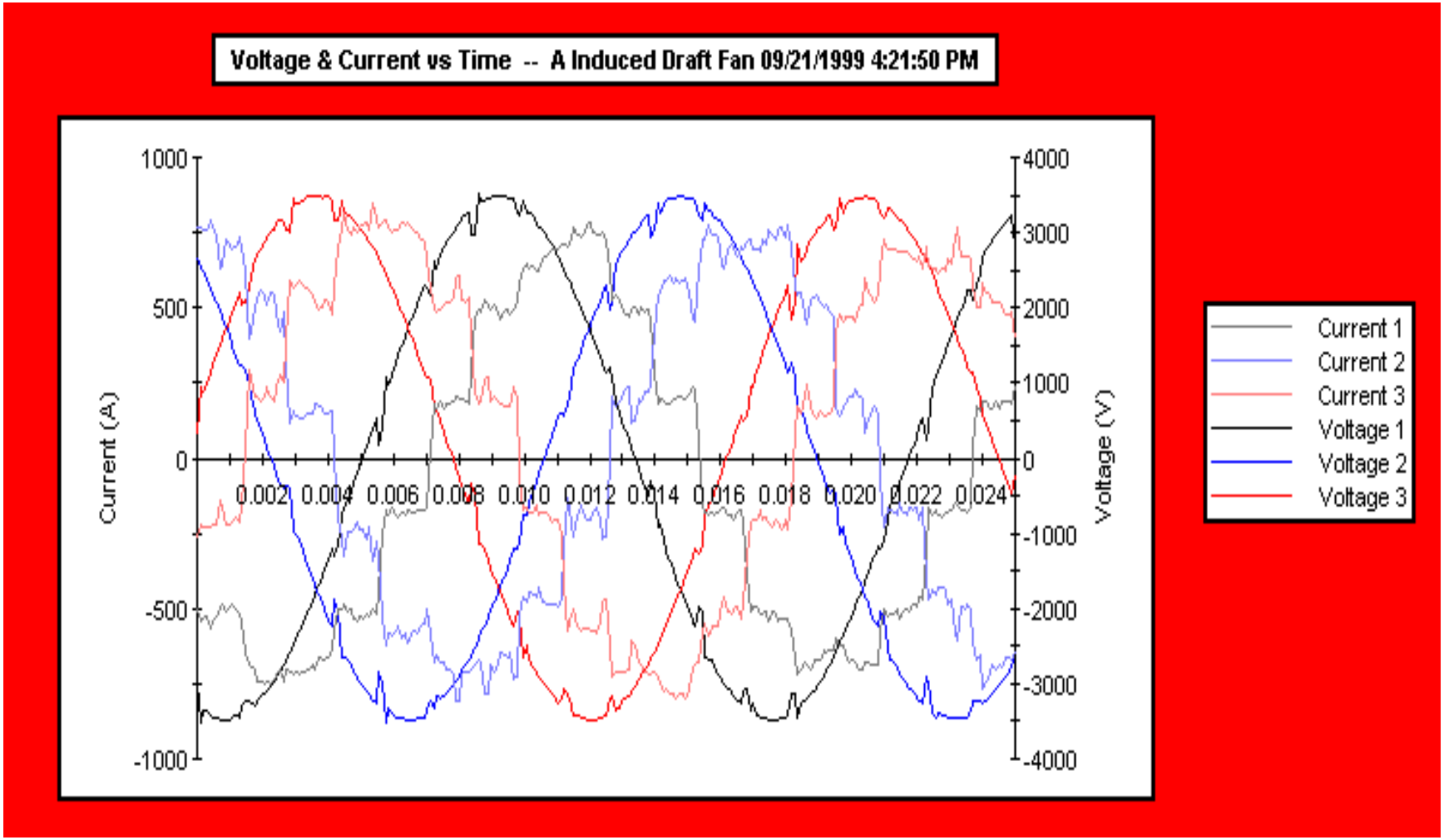
- Voltage and current values
- Voltage and current unbalance
- Voltage and current THD (Total Harmonic Distortion)
- Voltage and current crest factor
- System harmonics

EMAX

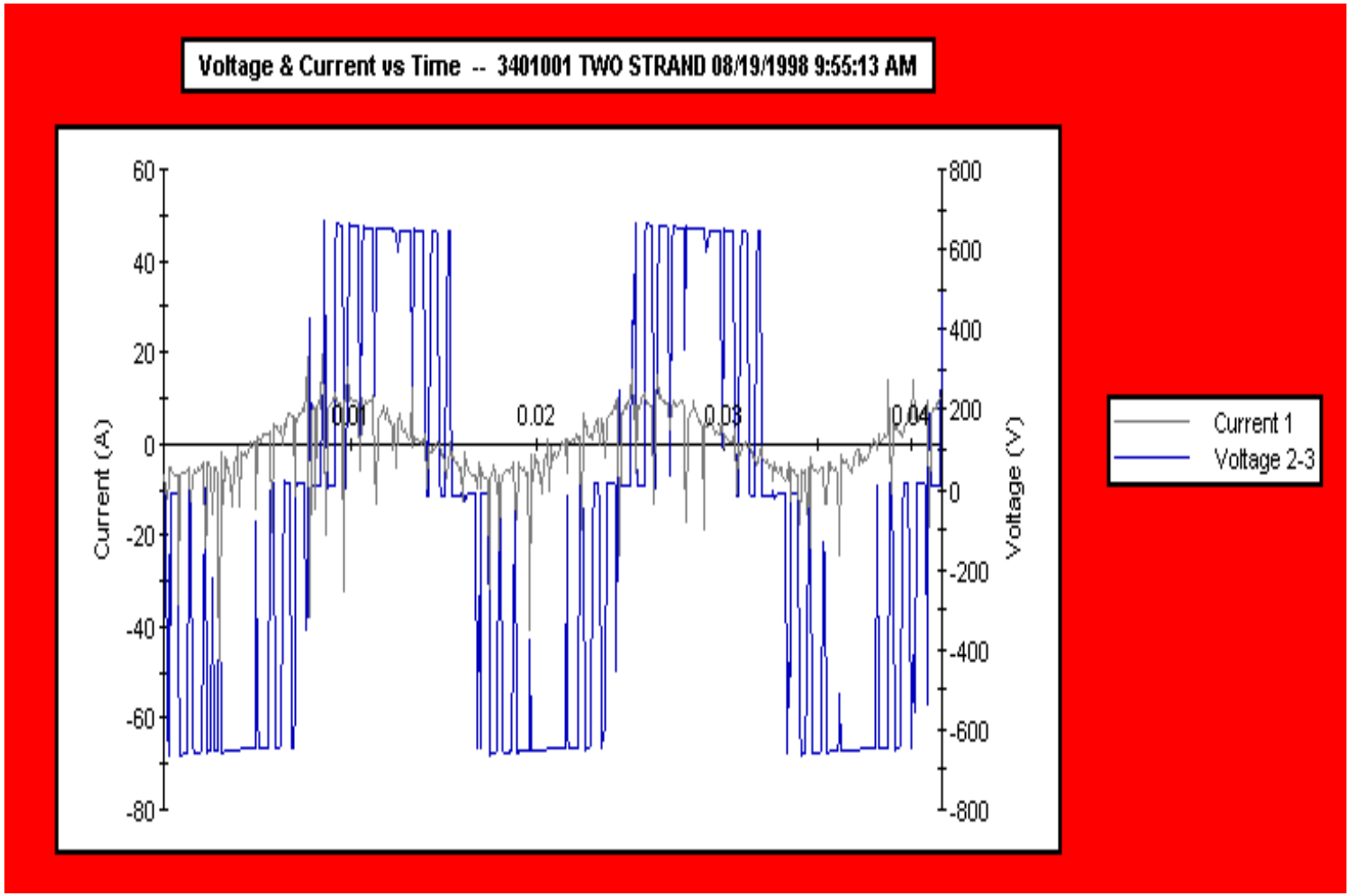
- 5 Second route based test
- Provides complete power data
  - Voltage quality
  - Current quality
  - Power information
  - Efficiency
  - Impedance



