

LOOKING FOR TROUBLE?

Especially YOU WILL FIND IT WILL.

THE ALL-TEST

Motor Testing Made Easy

ALL-TEST Pro, A Division of BJM Corp
Old Saybrook, CT 06475
By
Dr. Howard W. Penrose, Ph.D.

Motor Testing Made Easy™ is a presentation brought to you by ALL-TEST Pro, A division of BJM Corp. Your presenter is Dr. Howard Penrose, the leading expert in motor circuit analysis.

BJM Corp is a cutting edge manufacturer of electrical submersible pumps and motor circuit analysis equipment. Established 1983 in Old Saybrook, Connecticut by Steve Bjorkman, BJM Corp added motor circuit testing to its equipment line to, initially, test its own equipment as part of QA, and to test submersible pumps in place and in repair. The ALL-TEST Pro division introduced its equipment to general industry in 1985 with the analog ALL-TEST CWT II, which was heavily used by the elevator and nuclear industry. In 1993, it introduced the ALL-TEST III, which quickly won the Plant Engineering Product of the Year award. In 1996, ALL-TEST introduced the ALL-TEST IV PRO, which won the 1996 Plant Engineering Product of the Year award. ALL-TEST has continued by developing data interpretation standards that are so precise simple software packages can be used to interpret and trend data for any type of AC/DC electric motor, transformer or coil. These packages are available for Windows PC's, laptops and pocket PC's.

Dr. Penrose joined ALL-TEST Pro in 1999 following fifteen years in the electrical equipment repair, field service and research and development fields. Starting as an electric motor repair journeyman in the US Navy, Dr. Penrose lead and developed motor system maintenance and management programs within industry for service companies, the US Department of Energy, utilities, states, and many others. Dr. Penrose taught engineering at the University of Illinois at Chicago as well as serving as a Senior Research Engineer in the Energy Resources Center performing energy, reliability, waste stream and production industrial surveys. Dr Penrose has repaired, troubleshot, designed, installed or researched a great many technologies that have been, or will be, introduced into industry, including the coordination of the industry-funded modifications to the US Department of Energy's MotorMaster Plus software in 2000. Dr. Penrose is the Vice-Chair of the Connecticut Section IEEE (institute of electrical and electronics engineers), a past-Chair of the Chicago Section IEEE, Past Chair of the Chicago Section Chapters of the Dielectric and Electrical Insulation Society and Power Electronics Society of IEEE, is a member of the Vibration Institute, Electrical Manufacturing and Coil Winding Association, the International Maintenance Institute, NETA and MENSA. He has numerous articles, books and professional papers published in a number of industrial topics and is a trained vibration analyst, infrared analyst and motor circuit analyst.

Above all, Dr. Penrose's focus is to take complex engineering and scientific matters and present them in an easy to understand manner.

Presentation Outline

- Presented Over Four Quarters
 - Introduction to Motor Circuit Analysis
 - Troubleshooting with MCA
 - Predictive Maintenance with MCA
 - Motor Circuit Analysis Software
- Each Presentation will Consist of:
 - Basics
 - Details
 - Case Studies
 - Where to Get Additional Information



Over 2003, this presentation will be introduced in four basic chapters. The primary purpose is to provide knowledge in the importance of the application of motor circuit analysis including its business and maintenance impacts.

In this first presentation, we will introduce the basics of motor circuit analysis which include: Where it is used; What it can detect; How data is interpreted, basically the data interpretation rules; MCA related industry standards and several case studies.

In the second presentation, we will explore the area of troubleshooting with MCA instrumentation. What are the steps? When should you perform rotor testing? What is the monetary payback and business impact to the application of MCA for troubleshooting alone?

In the third presentation, using MCA for predictive maintenance will be explored. What can be detected? When can it be detected? How long before my equipment fails? And, What is the business case for MCA for predictive maintenance?

In the last presentation of the year, we shall explore Motor Circuit Analysis software and how it is used to save time and money. The key, of course, is simplicity. At ALL-TEST, we pride ourselves in the ability to present equipment and software that is simple enough that it can be applied without special training. This is so that the user does not have to re-train every time the equipment is selected for use.

