# User's Manual

## Advanced Winding AWA

AWAIV-2, AWAIV-4

**Baker Instrument Company, an SKF Group Company,**
4812 McMurry Ave. Suite 100
Fort Collins, CO 80525
(970) 282-1200
(970) 282-1010 (FAX)
800-752-8272 (USA Only)

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference with the equipment is operated in its installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the product manual, may cause harmful interference to radio communications. If this equipment does cause harmful interference, the user will be required to correct the interference.

Due to the phenomena being observed and the material properties being measured, this equipment does radiate radio frequency energy while in the active test mode. Care should be taken to insure this radio frequency energy causes no harm to individuals or other nearby equipment.

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***Note on Software***

While the AWA is a Microsoft Windows® based instrument, it is not a computer, which any software available in the market should be installed. The installed applications and Windows® configuration are set up to operate the AWA hardware. Modifications to this setup may cause unit malfunction.

## Software License Agreement

### Advanced Winding Analyzer (AWA)– test equipment and desktop versions.

Carefully read the following terms and conditions before opening the software envelope; either opening the envelope or using the software constitutes your acceptance of these terms and conditions. If you, the licensee, do not agree with them promptly, return the package unopened for a full refund.

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Use the test equipment version on only the Baker test equipment provided;

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## Limited warranty

Baker Instrument Company, an SKF Group Company, warrants to the user for a period of one year from delivery to the original purchaser that, if properly installed and operated, the program will perform in accordance with the documentation provided. The User will notify Baker Instrument Company, an SKF Group Company, in writing within ten days of discovering any error by sending:

1) A list of the command sequence or other input which causes the suspected repeatable error;
2) A printout or a summary of the result; and
3) The part number and revision of the program.

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By either opening the software packet or using the program, you acknowledge that you have read this agreement, understand it, and agree to be bound by its terms and conditions. You further agree that it is the complete and exclusive statement of the agreement and supersedes any proposal, dealings, whether oral or written, and any other communications relating to the subject matter of this agreement.

**Important notice concerning warranty and repairs**

The warranty is void if the AWA is shipped without shock absorbing packing material. If the AWA fails, whether it is under warranty or not, call the Baker Instrument Company, an SKF Group Company, service department before returning the unit for repair. If the unit needs in-house repair, our service staff might direct you to ship the unit to the authorized service center closest to you. This might save both time and money. When calling the Baker service department or one of the service centers, please have the model and serial numbers available. These numbers are located on the rear of the instrument. If the unit is out of warranty, a purchase order will be required if the unit is returned for repair.

**Service department number**: (970) 282-1200 or toll free at (800) 752-8272.

## Hardware Warranty Information

All products manufactured by Baker Instrument Company, an SKF Group Company, are warranted against defective materials and workmanship for a period of one year from the date of delivery to the original purchaser. Any product that is found to be defective within the warranty period will, at the option of Baker Instrument Company, an SKF Group Company, be repaired or replaced. This warranty does not apply to products damaged by improper use. The purchaser shall assume all responsibility and expense for removal, reinstallation, freight, or on-site service charges in connection with the foregoing remedies. Baker Instrument Company, an SKF Group Company's liability to purchaser relating to the product whether in contract or in part arising out of warranties, representations, instructions, installations, or defects from an cause, shall be limited exclusively to correcting the product and under the conditions as aforesaid.

### Virus Alert

The AWA contains computer software that is vulnerable to damage from computer viruses. Before shipping, Baker Instrument Company, an SKF Group Company, scanned all data to ensure the AWA is virus-free. Before inserting any disks into the disk drive or connecting the AWA to a computer network, scan all disks for viruses.

### Trademarks

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# Preface

**Inside this chapter**

# CE Declaration of Conformity

Manufacturer's Name & Address:

Baker Electrical Instrument Company, an SKF Group Company,
4812 McMurry Ave
Fort Collins, CO 80525
USA

EC Representative's Name & Address:
Baker Instrument GmbH
Hutbergstrasse 21
D-90475 Nurnberg
Germany

Equipment Description: Testers for Surge, DC Hi-Pot, and Winding Resistance of motors.