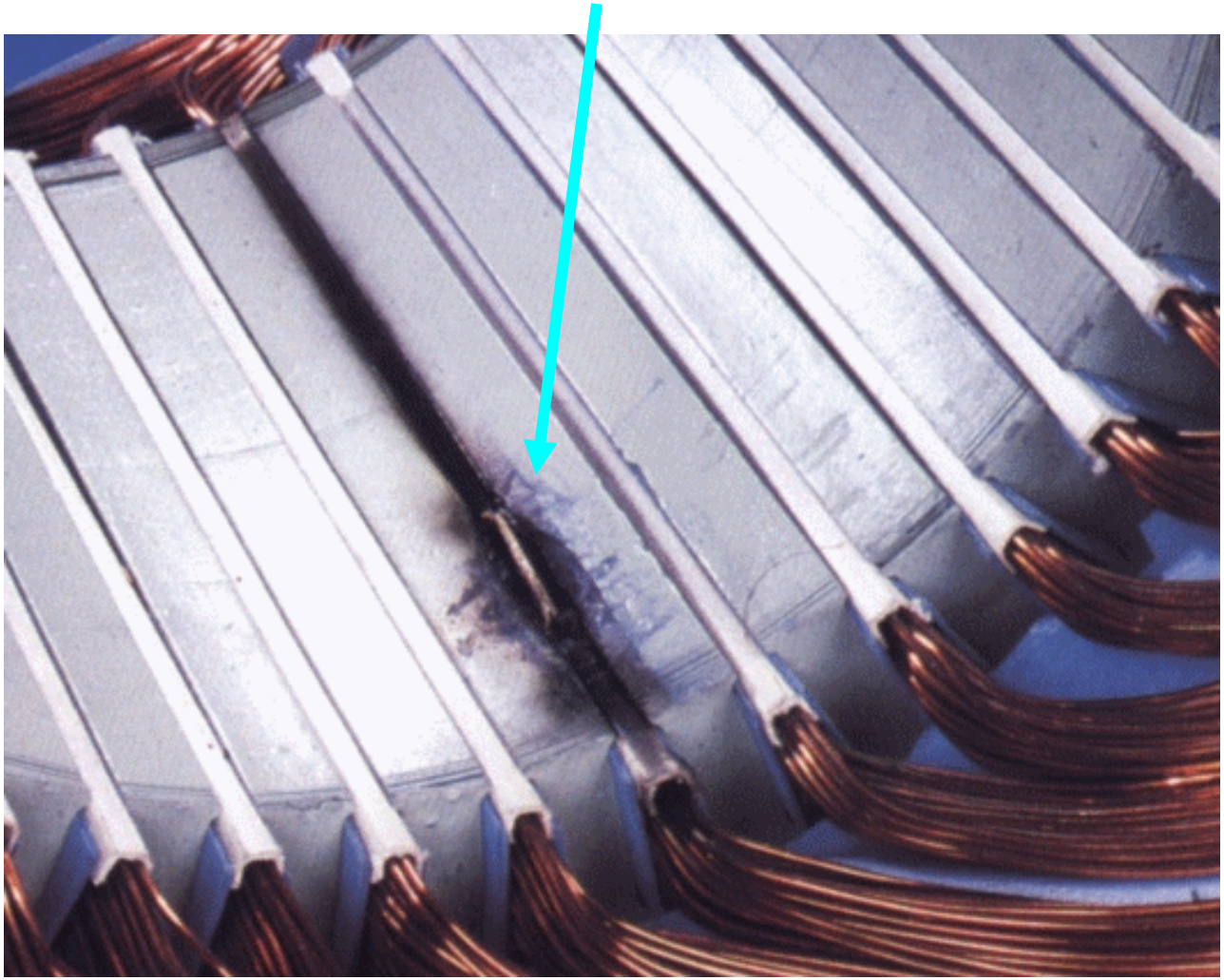
SCR (Silicon Control Rectifier) VFD Variable Frequency Drives



Pulse Width Modulated Inverter



Problems Associated With VFDs



Power Circuit

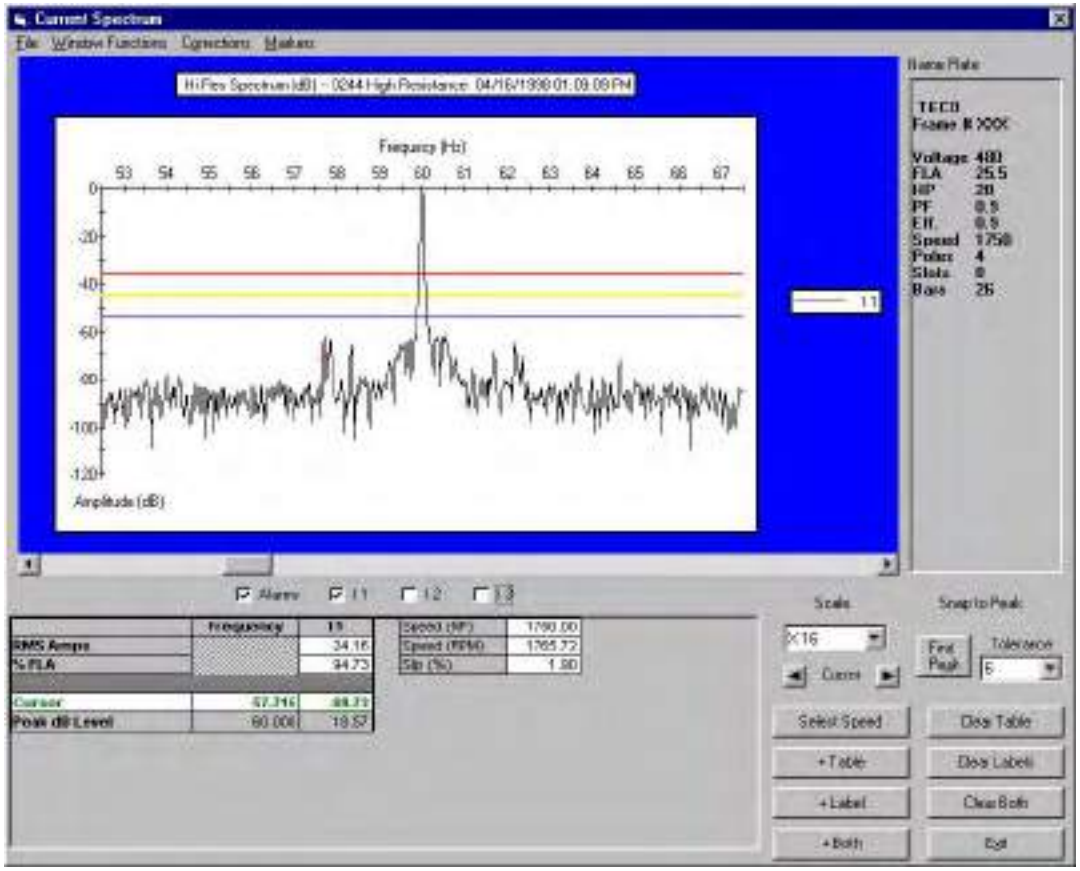
- High resistance connections
  - At the starter
  - At the local disconnect
  - At the motor connection box
- Defective Pf correction capacitors
- Defective cabling
- Defective contact surfaces