Above all, we shall present a different approach to the concept of maintenance. We view maintenance not as an expense or an investment that needs to be justified in 'cost savings' or 'payback,' but as a business unit that provides real income. The funds realized through the application of maintenance practices and training by maintenance professionals is income the company would not otherwise have access to. Maintenance makes a company profitable by allowing industrial processes to operate at peak performance. Leave out maintenance, and products become too expensive to produce very quickly.

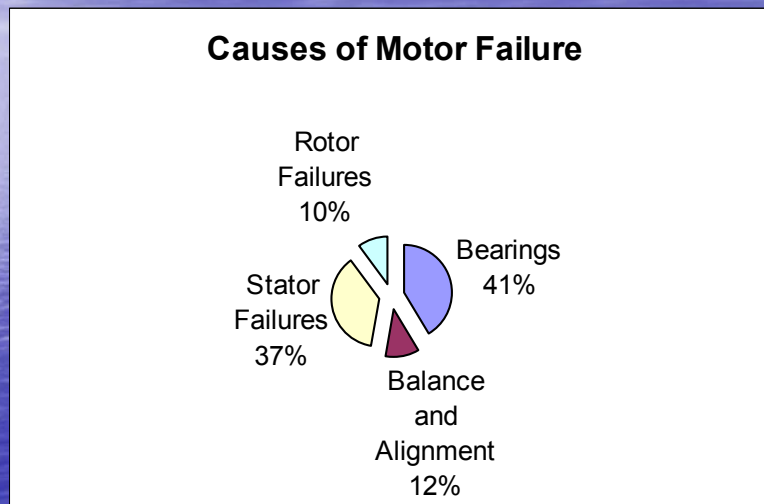
Defining Motor Circuit Analysis

- Static winding analysis of like coils in an electric motor, coils, transformers and other wound circuits. Uses readings of DC resistance, impedance, inductance, phase angle, current/frequency response and insulation resistance to determine the condition of the circuit.
- For the purpose of this presentation, we will cover three phase motors and transformers.

The first step to understanding motor circuit analysis is to understand the definition. For the purpose of this and the following presentations, the definition shall be: Static winding analysis of like coils in an electric motor, coils, transformers and other wound circuits. Uses readings of resistance, impedance, inductance, phase angle, current/frequency response and insulation resistance to determine the condition of the equipment. It is, basically, a comparison of readings between similar circuits.

For the purpose of this presentation, we will be covering three phase motors and transformers. However, the tolerances between like coils is the same in any equipment.

Stator and Rotor Reliability

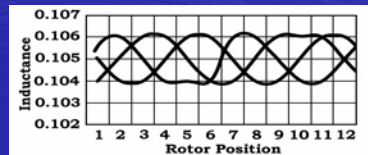
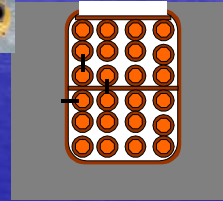


This graph has often been presented as the breakdown of average motor failures within industry. In a recent EASA study and presentation, the numbers have changed slightly. While all areas remain similar, for example 53% due to mechanical faults, the rotor-related failures have fallen to less than 5%. It is thought that this is primarily due to the increase of winding shorts in variable frequency and electronic drive applications and the improvements to rotor and rotor bar design for energy efficient applications. In the case of winding faults, over 95% of those start as a winding short that may eventually fault to ground. However, by then, it is too late. In other instances, a majority of winding faults start and fail within the end-turns of a motor winding, which are never seen as a ground fault. This can be seen when a motor has an over-current trip when on a variable frequency drive, but operates just fine when set into bypass. Time is wasted troubleshooting the drive when the fault is most likely an early turn fault at the end of a motor coil that cannot be detected with an ohm meter or insulation tester. MCA will find these faults.