Equipment Model Designations: AWAIV-2 AWAIV-4
Application of Council Directive 72/23/EEC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits, as amended by: Council Directive 93/68/EEC and Council Directive 89/336/EEC on the approximation of the laws related to Member States relating to the electromagnetic compatibility, as amended by: Council Directive 93/68/EEC. Note: due to the phenomena being observed and the material properties being measured, this equipment does radiate radio frequency energy while in the active test mode.
Referenced Safety Standards:
EN 61010-1
Referenced EMC Standards:
EN 61326:2001
EN 55011 Class A
EN 61000-3-2
EN 61000-3-3
EN 61000-4-2
EN 61000-4-3
EN 61000-4-5
EN 61000-4-5
EN 61000-4-6
EN 61000-4-11

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Signature:

Printed Name: John S. Wilson
Title: Manager, Standard Products.

### Intended use of instrument

The AWAIV-2, AWAIV-4 is offered by Baker Instrument Company, an SKF Group Company's standard products division. This machine is intended to be used for the detection of weak insulation within electric motors by trained professionals. It is intended to perform only the specified tests that this manual explains in detail. Please refer to chapters in this manual concerning specific operation of instrument.

### Technical assistance / Authorized Service Centers

| | | |
|---|---|---|
| Europe | Baker Instrument GmbH<br>Hutbergstrasse 21<br>D-990475 Nurnberg 60<br>GERMANY | 49-911-984600<br>49-911-832169 |
| United States | Baker Instrument Company, an SKF Group Company,<br>4812 McMurry Avenue<br>Fort Collins, CO 80525 | 970-282-1200<br>970-282-1010<br>800-752-8272 |
| Canada | Emsco, Ltd<br>57 Cannifton Road<br>Belleville, ON K8N 4V1<br>CANADA | 613-966-3235<br>613-966-5806 |
| | Prime Instrument Inc.<br>4407, rue Charleroi<br>Montreal-Nord PQ H1H 1T6<br>CANADA | 514-329-3242<br>514-329-3750 |
| | Pulse Engineering, Ltd<br>1137 Keewatin Street<br>Winnipeg, MN R2X 2Z3<br>CANADA | 204-633-4321<br>204-697-2264 |

### Positioning of equipment

**Note:** Do not position equipment in such a way that it is difficult to operate the disconnecting device(s).

### Accessory interconnection and use

The AWAIV-2 and AWAIV-4 are equipped with a footswitch. Please see details about the footswitch in later chapters in this manual.

### Intermittent operation limits

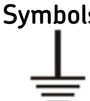
At this time there is no intermittent operation limits to the use of the AWA unit.

### Safety symbols & precautions

**Note:** The general safety information presented here is for both operating and service personnel. Specific warnings and cautions will be found throughout this manual where they apply.

**Note:** If the equipment is used in any manner not specified by Baker Instrument Company, an SKF Group Company, the protection provided by the equipment may be impaired.

### Symbols on equipment


Earth (ground) terminal


Protective conductor terminal


Frame or chassis terminal

Caution statements identify conditions or practices that could result in damage to the equipment or other property.

Warning statements identify conditions or practices that could result in personal injury or loss of life.

 This symbol indicates cautionary information.

 This symbol indicates: Caution, risk of electric shock.

Do **NOT** touch the test leads, winding or component under test while a test is being performed. **Severe electric shock may result.**

**Never** attempt a two-party operation. Always know what test is being performed and **when.**
**Never** attempt to test an energized motor.
For capacitor started motors or systems with surge arrestors/power factor capacitors; be sure to **disconnect** all capacitors from the test circuit **before** testing.
The surge test is **NOT approved** for use in an explosive environment.
Upon completion of a DC High Potential test, short the winding, motor, etc., to ground and allow time for discharge before disconnecting the test leads.
**Ensure** the tester leads are disconnected before the motor is energized or powered up.
**Do not** operate in an explosive environment.
**Do not** remove the product covers or panels or operate the tester without the covers and panels properly installed.