Low/High Resolution (MCSA) Tests

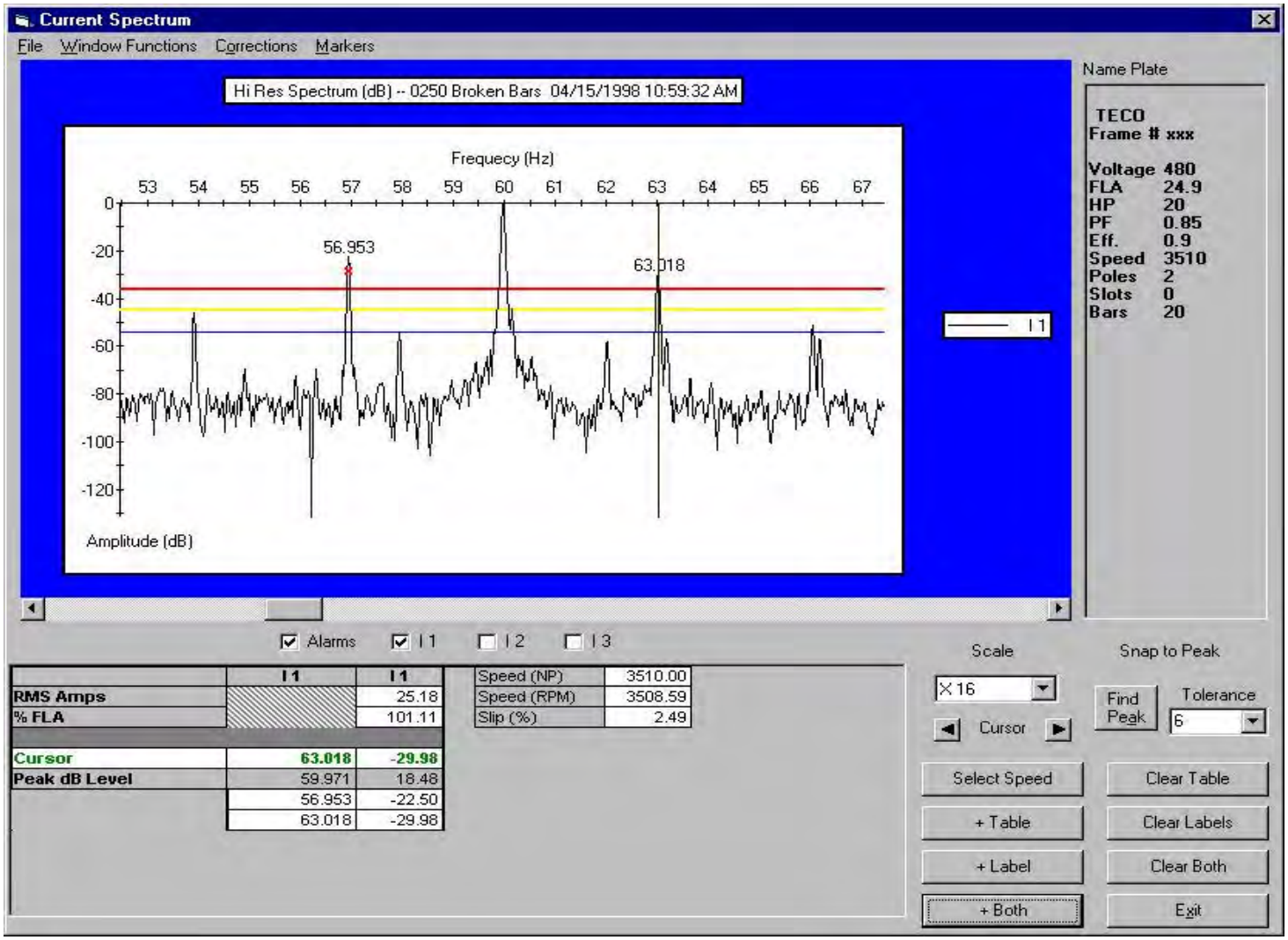
- Low Res. 0-480 Hz, 17 seconds
- High Res. 0-240 Hz, 34 seconds
- Determine amplitude of pole pass frequency (F_P) sidebands
- Uses speed of motor to identify pole pass frequency (F_P) sidebands

Emax

- High and Low resolution
- Data can be trended
- Pole pass amplitude comparison - rule of 4 & 5
- High Resolution
  - FMAX = 240
  - .03 Hz Resolution Steps
  - 480 Sample/Sec
- Low Resolution
  - FMAX = 480
  - .06 Hz Resolution Steps
  - 960 Samples/Sec

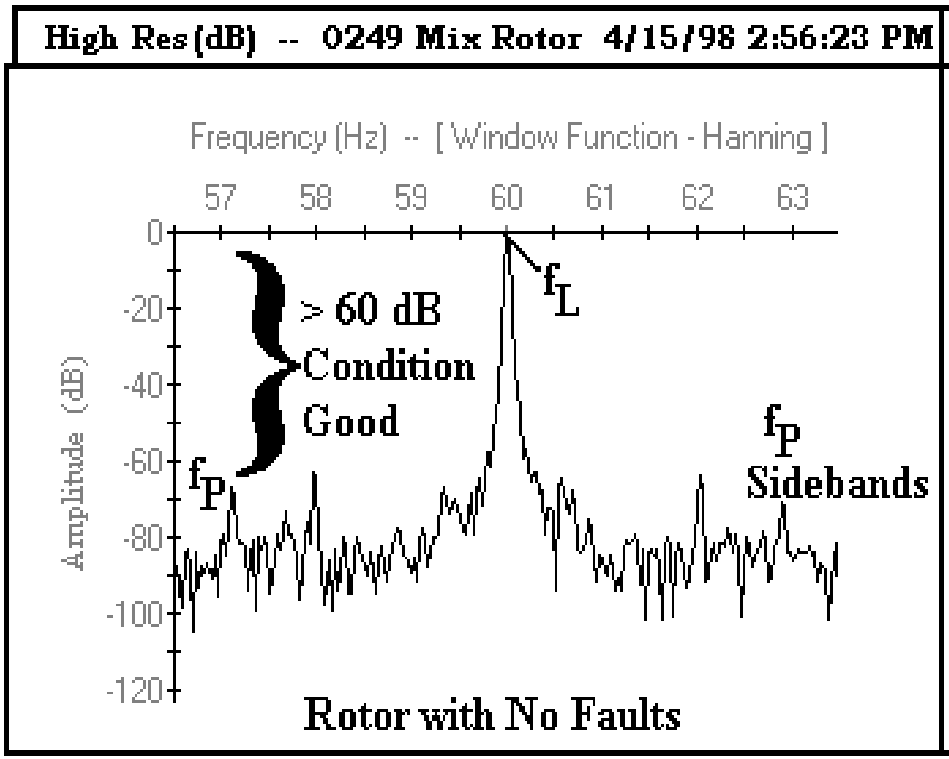


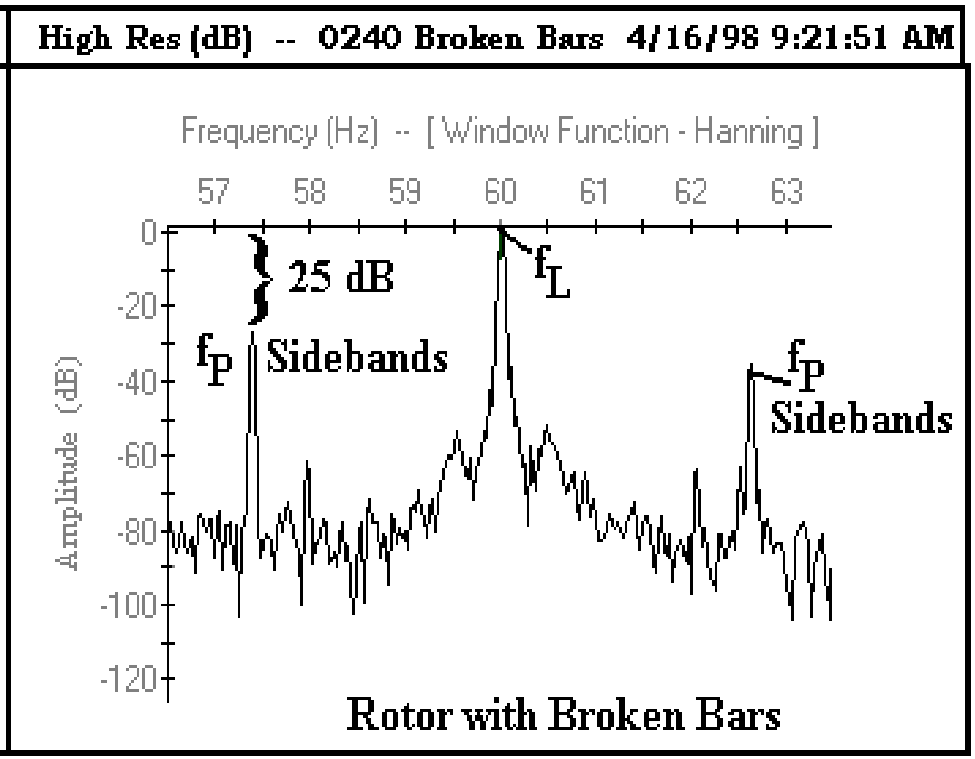
Emax


Current Spectrum
File
Window Functions
Corrections
Markers
Hi Res Spectrum (dB) -- 0250 Broken Bars 04/15/1998 10:59:32 AM
Frequecy (Hz)
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67
0 -20 -40 -60 -80 -100 -120
56.953
63.018
Amplitude (dB)
I 1
Name Plate
TECO
Frame # xxx
Voltage 480
FLA 24.9
HP 20
PF 0.85
Eff. 0.9
Speed 3510
Poles 2
Slots 0
Bars 20
Alarms
I 1
I 2
I 3
I 1 I 1
RMS Amps 25.18
% FLA 101.11
Cursor 63.018 -29.98
Peak dB Level 59.971 18.48
56.953 -22.50
63.018 -29.98
Speed (NP) 3510.00
Speed (RPM) 3508.59
Slip (%) 2.49
Scale
X 16
Cursor
Snap to Peak
Find Peak
Tolerance
6
Select Speed
Clear Table
+ Table
Clear Labels
+ Label
Clear Both
+ Both
Exit