The other, and primary, cause of winding faults is contamination. Contamination is a correctible problem that can be scheduled or trended. Detection of winding contamination normally provides enough time to schedule equipment downtime to repair the problem as well as plan corrective actions to ensure that the same problem does not re-occur.

Fault Detection

Turn Faults
Coil Faults
Phase Faults
Ground Faults
Cable Faults
Connection Resistance
Rotor Eccentricity
Broken Rotor Bars
Casting Voids



The purpose of MCA is to detect electric circuit faults with the equipment de-energized. This allows for safe fault detection by personnel.

Faults that can be detected with MCA include: winding shorts, including determining the type of short; ground faults; cable faults when testing from the motor control center or disconnect; connection resistance for loose and broken connections; and rotor problems including eccentric rotors, broken rotor bars and casting voids including the severity of the rotor problem.

These are all identified with a simple 3-5 minute test.

Capabilities



AC/DC Motors
AC/DC Traction Motors
Generators/Alternators
Machine Tool Motors
Servo Motors
Control Transformers
Transmission & Distribution
Transformers
(Virtually Any Size)

Motor circuit analysis has applications for a variety of equipment regardless of size, power or voltage. These include:

AC and DC motors, including synchronous and wound rotor motors.

AC and DC traction motors, including locomotives and hybrid electric vehicle motors.

Generators and Alternators of virtually any size.

Machine tool motors while still mounted in machine tool equipment.

Servo motors, including robot equipment.

Small control transformers, coils, and associated devices.

Transmission and Distribution transformers of all types, single or three phase.

Most faults can be detected without having to disconnect variable frequency drives, controls, amplifiers, etc., with the exception of the insulation to ground tests. Rotors do not have to be repositioned, unless performing a rotor test. And, causes of phase unbalances can be quickly identified from one reading.

Benefits of Static Testing

- Used easily with little training
- Simple interpretation
- Safe – de-energized and not rotating
- Test before installation
- Test after fault occurs
- Test prior to shipping for repair
- Pinpoints faulty components without interference
- Hand-Held equipment
- Follows recognized standards
- Pays for itself usually in the first fault detected
 - Detect faults quickly, reducing expensive equipment downtime
 - Detect defects that reduce equipment efficiency



There are distinct benefits to de-energized static testing.

•Very little training is required to apply MCA testing. In particular, the ALL-TEST IV PRO 2000 has been designed to be simple enough for a six year old. Is that meant as an insult? No, what it means is that you do not have to remember how to use the equipment each time you pick it up to use it and more time can be spent on identifying faults and trending.

•Data interpretation is extremely simple. All you need to do is compare the readings from one phase to the next or trend relative unbalance readings over time. In almost every case, faults are extremely obvious visually and numerically on the instrument.

•Safety is absolutely important. With equipment de-energized, you do not have to worry about burns due to arc-flash nor electrocution while having to make live connections and pulling out live, loose wires while attempting to attach current clamps.

•MCA allows you to test electrical equipment upon receipt and to accept or reject it before placing in storage or installation. This can help when dealing with warranty issues. Readings can be compared between instruments, allowing your repair center or manufacturer to share information with you.

•When a fault occurs, the equipment will not be able to run. Static testing will immediately identify whether the fault is in the electrical components of the equipment, or not. Identifying what is not at fault can reduce troubleshooting time and fault-guessing by more than 50%.

•MCA allows you to determine repair/replace on a small motor or estimate the repair costs of a large motor before sending it out for repair.

•MCA allows you to pinpoint faults or trend problems without interference from other areas. For instance, some electrical problems will look like mechanical problems and vice-versa when looking at energized testing requiring in-depth expertise in both the equipment being tested and the instrument output. A good example is the requirement of determining the number of rotor bars and stator slots with current signature testing. MCA does not require this type of information.

•ALL-TEST MCA equipment is hand-held and light-weight. The ALL-TEST IV PRO 2000 also has an on-board memory eliminating the need to drag large equipment and laptops with the user. This provides for additional safety for the user and for equipment, especially in dirty environments.

•MCA follows IEEE, ANSI/EASA and other recognized standards. Several will be discussed later in this presentation.