## Ground the product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting the product test leads.
**Danger from loss of ground – Upon loss of the protective ground connection, all accessible conductive parts, including knobs and controls that may appear to be insulated, can render an electric shock!**

## Installation requirements

The unit may be operated

1. Flat on the bottom of the unit,
2. Flat on the back of the unit, or
3. Held at an angle using the rotating handle.

There are no ventilation requirements.
The unit is intended for use in Installation Category II (Portable Equipment) areas and pollution Degree II Environments where occasional non-conducting condensing pollution can be encountered.

## Pollution Degree II

(From IEC 61010-1 3.6.6.2) Only non-conductive pollution occurs. However, temporary conductivity caused by condensation is expected.

## Power requirements

Using the provided AC power cord, connect the unit to a grounded AC power source. The unit's power requirements are 100-240VAC, 50-60 Hz, 2 amps AC maximum current draw. The unit is fused using 2.5A fast blow fuses. Replace fuses with like type and rating.

## Environment conditions

The unit is for indoor use. If used outdoors, the unit must be protected from rain, snow and other contaminants.
The unit has been tested for use up to 2000m.
The tester should only be operated in temperatures ranging from 41 to 104 degrees Fahrenheit (5° C to 40° C).

> **Danger**
> High-voltage test equipment should be handled with **CAUTION**. High-voltage test procedures should be followed, including the use of high-voltage gloves.

## Cleaning & decontamination

The AWAIV-2, or AWAIV-4 should be kept clean and in a dry environment. To clean the unit, wipe with a clean water dampened cloth. Do not submerge in water or other cleaners or solvents. To clean the screen, take a soft water dampened cloth and *gently* wipe the surface.

This unit is for use at a maximum relative humidity of 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40°C. This unit is intended for Installation Category II in a Pollution Degree II environment.

This instrument is **NOT** waterproof or sealed against water entry.

This tester is **NOT** approved for use in an explosive environment.

## Repair Parts

Warning: Electric Shock Hazard

During repairs, do not substitute any parts. Use only factory-supplied parts to minimize safety hazards.

Do not modify or repair test leads in any way. Defective, damaged, or broken test leads must be replaced with factory-authorized parts to ensure safe operation and maintain performance specifications.

### Unpacking the unit

Carefully remove the following items from the shipping boxes.

AWAIV-2, or AWAIV-4
Power Cord
Operator's Manual
Software CD

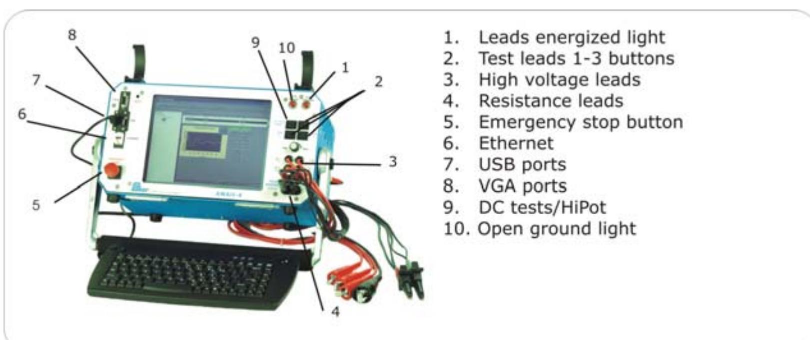



Fig Pre-1: AWAIV-2 AWAIV-4 front panel

# Chapter 1: Test sequence, voltages & applicable standards

**Inside this chapter**

- Recommended test sequence
- Coil Resistance
- Meg-Ohm test
- DC HiPot
- Step Voltage
- Surge
- Recommended test voltages
- Applicable standards

## Recommended testing sequence

In order to test motors adequately and to have effective predictive maintenance programs, Baker Instrument Company, an SKF Group Company, suggests using a specific test sequence. The general idea is to perform the test sequence as a series of progressively more rigorous tests, accepting the idea that if a test fails, troubleshooting and repair should begin at that time. More rigorous testing should only commence after satisfactory diagnosis and/or repair**.** The suggested testing sequence is:

1) Resistance,
2) Meg-Ohm, Polarization Index, Dielectric Absorption
3) HiPot, Ramp Voltage, Step Voltage
4) Surge

## Balance Resistance test or L-L Resistance

A coil resistance test looks for resistance imbalance between phases. If a large imbalance is found, the motor should be inspected for the cause of the discrepancies. Typical problems that may exist are:

1) Hard shorts to the motor's core,
2) Hard shorts between coils either within the same phase or between phases,
3) Coils rewound with the improper gauge wire,
4) Loose or corroded connections.
5) Further HiPot or Surge testing is not necessary until the resistance measurement is acceptable.