Rotor Evaluation

Evaluating the FFT Spectrum



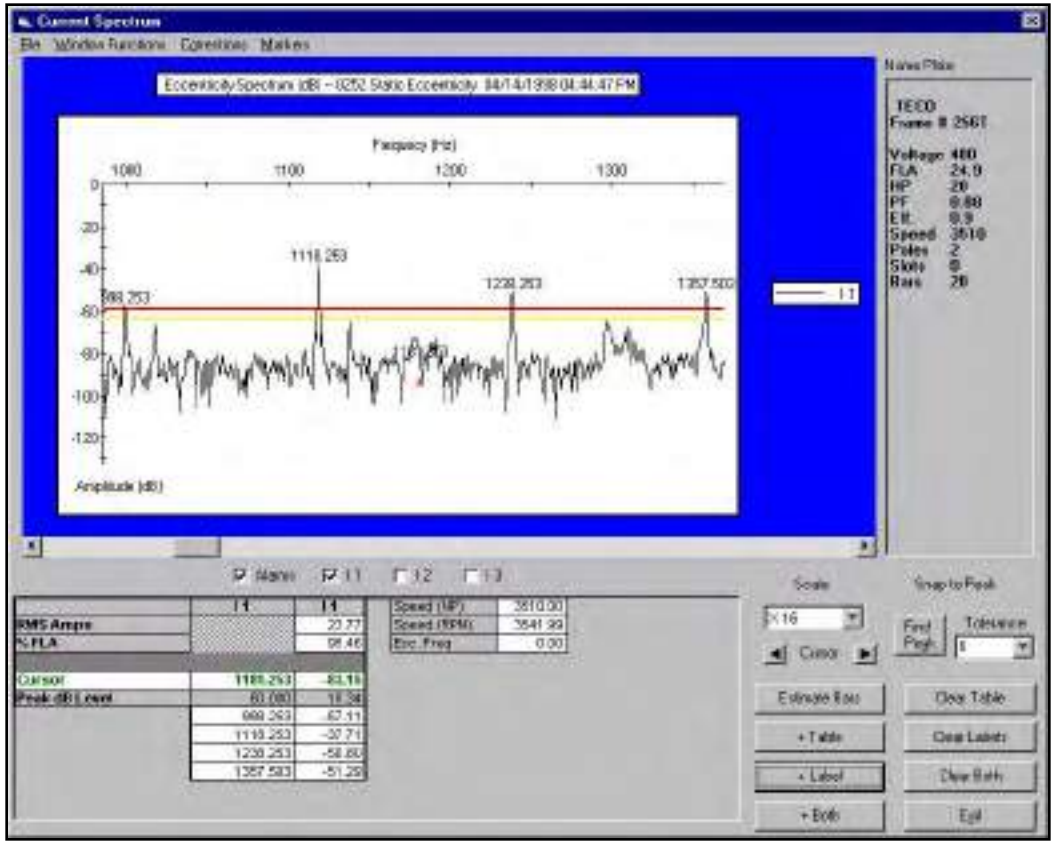


Air Gap

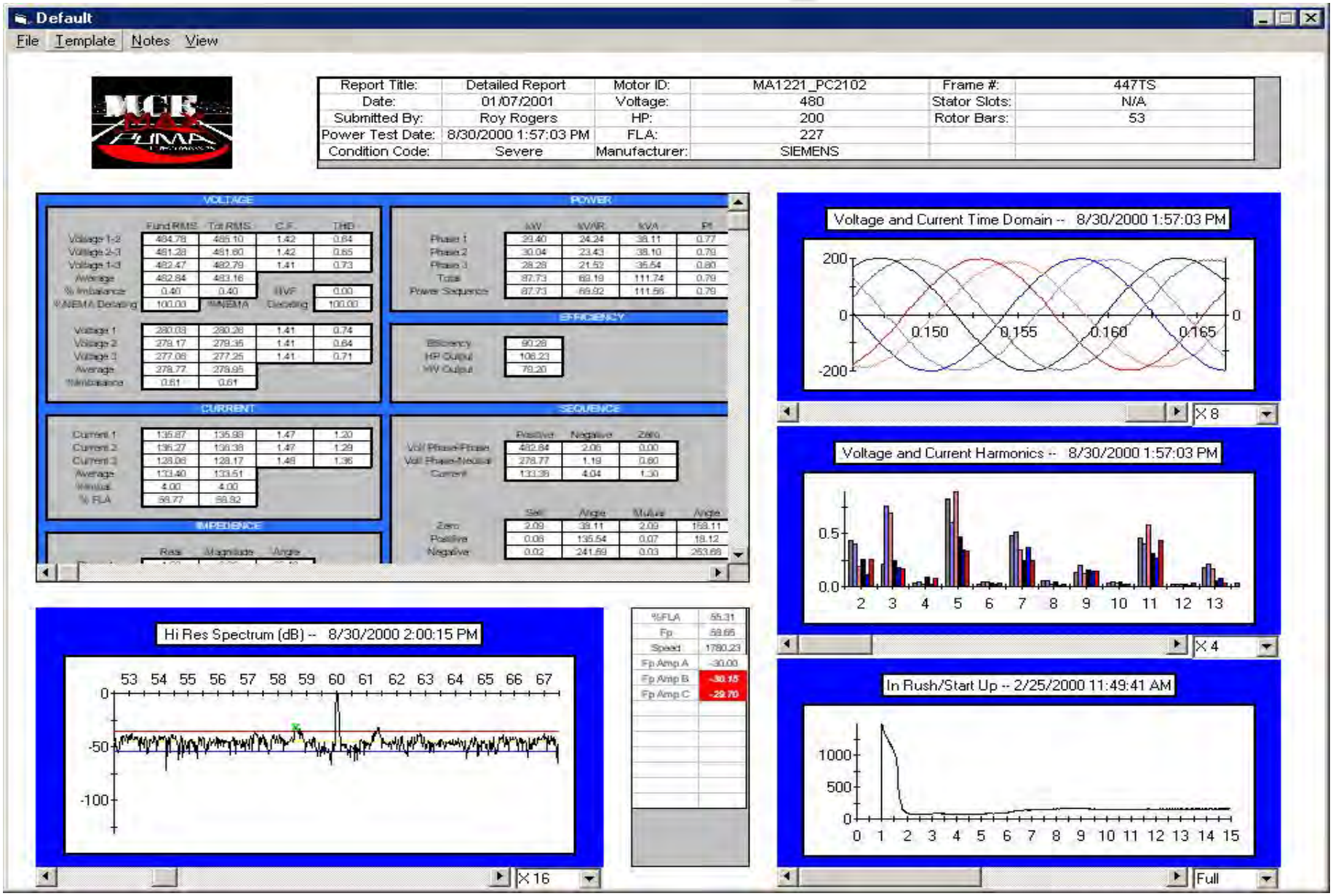
- Eccentricity
  - Dynamic
  - Static
- Causes
  - Warped or bowed rotors
  - Cocked end bells
  - Misalignment