•On average, more than 80% of the costs associated with unplanned downtime are due to lost production, with repair time and labor making up the difference. By detecting faults before they occur and rapidly detecting faults that do occur, you can change your maintenance organization from a 'necessary evil' to a company earner. Were you aware that by even implementing a planned maintenance program you can reduce energy costs, alone, by more than 14% in real money? That adds to the bottom line.

Test Standards

- IEEE Standards
 - 43-2000: IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery
 - 56-1977: IEEE Guide for Insulation Maintenance of Large Alternating Current Rotating Machinery
 - 118-1978: IEEE standard Test Code for Resistance Measurements
 - 120-1989: IEEE Master Test Guide for Electrical Measurements in Power Circuits
 - 388-1992: IEEE Standard for Transformers and Inductors in Electronic Power Conversion Equipment
 - 389-1996: IEEE Recommended Practice for Testing Electronics Transformers and Inductors
 - 1068-1990: IEEE Recommended Practice for the Repair and Rewinding of Motors for the Petroleum and Chemical Industry
- ANSI/EASA Standard AR100-1998

Motor circuit analysis is covered by a number of standards organizations. In particular is this list:

IEEE 43-2000, published in May of 2000, sets new standards for insulation test limits. It also set a new limit for polarization index, stating that readings above 5000 Megohms render the PI invalid. Also stated in the standard is that new insulation systems, post 1974, polarize rapidly which may show, on new insulation systems, as a failed PI. AC analysis of insulation conditions are covered under Annex B, which can include the comparison of impedance and inductance, which is an AC method for determining winding contamination.

IEEE 56, 118 and 120 cover MCA testing methods, including how data is collected by instrumentation.

IEEE 388 and 389 cover specific test methods and relate how to evaluate them in transformers and coil wound equipment. Covered under these standards are: inductance, impedance, phase angle and current/frequency response tests. Please download the MCA guideline acrobat file available from this presentation for more information.

IEEE 1068 covers the repair and rewinding of rotating equipment and recommended acceptance tests.

ANSI/EASA AR100-1998 discusses the application of phase balance testing through the process of repair.

Evaluation of Windings

- Winding Shorts
 - Phase Angle and Current/Frequency Response
- Loose Connections
 - Resistance
- Winding Contamination/Overheated
 - Inductance and Impedance
- Rotor Condition and Severity
 - Inductance and Impedance Waveforms
- The following rules are effective when a rotor is in the stator. A stator-only must be balanced in phase angle and I/F

Using motor circuit analysis, the evaluation of the condition of a winding is straight forward. Starting in this section, we will provide you with everything you need to know to evaluate an AC motor or transformer right now.

Winding shorts are detected using phase angle and current frequency response.

Loose connections are detected using DC resistance readings.

Winding contamination or windings that have been overheated are detected through the comparison of inductance and impedance.

Rotor condition and severity are detected using either inductance and/or impedance readings and waveforms.

The following set of rules apply when testing an assembled motor. If the rotor is removed from the motor and you are testing the stator only, all readings must be balanced.

Setting the Rules (MTME)

- Phase Angle and I/F readings
 - Both F_i and I/F $> \pm 2$ – Shorted Turns
 - $F_i > \pm 1$, I/F Balanced – Shorted Coils in the same phase
 - F_i Balanced, I/F $> \pm 2$ – Shorted Phase to Phase
- Rules stand regardless of motor size
- Resistance $\sim \pm 5\%$

If either the phase angle or current /frequency response are outside of 1 digit from the average reading, the winding is shorted. For instance, if a reading of 77, 78 and 79 degrees of phase angle and -42, -43, -44 percent current/frequency would be acceptable, and usually found in motors under 100 horsepower. A reading of 75, 78, 78 degrees and -40, -44, -44 would be a winding short.

We have taken analysis the next step so that, if required, the type of winding short can be estimated. For instance, if both the phase angle and current/frequency test show bad, then it is a turn-to-turn fault in the same coil; If the phase angle is bad and the current/frequency test is good, then the fault is coil-to-coil in the same phase; If the phase angle is good and the current/frequency is bad, then it is a phase-to-phase short.