### Meg-Ohm test

A Meg-Ohm test is performed using a test voltage based on the operating voltage of the motor and the appropriate standards/company guidelines. Look for an unusually low Meg-Ohm value when compared to previous measurements or industry accepted limits for the type of insulation in the motor. If a low Meg-Ohm value is measured, the motor should be inspected for ground wall insulation damage. Possible problems include:

1) Slot liner insulation or enamel wire insulation may be burned or damaged,
2) The motor might be full of dirt, carbon dust, water or other contaminates,
3) Connections to the actual coils may be damaged,
4) Wrong insulation may have been used to connect the coils to the motor's junction box, etc.

No further testing is necessary until the reason for the low Meg-Ohm reading is found and corrected.

### HiPot test

A HiPot test is performed using a test voltage that is substantially higher than the Meg-Ohm test; however, it should be based on the operating voltage of the motor and the appropriate standards/company guidelines.

1) Look for unusually high leakage currents or a leakage current that does not stay constant or intermittently jumps up and down.
2) Breakdowns or high leakage currents are an indication of damaged ground wall insulation.
3) Inspect the motor's slot liner, wedges, conductors between the junction box and the coils, etc.

No further testing is necessary until the reason for the unacceptable HiPot reading is found and corrected.

### Step Voltage Test

The Step Voltage test is used for predictive maintenance and field-testing. This DC test is performed to a voltage of what the motor typically sees during starting and stopping. The test voltages are governed by IEEE and other industry accepted organizations (NEMA, EASA, IEC). The DC voltage is applied to all three phases of the winding, raised slowly to a preprogrammed voltage step level, and held for a predetermined time-period. This is continued until the target test voltage is reached. Since the test is the most stable at the end of each step, data is logged at this point. If at this point the leakage current (IμA) doubles, there is an indication of insulation weakness and the test should be stopped. If the leakage current (IμA) raises consistently less than double, the motor insulation is likely in good standing.

## Surge Test

A Surge test is performed of each phase of the motor, using a test voltage based on the operating voltage of the machine and the appropriate standards/company guidelines. Look for a jump to the left of the surge waveform pattern. This is the signature of the turn-to-turn short. If a jump is observed, an inspection of the motor should be made. Look for damaged insulation between adjacent conductors. The insulation may be hard to see visibly, so the motor may have to be disassembled to find the problem. If no jump in the wave patterns is observed, the likelihood of motor failure due to turn insulation failure is greatly reduced.

### *Recommended Test Voltages – HiPot and Surge Tests*

Recommended test voltages for HiPot and Surge testing a motor, generator or transformer are twice the AC line voltage plus 1000 volts. This test voltage is consistent with NEMA MG-1, IEEE 95-1977 (for test voltage greater than 5000 volts), and IEEE 43-2000 (test voltages less than 5000V).
Examples for 460VAC and 4160VAC motors are as follows:

2 x 460V + 1000V= 920 + 1000 = 1920 V

For new windings or rewound motors, the test voltage is sometimes increased by a factor of 1.2 or even 1.7. This provides for a higher level of quality control on the work performed. For motors above 460V, the test voltage would be:

1920V * 1.2 = 2304
or
1920 * 1.7 = 3264

## Applicable Standards

- EASA Standard AR100-1998 Recommended Practice for the Repair of Rotating Electrical Apparatus
- IEC 60034-1 (1999-08) Consolidated Edition, Rotating Electrical Machines Part I: Rating & Performance Ed. 10.2
- IEEE 43-2000 Recommended Practice for Testing Insulation Resistance of Rotating Machinery
- IEEE 95-1977 Guide for Insulation Maintenance of Large AC Rotating Machinery
- IEEE 112-1991 Test Procedures for Polyphase Induction Motors and Generators
- IEEE 113-1985 Guide on Test Procedures for DC Machines
- IEEE 115-1983 Test Procedures for Synchronous Machines
- IEEE 429-1972 Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form-Wound Stator Coils
- IEEE 432-1992 Guide for Insulation Maintenance for Rotating Electrical Machinery (5hp to less than 10,000hp)
- IEEE 434-1973 Guide for Functional Evaluation of Insulation Systems for Large High-Voltage Machines
- IEEE 522-1992 Guide for Testing Turn-To-Turn Insulation on Form-Wound Stator Coils for Alternating-Current Rotating Electric Machines.
- NEMA MG1-1993 Motors & Generators

