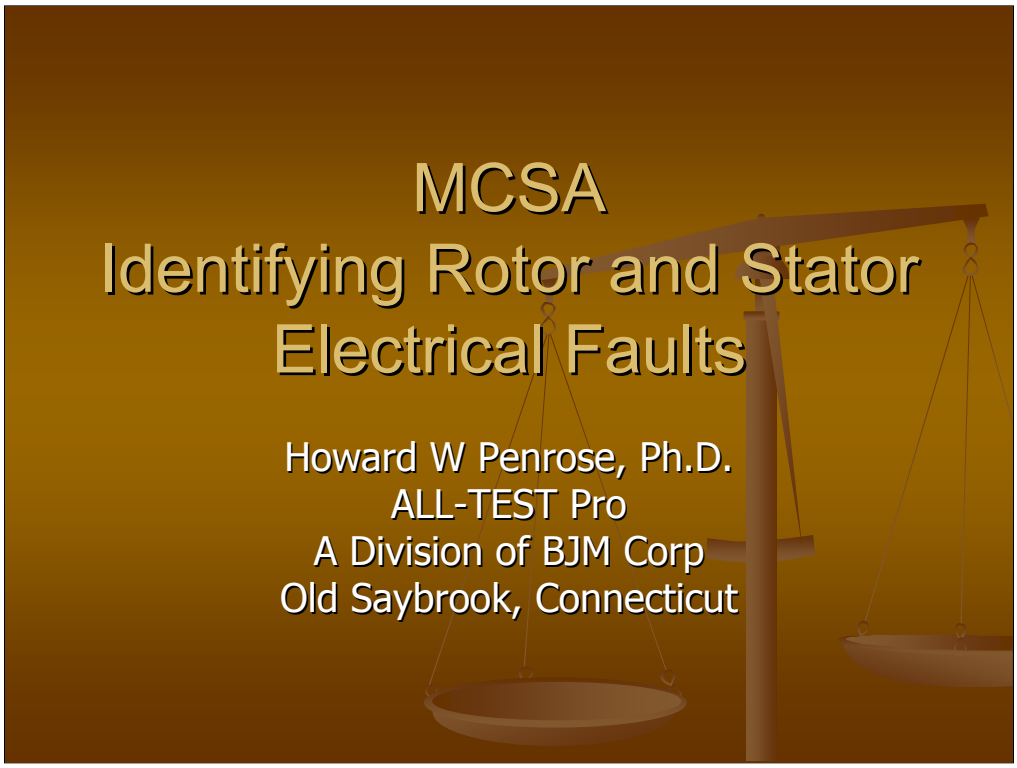
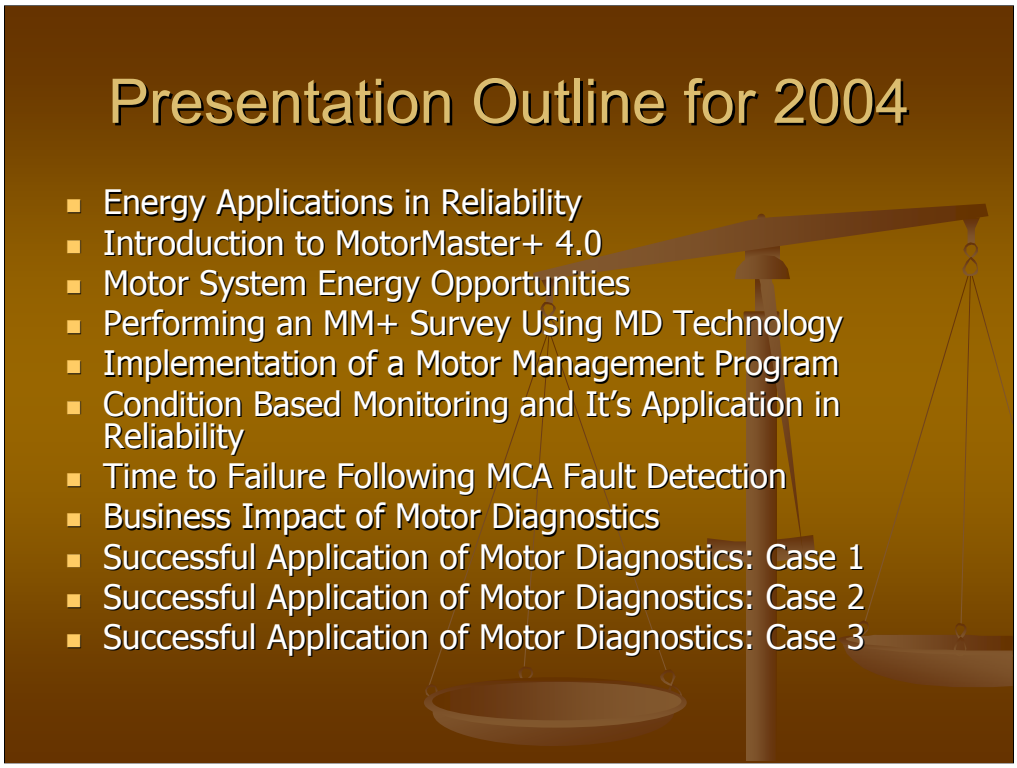