These rules apply regardless of equipment size, voltage and connection.

The general rule is resistance should be within 5% peak to peak. However, the rule is more along the lines of appearance. If the values appear to be balanced, then the reading is good. For instance: 0.062, 0.060, 0.070 ohms would be good; 0.100, 0.062, 0.066 would be poor. In most cases, if you see resistance unbalance and you are testing from the motor control center, tightening the connections at that point will most likely correct the unbalance.

Setting the Rules (Cont.)

- Impedance and Inductance
 - If impedance and inductance are parallel, phase unbalance is most likely due to rotor position
 - If impedance and inductance are not parallel, phase unbalances are most likely due to winding contamination or overheated winding.
 - Meets IEEE Std 43-2000 AC Analysis of Insulation Systems (App. B, p. 19)

Impedance and inductance readings will immediately indicate the condition of the insulation system. If the readings run the same direction, for instance both readings show high, medium and low, or some combination, then the insulation system is good and the unbalance is due to rotor position. However, if the readings show different, such as the inductance pattern is high, medium and low and the impedance pattern is low, medium and high, they do not follow and the insulation system is suspect.

For example: Inductance readings are 5 mH, 6 mH and 7 mH and impedance readings are 12 ohms, 14 ohms and 18 ohms, the readings are both low, medium and high, indicating that the insulation system is in good order. The unbalance is actually due to the position of the rotor in relation to the stator winding, which is perfectly normal. This prevents the need to rotate the shaft when performing MCA.

Setting the Rules (Cont.)

- Inductive and Impedance Rotor Tests
 - Measurements of inductance due to rotor position will present an idea of the condition of a rotor due to casting voids or broken rotor bars.
 - Measurements of impedance matched to inductance provides a relative severity of rotor condition.
 - Rotor tests should be symmetrical and not necessarily 'perfect' sine-waves

The condition of the rotor can be immediately analyzed by taking a series of inductance or impedance readings across all three phases with the rotor in measured positions through 360 degrees of rotation. The recommended minimum is 15 degree increments.

All low voltage (under 600 Vac) induction motors with cast aluminum rotors have casting voids. It is an inescapable fact. The key is to determine at which point the defect will cause the motor to lose torque. This occurs only when the defect, shown as an indentation or spike in the waveform, impacts the peak or valley of the sine wave of at least one phase when the tests are graphed. Indentations in the slope of the sine wave only indicate that casting voids exist, do have a small impact on the current of the motor, but will not impact the motor's ability to produce torque (efficiency).

It is important to mention, at this point, that you are basically looking for phase to phase symmetry. Therefore, if the graphed results do not show a sine wave, as long as the readings are repeatable, the rotor should be OK. More detail on rotor testing will be found in part 2 of this year's presentations.

Applications: Where To Test

- Motor Control Center or Disconnect
 - Will detect all faults between test point and motor winding
 - If fault found, go to equipment
 - 'Is there a motor up there?' – If so, safer to test at equipment with hand-held if potential fault found
- At Winding Connections
- Not only detects faults, but will identify what is NOT faulty

The key to motor circuit analysis is the ability to test the electric motor from a disconnect or motor control center. When you do, you have to remember that you are looking at the condition of the complete circuit from the point of test all the way through the equipment winding. This will include contacts, connections, cables, etc.

Therefore, if you detect a fault from the MCC, you should go to the motor in order to determine if the fault is in the motor or in the supply cable. If you do not see the fault in the motor, then the fault will be found in the cable supplying the motor. This is where hand-held equipment is crucial, as if you have to climb to an electric motor, or it is in a tight area, it is better to bring a small portable instrument rather than a bulkier instrument. An ALL-TEST will fit in with your tools.

If testing from the winding connection, you will be able to immediately determine the condition of the electric motor, transformer, etc.