**Reprints or EASA standards are available from:**
www.easa.com
1331 Baur Boulevard
St. Louis, MO 63132
Phone: 314-993-2220

FAX: 314-993-1269

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National Electrical Manufacturers Association (NEMA)
Global Engineering Documents
Phone: 1-800-854-7179
International: 303-379-2740

# Chapter 2 Principles of Offline Tests

**Inside this chapter**

This chapter briefly explains the fundamentals of the tests the AWA performs. They are treated in the same sequence that the AWA performs them during an automatic test and they are subdivided based on voltage level and function. The tests are all listed on the tests tab of the AWA software.

## Temperature compensation

The effect of temperature on both copper resistance and ground wall resistance can be substantial. Knowledge of temperature is especially important if test data is to be compared or trended to previous measurements. The temperature is entered manually into the AWA from acquired temperature readings of a third party device. The AWA will correct the coil resistance tests to 25ºC (per IEEE 118) and the IR (insulation resistance/Meg-Ohm) reading to 40ºC per IEEE 43. The effects of temperature will be discussed further in each section below as it applies to each test.

## Principles of Coil Resistance testing

The Resistance test is a very simple test to perform and gives a first order indication of the health of the conductors in a winding. The test consists of injecting a known constant current through the winding, measuring the voltage drop across the winding, and calculating the coil resistance using Ohm's law. If a coil is shorted somewhere in the interior of the winding, the resistance will be lower than normal. This lower coil resistance can be compared to previous measurements of the same coil, compared measurements of identical coils, or compared to the motor nameplate value to identify a bad coil. Measured values can also be higher than normal such as loose or corroded connections.

As mentioned above, the measured resistance is affected by the variation of copper conductivity with temperature. The measured resistance value should be corrected to a common temperature, usually 25ºC per IEEE 118, before comparing two different measurements.

Performing Resistance tests on the same motor over a time frame provides early warning signs of motor problems. Motors operated in conditions that allow corrosion, contamination, or other physical damage may show initial warning signs of failure through the Resistance test.

Since the windings found in many motors have very low resistances, the injected current might have to be many amps to accurately measure the voltage drop across the coil. Difficulties in measuring the voltage drop across the coil itself are the affects of the contact resistance of internal relays and the contact resistance of the clip leads used to connect to the motor's winding. Contact resistances can be comparable or even greater than the resistance of some coils.

A practical lower limit of the coil resistance test exists to evaluate the copper winding conductors. An instrument must be able to resolve the change in copper resistance caused by a short in the winding before conclusions can be made regarding the coil resistance. The AWA is capable of a 1 milli-ohm resistance measurement with a separate, 4-wire resistance test cable.

The AWA Resistance test compares the percentage difference in resistance between leads with the calculation of Max Delta R. The user defines the acceptable Delta R tolerances for each motor, thereby giving the AWA its pass/fail limits.

When the Resistance test results are displayed by the AWA, measured resistance values, resistances corrected for temperature and the Delta Resistance percentage are listed. A problem with the motor under test may be indicated when Delta Resistance is high. The motor fails the test when the AWA detects Delta Resistance values not within the prescribed limits. No further testing is necessary until the reason for the faulty resistance measurements is resolved. However, the test sequence after a test failure is possible.

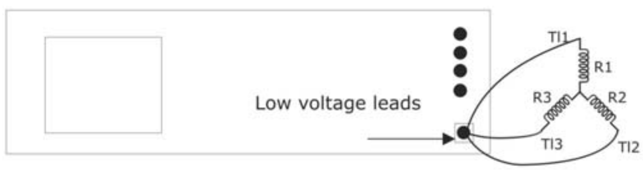
The AWA can also compare measured resistances to expected or target values. The user specifies the target value. At the end of the Resistance test, the target values will be compared to measured values. If measured values are out of tolerance, the AWA will fail the motor.