Welcome to the last of the 2003 Motor Diagnostic training presentations presented by ALL-TEST Pro, A Division of BJM Corp.

In this presentation we will focus on rotor bar and stator electrical faults in an AC induction motor. A short overview of how the ALL-TEST PRO MD kit operates will also be introduced.

BJM Corp is a submersible pump, motor diagnostic instrument and software manufacturer established in 1983. BJM Corp is a USA Federal Government GSA Approved Supplier and a US Department of Energy Best Practices Allied Partner.

Dr. Penrose is the General Manager of the ALL-TEST Pro Division of BJM Corp. Dr. Penrose is the Vice Chair of the Connecticut Section of IEEE and is active in the development and implementation of IEEE and other industry specifications.



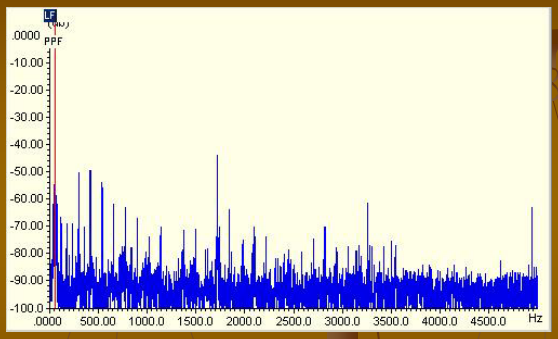
MCSA – Identifying Rotor and Stator Electrical Faults is the final installment of the 2003 series by ALL-TEST Pro. It discusses the ALL-TEST PRO OL motor circuit analyzer, rotor faults and stator winding faults.

In 2004, we shall change direction slightly with an application directed approach with a series of 10 to 15 minute presentations. The series will be issued monthly along with a supporting IQ Quiz. The following IQ Quiz will encompass the complete series with those successfully completing the quiz receiving a Certificate of completion.

The presentations for 2004 include:

•Energy Applications in Reliability
•Introduction to MotorMaster Plus 4.0
•Motor System Energy Opportunities
•Performing an MM+ Survey Using motor diagnostic technology
•Implementation of a motor management program
•Condition based monitoring and its application in reliability
•Time to failure following mca fault detection
•Business impact of motor diagnostics
•Successful application of motor diagnostics case 1
•Successful application of motor diagnostics case 2
•Successful application of motor diagnostics case 3