The key to this is that you will not only be able to detect what is faulty, but also what is not faulty. This may prevent you from having to remove an electric motor that is in a tight or dangerous area and allow you to immediately troubleshoot other parts of the system which may be causing the problem. Troubleshooting by replacement is not cost effective and is dangerous to both equipment and personnel.

400 HP Fault at Steel Mill

- High electrical vibration that increases as the motor heats up



In this first case study, a problem in a 400 horsepower electric motor at a steel mill was identified. This problem had been driving the maintenance and reliability group crazy for about two months. As it was part of a parallel system, this motor was used only as a back-up, which created another problem – an unreliable back up system.

The motor had an electrical vibration that showed some looseness, when the motor was energized. The vibration would continue to increase as the motor's operating temperature increased. The signature would disappear when de-energized. The bearings had been replaced and a number of other symptoms were addressed to no avail. As a high-frequency signature in vibration looked like rotor bars, which were known, with multiple harmonics, it was determined that the fault must be a rotor problem. The motor was sent to a local repair shop who happened to have MCA equipment.

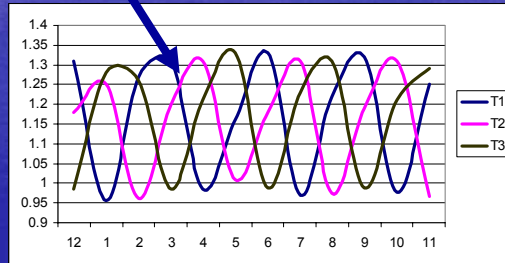
The rotor and stator were tested.

Test Results

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	##		

Rotor Test



As you can see from these readings, the stator winding was in excellent health. The rotor shows a few flat spots in the waveform and a slight arch as you go right to left. These findings indicate small casting voids in the rotor and that there is a little rotor eccentricity. However, neither of these findings indicate a problem as severe as what was being seen.

Time to test, including rotor test: <30 minutes.

Findings



If all of the least likely problems are eliminated, what remains, however improbable, is the fault.

In this case, a single pin from the bottom of the stator housing holds the stator core in place. There are no welds, as they would break during thermal growth. However, the stator was not completely tight within the stator housing and both the stator housing and core are made of two different materials. It appears that the stator housing was growing faster than the stator core, causing the vibration and looseness. Marks on the core and stator housing ribs proved the indication (as well as a slightly visible spacing).

You will note balancing weights on the second picture. As an interesting tidbit of knowledge, significant casting voids, because they are missing metal, can usually be found right behind balancing weights on the rotor.

So, What if this motor on a VFD was tested with a multi-meter and insulation tester?

	T1-T2	T1-T3	T2-T3
Resistance	0.47	0.47	0.47
Impedance	?	?	?
Inductance	?	?	?
Fi	?	?	?
I/F	?	?	?
Ins Res	Inf		

Would you pass this motor? Or, would you Work on the VFD?

As is typical, many maintenance professionals rely on their multi-meter and insulation tester to evaluate electric motors. This will catch less than half of motors that are 'nuisance tripping' in a standard application and virtually none of the motors that are nuisance tripping on a variable frequency drive. If the motor passes these tests, additional troubleshooting is performed on the drive, control, load and other areas to try to hunt the problem. In some cases, parts are swapped until the problem is actually found, in others the problem is allowed to continue until something breaks.

The question, in this case, is: Would you pass this motor if all you had was a multi-meter and insulation tester? By the way, your answer should be 'yes.'

Now, same motor with ALL-TEST

	T1-T2	T1-T3	T2-T3	Tolerance
Resistance	0.466	0.466	0.467	5%
Impedance	67	71	64	Para
Inductance	13	14	12	Para
Fi	73	71	73	+/- 1
I/F	-43	-41	-43	+/- 2
Ins Res	Inf			> 5

Single turn fault in this 30 hp. Troubleshooting drive, etc. would Cost many hours. Possibly pay-off ALL-TEST on just this one Fault.

However, if I review this motor using motor circuit analysis, you can see it falls outside the range. This motor would still run on 60 Hz, at least until the winding finally vaporized, but is tripping on a variable frequency drive. It has a turn to turn short in the end of one of the winding coils. This motor would require rewind or replacement.