Emax

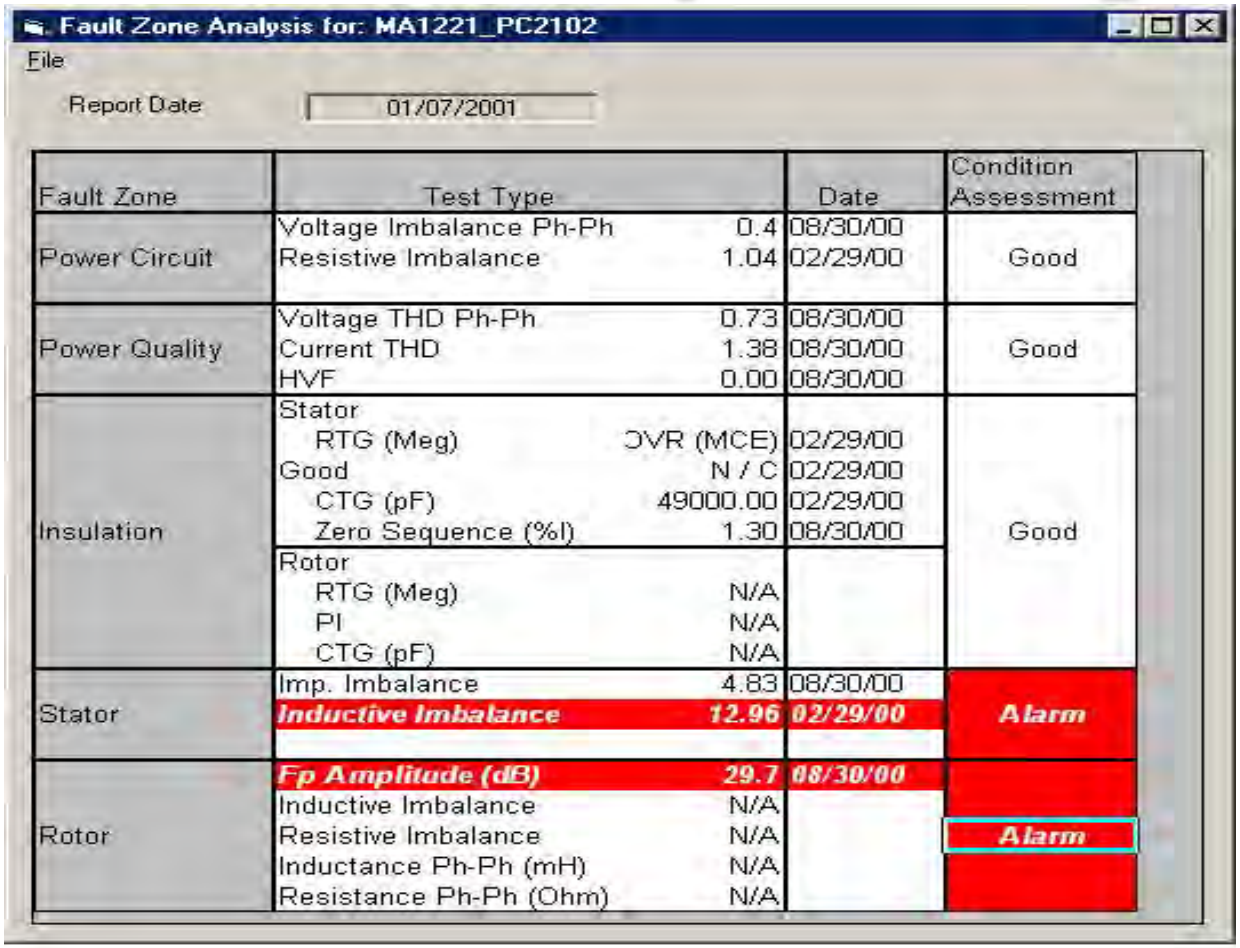
- Looks for static or dynamic eccentricity
- Eccentricity frequency determined by # rotor bars X speed
- Searches for 1st and 3rd of FL sidebands of eccentricity frequency
- 20 db above noise level is cause for concern



EMAX Detailed Report



Fault Zone Analysis Report



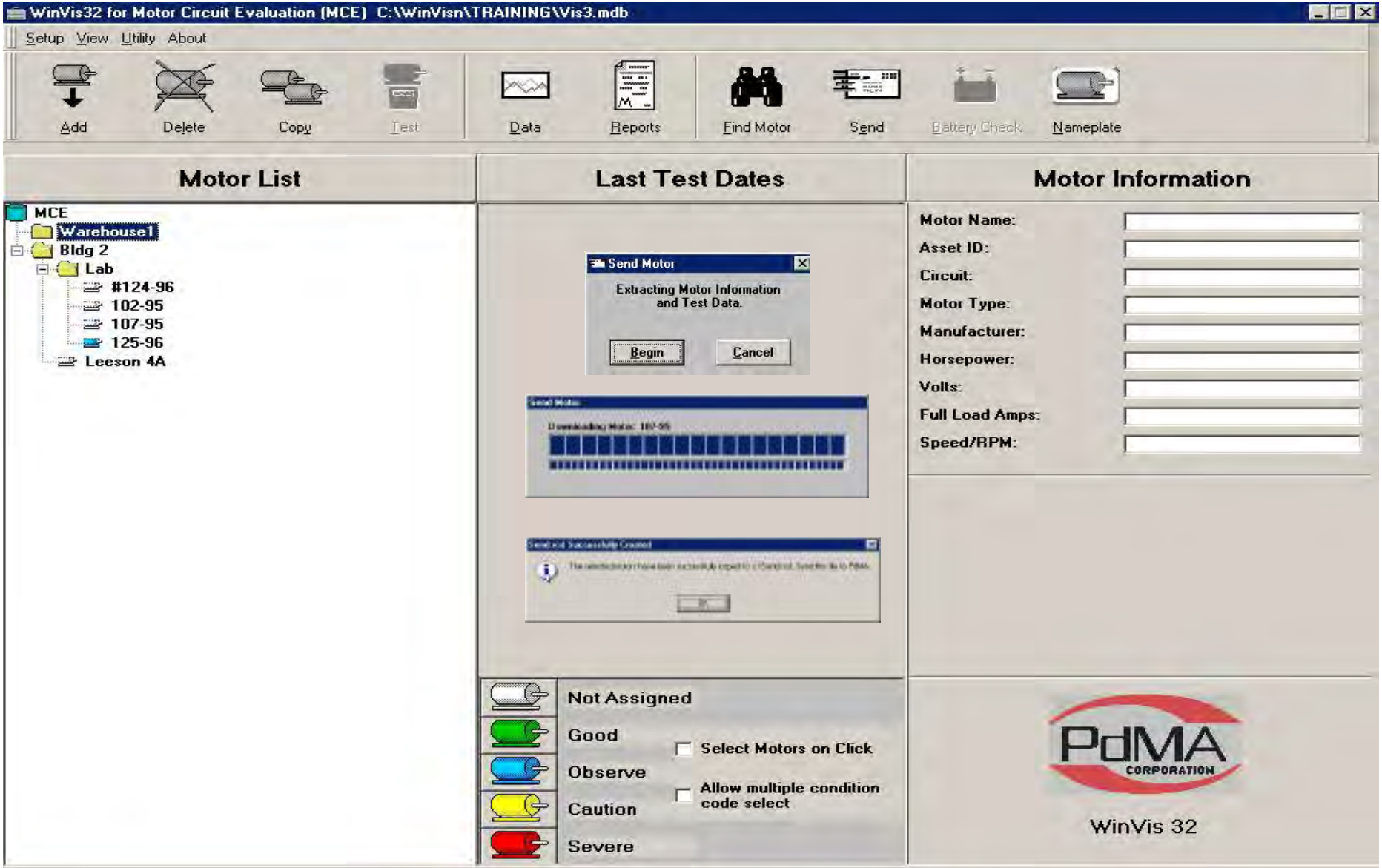
Fault Zone Analysis for: MA1221_PC2102

File

Report Date: 01/07/2001

Fault Zone	Test Type		Date	Condition Assessment
Power Circuit	Voltage Imbalance Ph-Ph	0.4	08/30/00	Good
	Resistive Imbalance	1.04	02/29/00	
Power Quality	Voltage THD Ph-Ph	0.73	08/30/00	Good
	Current THD	1.38	08/30/00	
	HVF	0.00	08/30/00	
Insulation	Stator			Good
	RTG (Meg)	OVR (MCE)	02/29/00	
	Good	N / C	02/29/00	
	CTG (pF)	49000.00	02/29/00	
	Zero Sequence (%I)	1.30	08/30/00	
	Rotor			
	RTG (Meg)	N/A		
	PI	N/A		
	CTG (pF)	N/A		
Stator	Imp. Imbalance	4.83	08/30/00	Alarm
	Inductive Imbalance	*12.96*	*02/29/00*	
Rotor	*Fp Amplitude (dB)*	*29.7*	*08/30/00*	Alarm
	Inductive Imbalance	N/A		
	Resistive Imbalance	N/A		
	Inductance Ph-Ph (mH)	N/A		
	Resistance Ph-Ph (Ohm)	N/A		