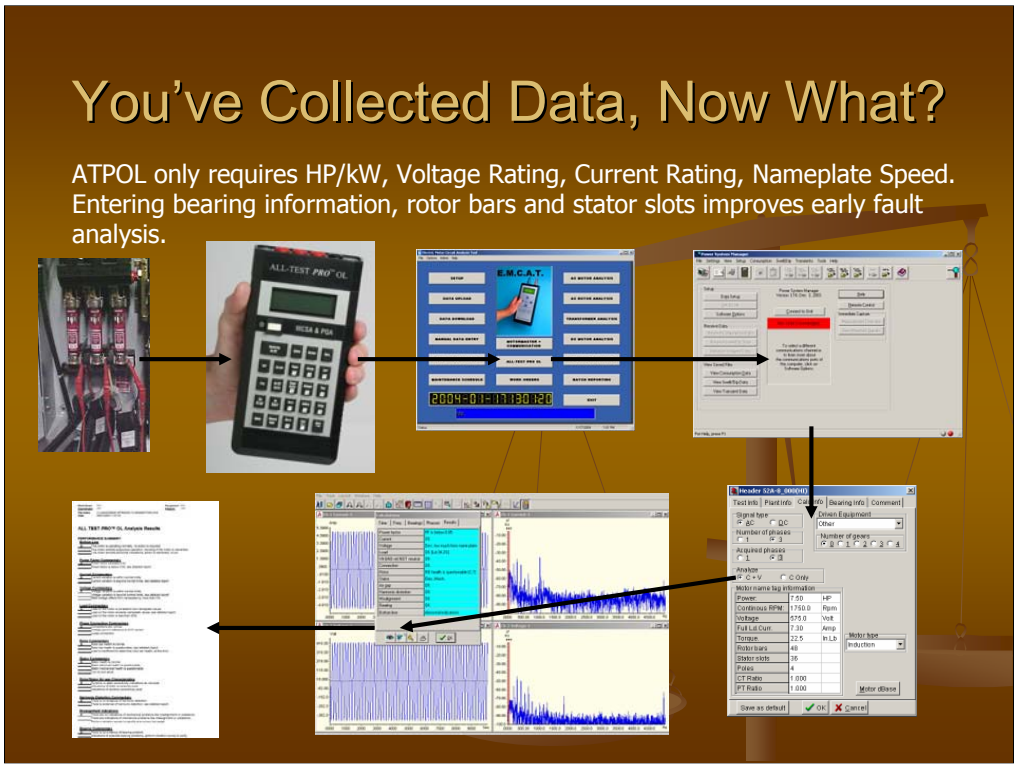
ALL-TEST Pro Motor Diagnostics



- Hand – Held
- Full Power Quality and Motor Current Signature Analysis Capabilities
- Auto-Analysis of Electric Motor Electrical and Mechanical Condition
- Does not require Number of Rotor Bars or Stator Slots to Analyze
- PQ and MCSA Modules Integrated with EMCAT Motor Management Software
- Can also be used as Stand-Alone System (ATPOL and Power System Manager)

The ALL-TEST Pro line of Motor Diagnostic instruments includes the ALL-TEST PRO OL motor current signature analyzer. It is a hand-held instrument which maintains full Power Quality, data logging and motor current signature analysis data collection.

The included software performs automated analysis of electric motor electrical, mechanical and power quality health. The ATPOL and Power System Manager software modules are fully integrated with the EMCAT motor management software and can operate as independent software programs. The ALL-TEST PRO OL system does not require rotor bar or stator slot information to analyze data.