Finding: ~10 minutes. If the drive had been troubleshot, other systems checked and tested, this problem may have continued for days. Worse, the motor may have been kept running either on the drive or in bypass, causing major production problems until the winding finally fully faulted. This would cause a dangerous situation for personnel and equipment, a very expensive option.

Example 1: Bad 15 HP (Garlic Mill)

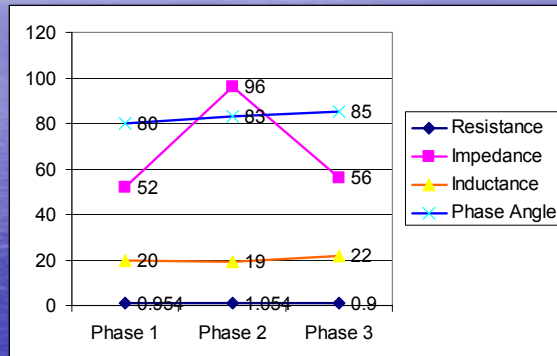
	T1-T2	T1-T3	T2-T3
R	0.954	1.054	0.9
Z	52	96	56
L	20	19	22
Fi	80	83	85
I/F	-44	-39	-39
Megger		>99M	

Note that both Fi (Phase Angle) and I/F (Current-Frequency Response) are bad. This Motor was still operating but tripping intermittently. The test results show that this Winding is shorted (most likely turn-to-turn shorts).

In this case, a 15 horsepower, 1800 RPM standard motor was in operation in a dust-contaminated environment (even better, garlic dust!). The motor operates but nuisance trips on a 60 Hz supply.

You may note the following: Greater than +/- 1 digit on both the phase angle (Fi) and current/frequency test (I/F), which indicate a turn to turn short. The impedance reads low, high, medium and the inductance reads medium, low, high, indicating winding contamination.

Garlic Mill Motor Condition



Note that the impedance and inductance are not parallel. This would indicate That the winding short was most likely the result of contamination or winding Overheating (burned insulation).

The visual of impedance and inductance again shows that they do not follow each other.

When this motor was disassembled, it was found that the winding was completely coated in grease and garlic dust and a small blackened area at the end of one coil showed the turn to turn short.

8,000 HP Synchronous Motor Case Study

- 8,000 HP, 200 RPM Synchronous Motor – 36 rotor coils and 244 stator coils
- Failed on start-up but unable to determine cause of fault with other winding test technologies
- 25% of compressed air capacity for chemical plant unavailable during downtime
- Motor circuit analysis applied in two tests – rotor position 1 and rotor position 2 (next slide) – which identified faults within the rotor (note winding faults show in both readings, but rotate with new position).
- Four rotor coils found to be directly shorted, causing a fault in the motor secondary circuit.
- Repaired and returned to service

This 8,000 horsepower, 200 RPM synchronous motor tripped off line in about 27 milli-seconds on start-up using fault detection equipment. As the motor could not operate and there was no prior warning to this failure, the maintenance staff had to rely on de-energized tests. At an estimated cost of \$175,000 per hour downtime, work was performed over two days. Surge testing did not detect any faults, the buss work showed OK, but the secondary circuit showed a bad SCR. This caused a severe problem as the rotor winding would saturate on startup, causing an exponential increase in starting current.

In order to determine the root cause, and to double-check the stator, an MCA test was performed. The operator of the instrument had never used an ALL-TEST IV PRO 2000 in the past.