***AWAIV-12 Resistance Test***

The AWAIV-2 and AWAIV-4 can make resistance tests through a separate set of low voltage test leads (LV).

The AWA does a lead to lead measurement with separate, 4-wire type leads (low voltage measurement).

Fig 2-2: AWAIV-12 low voltage test leads resistance test




$R_{TL1} = R_1 + R_2$ (Lead 3 float)
$R_{TL2} = R_2 + R_3$ (Lead 1 float)
$R_{TL3} = R_3 + R_1$ (Lead 2 float)

The AWAIV-2 and AWAIV-4 low voltage test leads (LV) are not influenced by the contact resistance of the test lead connection because the LV test leads are four wire or Kelvin type. As a result, the LV test leads will give a more accurate resistance reading. Coils with resistances of 0.001 ohm/1.0 milli-ohm can be evaluated for damage. Of course, the unit is capable of reading well below 1 milli-ohm. Once again, for resistance measurements to be useful in motor testing, the measurement must be able to resolve a 1-5% change in resistance that can be indication of damaged coils. An example of the ability of the LV test leads to resolve potential problems, the unit is able to see the difference between 12 inch (30cm) and 11 inch (28cm) of 14ga solid copper wire.

### Target corrected Resistance

The Target corrected Resistance is the expected resistance the AWA should measure for the stator. This value *must* be a temperature corrected resistance value. This expected resistance will be compared to the measured temperature corrected values; therefore, it is necessary to know whether a line-to-line resistance measurement will be obtained.

These measurements are very different than the lead to lead (or phase to phase) measurements that are shown on nameplates. When entering target corrected resistance values on the Resistance test screen, the AWA's balance values should be used – not lead to lead / phase to phase values.

## Principles of the Meg-Ohm test

The **Meg-Ohm** test consists of applying a DC voltage to the windings of a machine after isolating the winding from ground. The AWA's internal relays automatically isolate the windings – no operator action is required. According to IEEE 43 the test voltage is usually near the operating voltage of the machine.

The intended purpose of the Meg-Ohm test is to make an accurate measurement of the insulation resistance of the ground wall insulation. The insulation resistance, abbreviated IR, is a function of many variables: the physical properties of the insulating material, temperature, humidity, contaminants etc. The IR value is calculated using Ohm's law – the applied voltage is divided by the measured leakage current. This leakage current is the current which passes from the winding through the ground wall insulation to the motor's steel core plus any surface leakage currents. The surface leakage currents flow through moisture or contaminants on the surface of the insulation. To accurately determine the insulation resistance, the surface leakage must be reduced to an inconsequential level.

## Principles of the Polarization Index (PI) Test

Due to the subtleties in the interpretation of the results, the **Polarization Index Test (PI test)** is the most confusing HVDC test in use. The PI test is performed in order to quantitatively measure the ability of an insulator to polarize. When an insulator polarizes, the electric dipoles distributed throughout the insulator align themselves with an applied electric field. As the molecules polarize, a polarization current, or absorption current, is developed that adds to the insulation leakage current. This additional polarization current decreases over time and drops to zero when the insulation is completely polarized.

PI results become confusing when attempting to attribute variations in the PI value to the polarizability of the insulator or other affects such as humidity or

$$PI = \frac{IR(10\,\text{min})}{IR(1\,\text{min})}$$

moisture, surface leakage or instrument error. The result is even more confusing when attempting to reconcile a PI of 1 when expecting a different PI result. The PI test is typically performed at 500, 1000, 2500 or 5000 volts. This depends on the operating voltage of the motors being tested. The duration of the test is 10 minutes. The PI value is calculated by dividing the insulation resistance at 10 minutes by the resistance at 1 minute as shown below:

In general, insulators that are in good condition will show a high polarization index while insulators that are damaged will not. See IEEE 43-2000 for recommended minimum acceptable values for the various thermal classes of motor insulation. Unfortunately, most insulating materials recently developed (last 20 years) do not easily polarize. For example the newer inverter grade wires and epoxy resins do not readily polarize. As recommended in IEEE 43-2000, if the one-minute insulation resistance is greater than 5000Mohms, the PI measurement may not be meaningful.