Send Feature



Motor Cleared

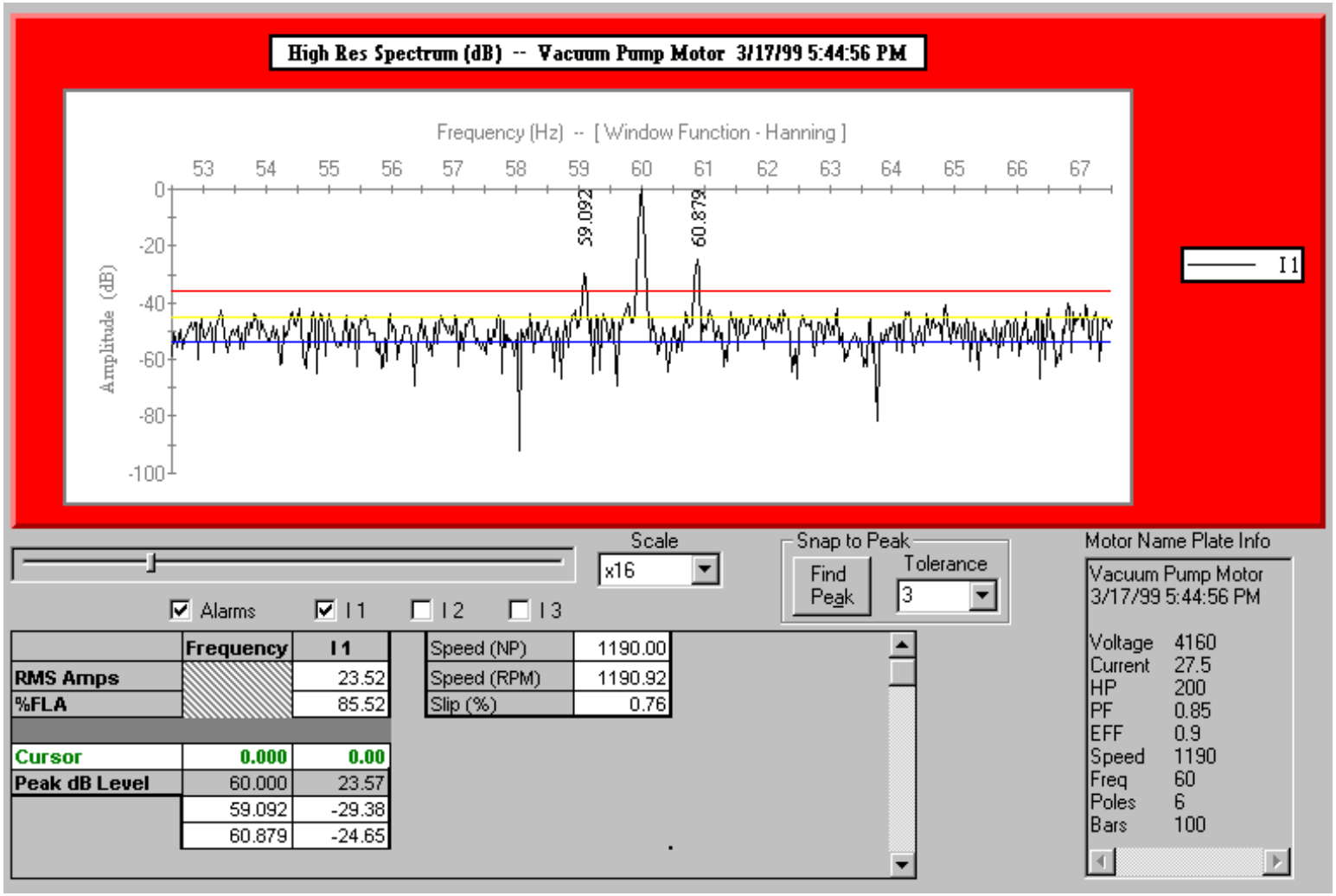
- EMAX testing can help to show that problems in a motor circuit are being caused by:
  - **Poor power quality**
  - **Power circuit faults**
  - **Faulty motor load**
  - **Improper application**
- Always perform other testing to confirm the problem.

Case Study

- Motor was running at high temperatures
- Vibration levels were above normal but not conclusive
- Dynamic Testing performed from the CTs

Motor ID:	Vacuum Pump Motor
Circuit:	
Volts:	4160
Horsepower:	200
Manufacturer:	LOUIS ALLIS
Motor Type:	AC Induction
Condition:	Not Assigned