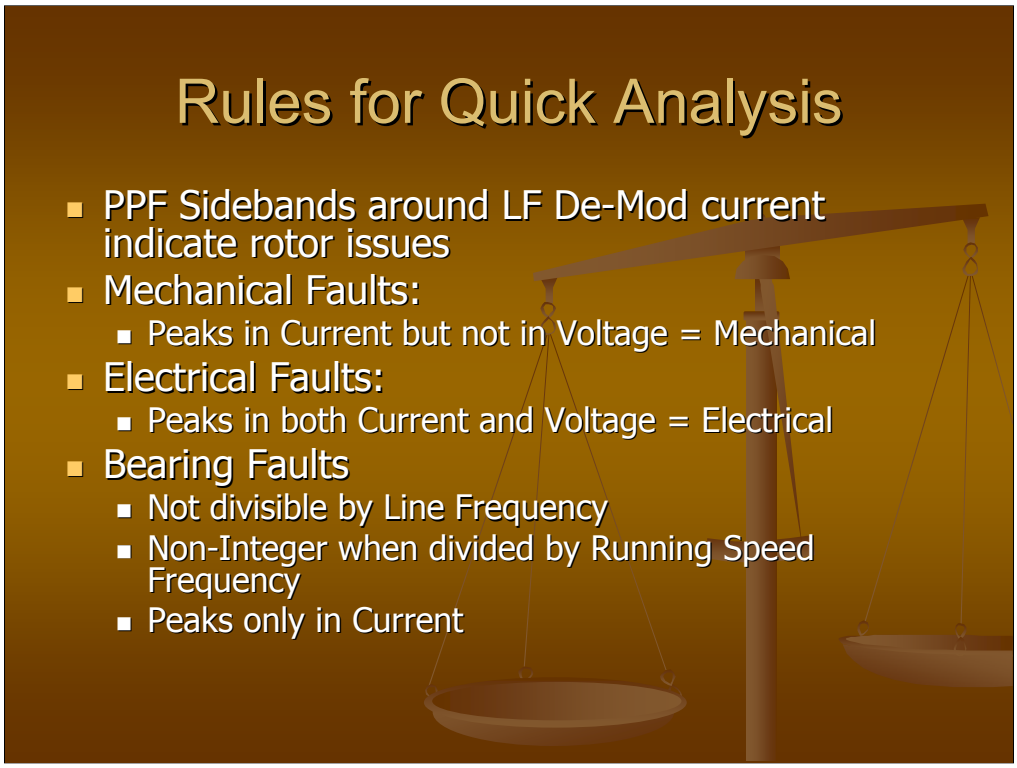


The ATPOL system only requires nameplate horsepower or kW, voltage, current and speed. Rotor bar, stator slot and bearing information assists in earlier fault analysis.

Steps in a standard analysis include:

1. Collection of data from the MCC, disconnect or motor
2. Upload of data through the EMCAT Power System Manager software
3. Enter basic nameplate information into the ATPOL software
4. Run analysis through the ATPOL software
5. Print a summary report

Detailed independent analysis of low and high frequency data is available within the ATPOL software. In this presentation, we will start identifying how to perform independent analysis using FFT spectra of demodulated voltage and current.



There are a number of simple rules for quick analysis of the condition of an electric motor and to assist in the analysis of types of faults:

•PPF Sidebands around Line Frequency demodulated current indicates rotor bar faults.

•In the high frequency spectra, Mechanical faults show peaks in current but no corresponding peak in voltage at the same frequency.

•Electrical faults show as peaks in both current and voltage.

•Bearing faults are not divisible by line frequency and will appear as a non-integer when the center frequencies are divided by the running speed frequency. Peaks also show only in current.

In this presentation, we will focus on rotor analysis and a quick method of confirming stator electrical faults. Electrical faults are normally defined as winding shorts or internal coil unbalances.

Rotor Fault Sideband Values

dB	Rotor Condition Assessment	Recommended Action
>60	Excellent	None
54 – 60	Good	None
48 – 54	Moderate	Trend Condition
42 – 48	High Resistant Connection or Cracked Bars	Increase Test Frequency and Trend
36 – 42	Broken Rotor Bars Will Show in Vibration	Confirm with Vibration, Plan Repair / Replace
30 – 36	Multiple Cracked/Broken Bars, Poss Slip Ring Problems	Repair/Replace ASAP
<30	Severe Rotor Faults	Repair/Replace Immediately

Rotor testing involves viewing the pole pass frequency sidebands around the line frequency peak. Pole pass frequency is calculated in one of two ways:

Synchronous Running Frequency – Running Frequency times the number of poles. For instance, a 4 pole motor with a 29.200 running frequency at 60 Hz would have a pole pass frequency of 30 Hz – 29.2 Hz = 0.8 Hz times 4 poles = 3.2 Hz.

- Values less than 60 dB sidebands would show a rotor in excellent condition requiring no action
- Values from 54 to 60 dB would show a rotor in good condition requiring no action
- Values from 48 to 54 dB would indicate a rotor in moderate condition with recommended trending
- Values from 42 to 48 dB would indicate at least one high resistant joint or cracked bars with recommended trending.
- Values from 36 to 42 dB would indicate broken rotor bars that may show in vibration
- Values from 30 to 36 would indicate multiple cracked or broken bars, as well as possible slip ring problems. Will require repair or replacement as soon as possible
- Values less than 30 dB indicates severe rotor faults that requires immediate attention.

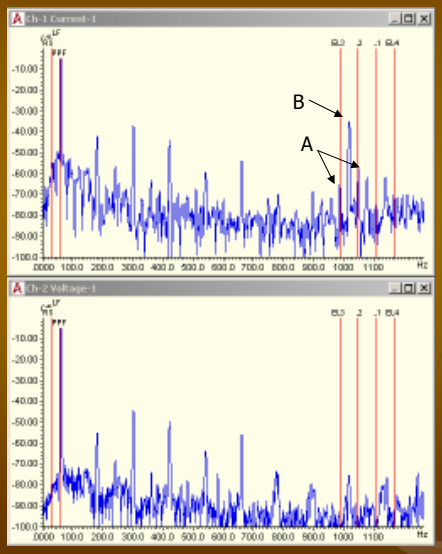
Rotor Analysis Example

Single large PPF sidebands would indicate broken rotor bars as they increase towards the peak LF value. Multiple PPF sidebands indicate casting voids. In this case, multiple PPF-sidebands at -50dB or greater, would indicate minor rotor casting voids.