## Principles of the Dielectric Absorption (DA) test

The Dielectric Absorption (DA) test is essentially a short-duration PI test and is usually intended for smaller motors. Larger motors whose insulation does not easily polarize are also good candidates for the DA test. Other than the shorter test time, all other principles are the same as the PI test, explained in the previous section.

While the PI test is recommended only for motors 200 horsepower or greater, the DA test is often useful for motors in approximately the 50 to 200 horsepower range. In the situation where PI results may not be meaningful, the Dielectric Absorption (DA) is widely used. The DA is the IR value at 3 minutes divided by the IR value at 30 seconds.

$$DA = \frac{IR(3\text{ min})}{IR(30\text{ sec})}$$

The motivation for doing a DA test is to reduce the test time from 10 minutes to 3 minutes. To date there are no standardized accepted values for the DA test; however, useful information can be obtained by trending the DA values over time.

## Principles of the DC High-Potential (HiPot) test

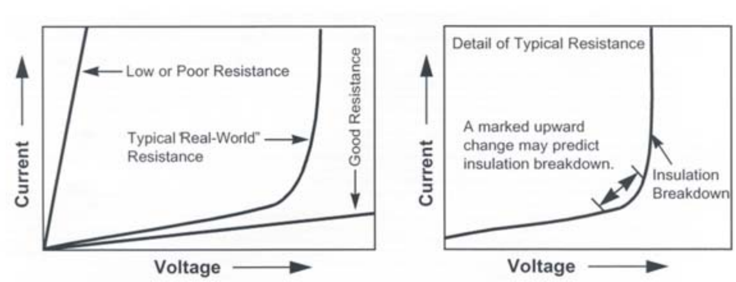
The **HiPot** test consists of applying a DC voltage to the windings of the machine, same as a Meg-Ohm/PI test, but at a higher voltage. See, Recommended test voltages HiPot and Surge tests, regarding proper test voltages for the HiPot test. The intended purpose of the HiPot test is to prove that the ground wall insulation system can withstand a high-applied voltage without exhibiting an extraordinarily high leakage current. Therefore, the HiPot test is often called a proof test. The observed insulation resistance or leakage current is recorded and compared to acceptable limits. If the insulation fails the HiPot test, the insulation to ground is determined to be unreliable. Knowledge of the real behavior of insulators/resistors, not just ideal resistors, will help the operator to test the winding insulation to a point before insulation breakdown.

For an ideal resistor, good or poor, as the voltage is increased, the leakage current will increase proportionately. In real world applications, insulation resistance rarely behaves in this manner. Instead, the current in a typical resistor will increase proportionately with voltage until the voltage is within as little as five percent of breakdown voltage.

**Note**: Just before insulation breakdown, the current will rise faster than the voltage. At still higher voltages, the insulation will completely breakdown and the current will rise extremely fast.

***Note**: The key to DC HiPot testing is to look for leakage current that is rising faster than the increase in voltage that is applied to the winding.* The test can then be stopped before the insulation is damaged. The HiPot test is considered a mainstay of motor testing. HiPot tests can be performed in one of two

Fig 2-3: Details of typical Resistance




ways, AC or DC. The HiPot test brings the entire motor winding up to the same potential. Since all the windings are at the same potential, there is no turn-to-turn, or phase-to-phase insulation stress. There is uniform voltage stress applied between the winding insulation and the ground wall, throughout the entire winding. Although the Surge test can also test for grounds, it does not uniformly test all the ground wall insulation as does the HiPot test.