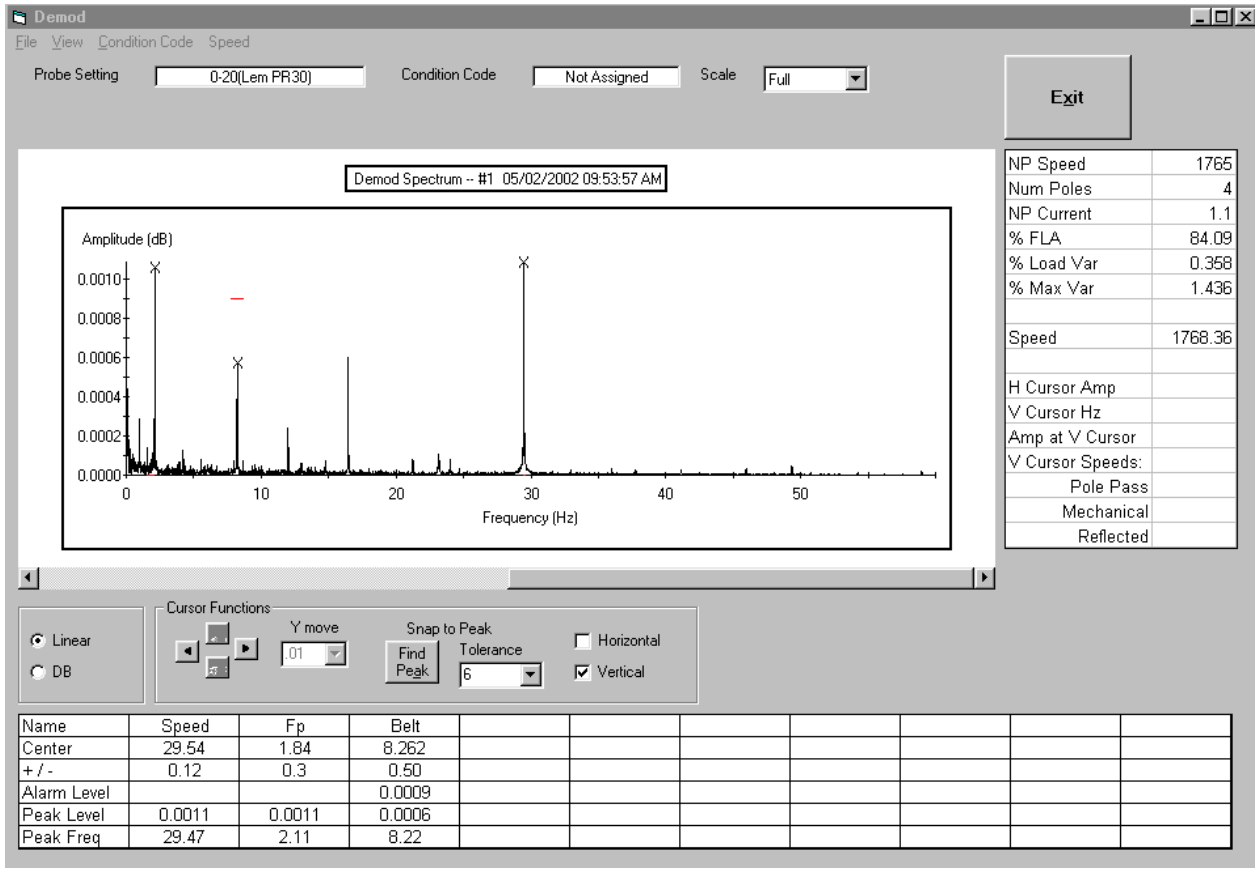
Emax Results



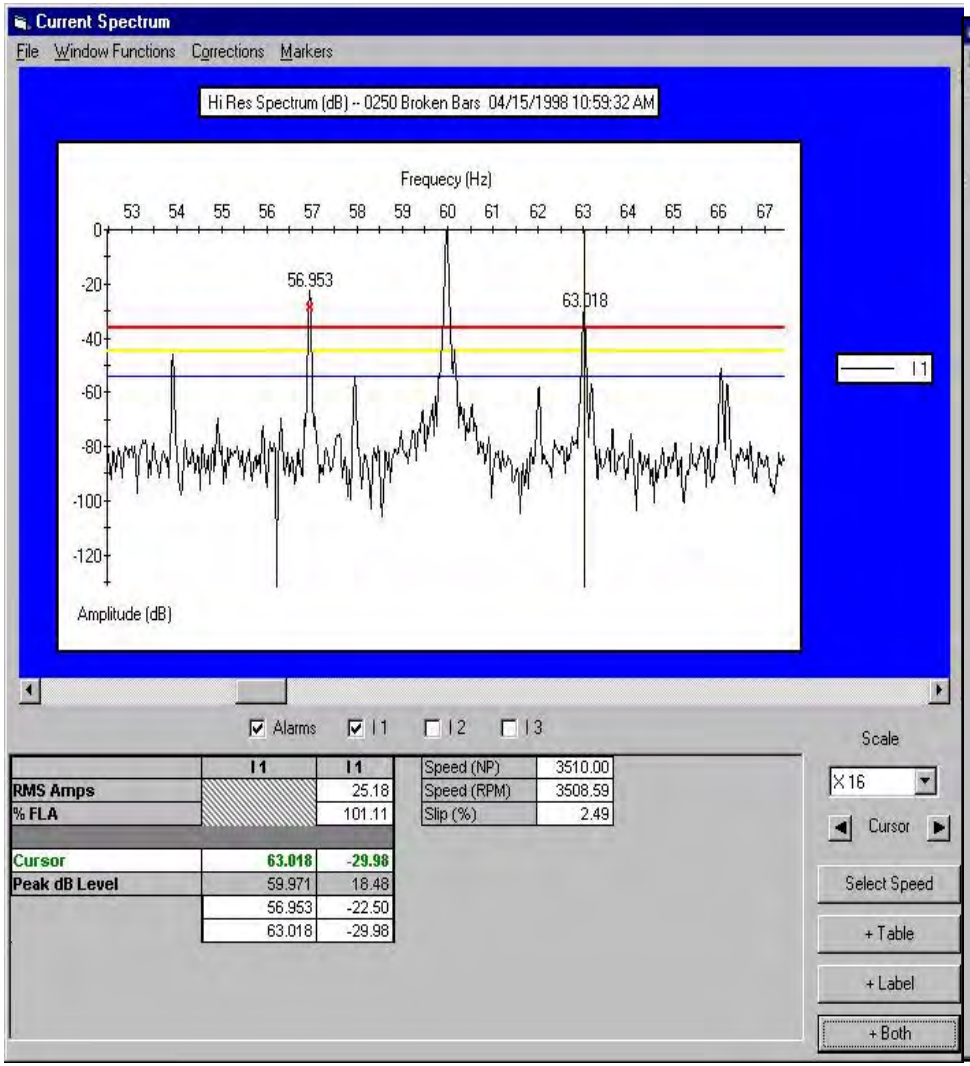
Conclusion

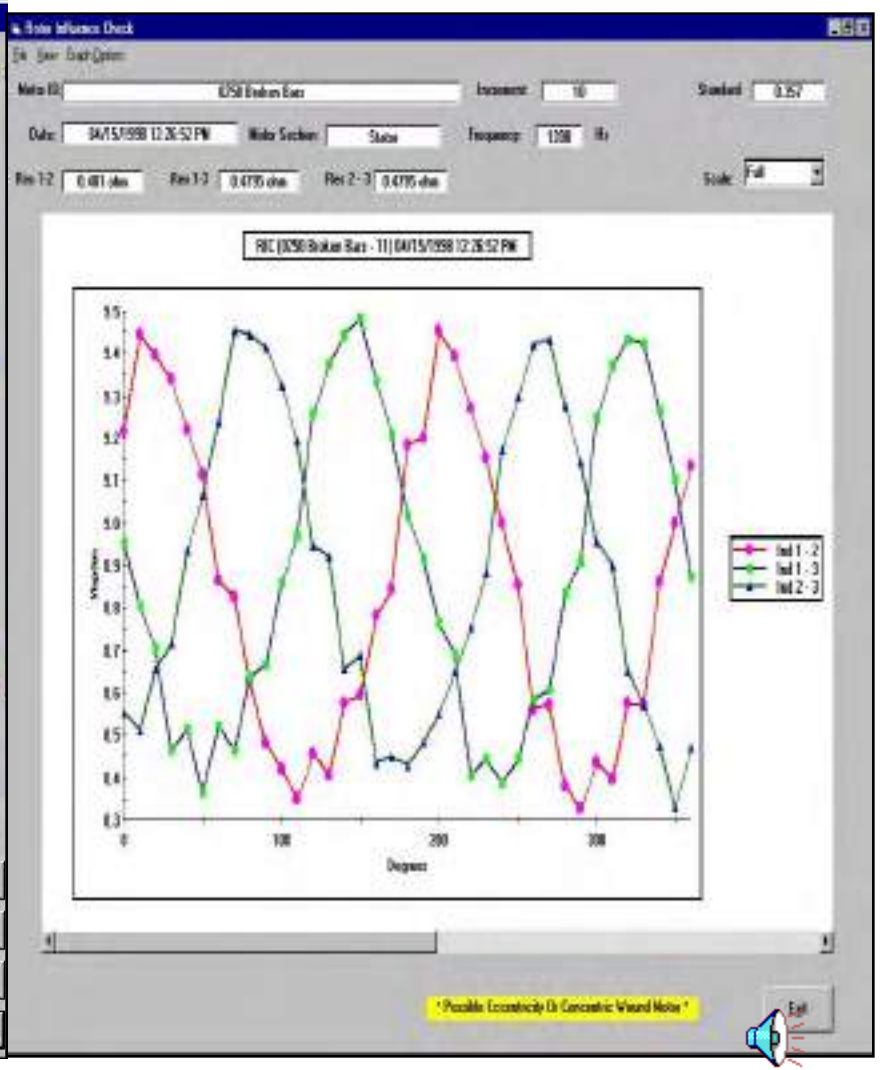
- Broken Rotor bars for vacuum pump motor
  - Emax
    - Spectral analysis confirms pole pass sidebands around the fundamental frequency indicating cracked rotor bars