In cases where signatures show significant sidebands, broken rotor bars would be indicated. In cases where harmonics of these sidebands exist at low levels, casting voids exist. In this case, multiple PPF sidebands in the 50 dB range indicate significant casting voids. The light green lines indicate the PPF sidebands around the line frequency.

Confirmation of the severity of the casting voids using motor circuit analysis should be performed at this point.

Stator Electrical Faults



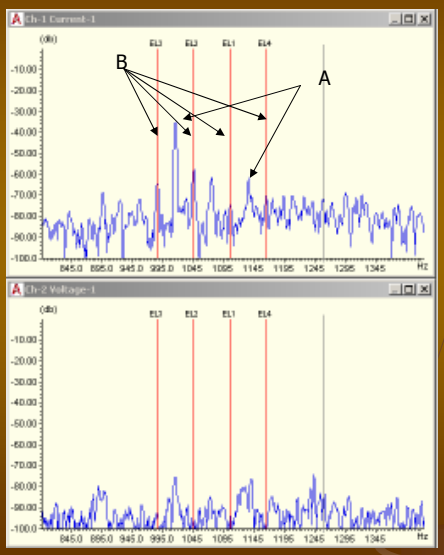
- Possible Mechanical Fault Peaks show in current but not Voltage (A)
  - These are separated by 2x Running Speed (29.907 Hz)
  - The CF is 34 times RS

    -OR-
  - RS sidebands of stator 60Hz Sideband Frequency
- Actual Finding – 36 SS times RS = 1076.65 Hz
  - +/- 60 Hz = 1016.65 (high peak) w/ RS Sidebands
  - Stator Electrical Fault

In this example, the frequencies indicated by ‘A’ are separated by two times the running speed frequency. The Center Frequency actually shows 34 times running speed which does not match the number of rotor bars or stator slots. Alternately, these could indicate running speed sidebands around peak B.

In this case, 36 stator slots times the running speed places a stator center frequency of 1076.65 Hz, which is 60 Hz higher than the peak at ‘B’. This would indicate a potential stator electrical fault.

Confirmation of Stator Electrical



- A Peaks are 1076.65 +/- 60 LF (1016.65 and 1136.65)
- B Peaks are RS sidebands of A Peaks
- Stator Electrical Fault Frequencies:
  - SS x RS = 1076.65 Hz
  - W/ LF Sidebands
  - W/ RS Sidebands

By reviewing the signature for stator electrical faults:

Stator slots times running speed provides the center frequency. Line frequency sidebands with running speed sidebands around the line frequency sidebands.

In this case, Peaks ‘A’ are + and – line frequency around the stator center frequency. The peaks labeled ‘B’ are running speed sidebands around the ‘A’ peaks. This would confirm that this is a stator electrical fault indication.

Confirmation Test and Analysis of Stator and Rotor Electrical Faults

Winding Test

	T1-T2	T1-T3	T2-T3
Resistance	0.009	0.009	0.009
Impedance	6	6	6
Inductance	1	1	1
Phase Angle	53	52	53
I/F	-40	-40	-40
Insulation	#.#		

MCA Can Be Used

Rotor Test

If a potential fault is detected, motor circuit analysis can be used to confirm the finding from the MCC, disconnect or at the motor connection box.

In this case, winding analysis shows that the stator and rotor are in good condition.

For evaluating motor system health, ALL-TEST Pro provides the ALL-TEST PRO MD kit for motor diagnostics. It includes both motor circuit and motor current signature analysis systems integrated through the EMCAT motor management software system. On-site and classroom training is available.

For more information, contact ALL-TEST Pro, A division of BJM Corp, 123 Spencer Plains Rd, Old Saybrook, Connecticut. Our phone number is 860 399-5937, fax number is 860 399-3180, sales and technical support email through alltest@bjmcorp.com and website www.alltestpro.com

Dr. Penrose may be contacted via email at hpenrose@bjmcorp.com.