Equipment Size Limits? 8,000 hp, 200 RPM, 13.2 kV, Synchronous

	T1-T2	T1-T3	T2-T3
Resistance	0.322	0.319	0.319
Impedance	189	181	190
Inductance	37	38	37
Phase Angle	81	85	83
I/F	-42	-49	-46
Insulation	#. #		

Position 1

Position 2

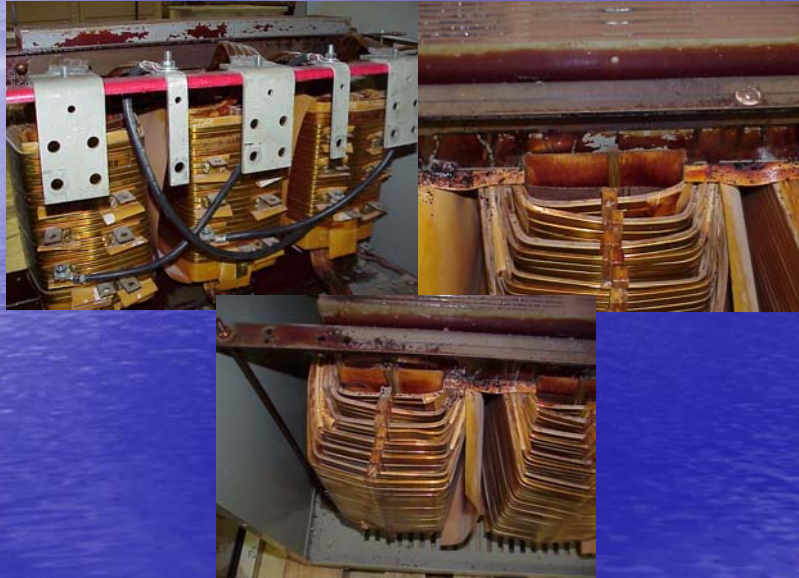
	T1-T2	T1-T3	T2-T3
Resistance	0.318	0.316	0.321
Impedance	190	192	190
Inductance	37	38	37
Phase Angle	83	86	81
I/F	-45	-49	-44
Insulation	#. #		

The first test, using an ALL-TEST IV PRO 2000, indicated a winding short. Because the rotor has wound stator fields, the rotor was moved about 5 to 10 degrees and re-tested. The second reading showed a rotation of the winding short (note that the T1-T2 measurements changed to the T2-T3 measurements and vice-versa). This was an immediate indication of a short in the rotor fields.

Total test time, including rotating the shaft of the reciprocating compressor and training of the ALL-TEST IV PRO 2000 operator: < 1 hour.

Six of the thirty-six rotor fields were found to be shorted due to age (34 years old). They were replaced and the motor returned to operation.

Noisy Transformer



This 150 kVA transformer had been in operation for about 9 years and was becoming noisy. Visual identifiers showed bluing around the top center of the transformer indicating the loose coil. In order to determine if a fault existed, an MCA was performed using the ALL-TEST IV PRO 2000 and following the IEEE 389 test method for transformers.

Identification of Defects



	T1-T2	T1-T3	T2-T3
Resistance	0.053	0.062	0.082
Impedance	1	1	1
Inductance	0	0	0
Phase Angle	19	19	19
I/F	-29	-29	-30
Insulation	2.202		

Several things were noted. Wear and tear due to vibration caused a breakdown in insulation between the primary and secondary which resulted in a 2.2 MegOhm resistance between the primary and secondary. In addition, an original defect was found when a slight shift in current/frequency was detected. The housing on the side opposite the connections was removed and a knife-mark between two turns was visually identified. When an insulator was placed between the two turns, the coil became balanced.

Benefits of ALL-TEST Pro MCA Instruments

- Rapid Training and Learning Curve!
- ROI upon first fault detection!
- Quickly implement a Preventive or Predictive Maintenance Program with a Minimum Investment!
- Include in Energy Programs! Reduce Energy Costs!!



Looking For Trouble?



Motor circuit analysis using the ALL-TEST Pro method has a number of distinct benefits:

- A very rapid training and learning curve. The equipment can be put into operation within minutes.
- Best cost approach with a return on investment during the first fault detection being the norm.
- With both included and upgrade software, an electrical preventive or predictive maintenance program can be put into place within hours.
- The application of a maintenance program that includes MCA will reduce energy costs by at least 14% (US Dept of Energy)

So, are you looking for trouble? Let us help you find them quickly and safely using the ALL-TEST

For More Information

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