Advanced Spectral Analysis



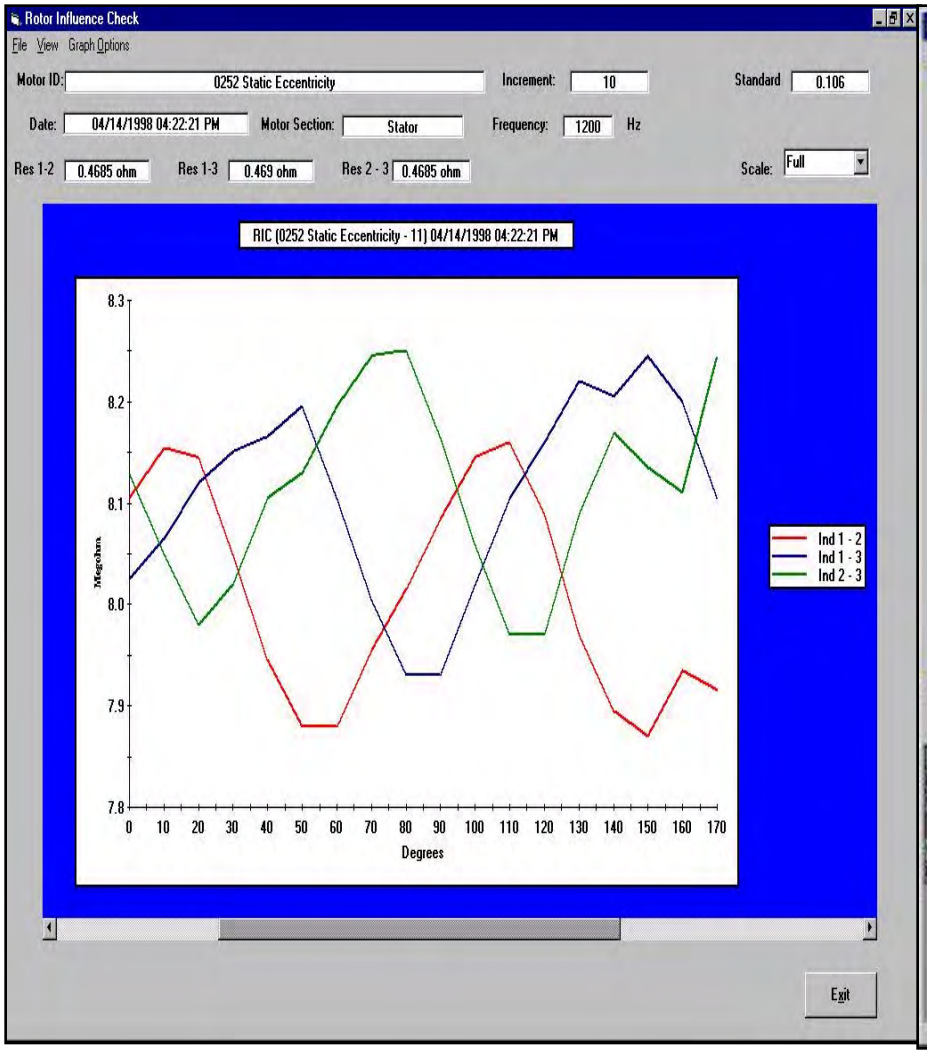
Broken Rotor Bars
Detected with Two Independent Technologies

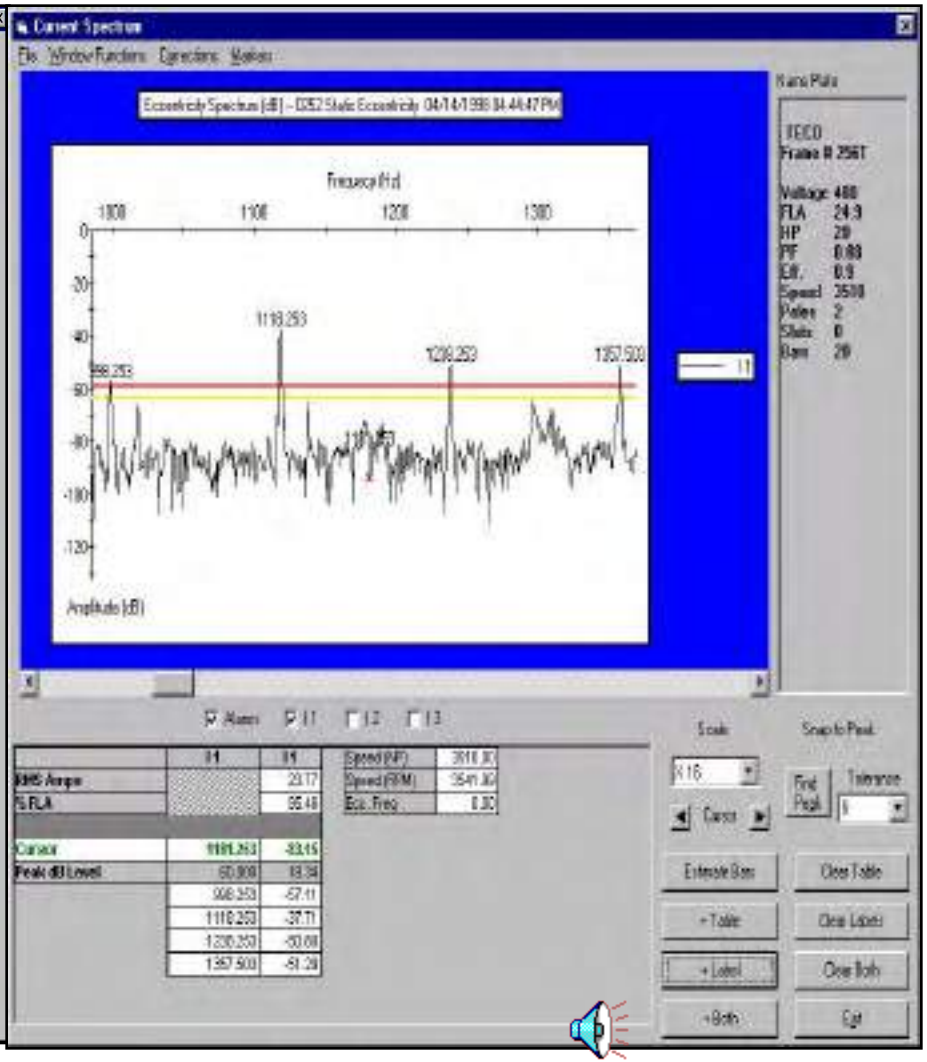




Air Gap detected

With Two Independent Technologies





Surge Testing Comparison

	MCE System 3000	Surge Testing
Description	Static testing which looks at the natural inherent characteristics of the motor and its circuit by use of a high frequency, low voltage signal. The presence or development of anomalies will cause a corresponding change in these parameters, permitting diagnostic application or trend analysis.	Static testing which uses a series of high potential capacitive discharges to determine winding and insulation integrity. The amount of potential is 2 X Line voltage + 1000V. The potential is applied to each phase and the return signal monitored for discrepancies.
Fault Zones Analyzed	Power Circuit, Insulation, Stator, Rotor, Air Gap Eccentricity	Insulation, Stator
Portability	17 lbs., Battery powered, no external power source required	40-80 lbs., AC power source required
Advantages	Versatile and totally non-destructive. Tests apply no additional stress to motor or circuit. There is no limit on the number of motors that can be tested consecutively. Instant access to historical data, trending features, graphs and reports. Data interpretation and operational learning curves are very short with the majority of the data objective in nature. The equipment may be used for quality assurance, trend analysis or diagnostics for the entire motor, not just the stator. The high frequency AC signal ensures complete penetration through the entire winding. Able to test specialty motors such as small servos and spindles, rotor fields and resistor banks.	An established technology for stator analysis. The high potential enables the signal to arc across weak areas and expose future faults. A valuable quality assurance tool in the shop atmosphere that can expose stator flaws in new or operational equipment.
Disadvantages	The applied signals may not be significant enough to arc across weak dielectric. The rotor influence check requires the incremental rotation of the shaft in order to confirm rotor or air gap anomalies. The potential applied during the resistance to ground check is limited to 5000V.	Gives little information regarding power circuit, rotor or air gap condition. **Very limited trending capability and according to EPRI, is a "go /no-go proof test" that "could be destructive."** Concerns exist that a majority of the signal is dropped across the first few turns of the winding in larger motors. This may impose destructive stresses to that portion of the winding while leaving faults closer to the knuckle undetected. Data can be influenced by rotor position, therefore, it is recommended that the rotor be removed when performing tests. The bulkiness and weight of the equipment can be a liability in the field and limitations exist on the number of motors that can be tested consecutively.

Review of Equipment Benefits

- Financial Savings
  - Reduce unexpected motor failures
  - Reduction in motor costs
- Unparalleled Support
  - Technical Support
  - Annual Conference
  - Quarterly Newsletter
- User Friendly
  - Multiple technologies
  - Equipment Portability
  - Automatic Analysis
  - Equipment Safety
- Equipment Versatility
  - Plant conditions
  - Applications
  - Motor types
  - Fault zones