## Principles of the Step Voltage test

The Step Voltage test is performed to a voltage of what the motor typically sees during starting and stopping. The test voltages are governed by IEEE and are posted below for reference.

| Vline | Min Test V Vline x 1.25 x 1.7 | Max Test V Vline x 1.5 x 1.7 |
|---|---|---|
| 480 | 1020 | 1224 |
| 575 | 1222 | 1466 |
| 600 | 1275 | 1530 |
| 2300 | 4888 | 5865 |
| 4160 | 8840 | 10608 |
| 6900 | 14663 | 17595 |
| 13800 | 29325 | 35190 |

Table 2-1 IEEE test voltages

***Note**: IEEE references NEMA MG 1-2006 Part 12, Page 2 and states that in no case should the test voltage be less than 1500 volts.

The DC voltage is applied to all three phases of the winding, raised slowly to a preprogrammed voltage step level, and held for a predetermined time period. It is then raised to the next voltage step and held for the appropriate time period. This is continued until the target test voltage is reached. Typical steps for a 4160-volt motor are 1000-volt increments, holding at one minute intervals. For motors less than 4160, the step voltages should be 500 volts. (See Fig 2-4).

Data is logged at the end of each step. This is to ensure the capacitive charged, polarization current is removed, and only real leakage current remains, thus providing a true indication of the groundwall insulation condition. If at this point the leakage current (IμA) doubles, there is an indication of insulation weaknesses and the test should be stopped. If the leakage current (IμA) raises consistently less than double, the motor insulation is in good standing.

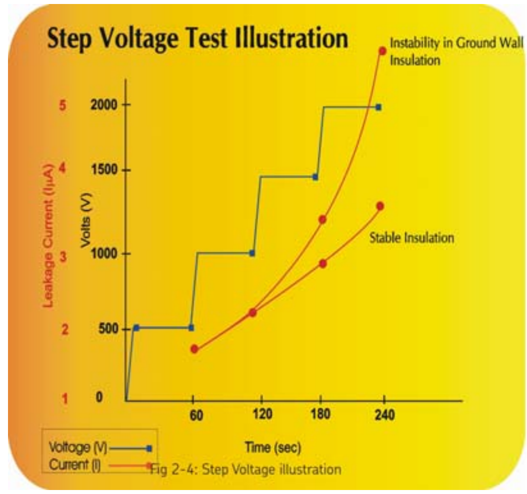


Fig 2-4: Step Voltage illustration

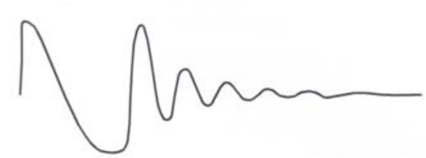
The Step Voltage test is necessary to insure the ground wall insulation and cable can withstand the normal day-to-day voltage spikes the motor typically sees during operation.

## Principles of the Surge test

Whereas the Meg-Ohm/PI/ HiPot tests are used to detect ground wall insulation weakness, the Surge test is used to find turn-to-turn insulation weakness. Motor winding insulation failures often start as turn-to-turn failures, which eventually damage the ground wall insulation and lead to catastrophic failure. Surge testing can detect the early stages of a problem before it becomes severe.

The surge test consists of applying a fast rise time, high current impulse to a winding. This high-rise time impulse will induce a voltage difference between adjacent loops of wire within the winding. If the insulation between the two loops of wire is damaged or somehow weakened, and if the voltage difference

Fig 2-5: Surge waveform



between the wires is high enough, there will be an arc between the wires. This arc shows up as a change in the surge waveform.

The surge test is performed with an impulse generator and a display to observe the surge waveform in progress. The surge waveform is the voltage present across the test leads of the Baker during the test. The indication of a turn-to-turn fault is a shift to the left, and/or a decrease in amplitude of the waveform when the arc between loops of wire occurs.

The wave pattern observed during a Surge test is directly related to the coil's inductance. There are other factors that influence the wave pattern, but inductance is primary. The coil becomes one of two elements in what is known as a tank circuit or an **LC-type** circuit

$$Frequency = \frac{1}{2\pi\sqrt{LC}}$$

made up of the coils inductance **(L)** and the surge tester's internal capacitance **(C).**

The inductance **(L)** of a coil is determined by its geometry, number of turns of wire and the type of iron core. The frequency of the wave pattern is approximated by the formula:

This formula implies that when the inductance decreases, the frequency will increase.

A surge test can detect a fault between turns by observing a jump in the resonant frequency of this LC tank circuit. If the voltage potential is greater than the weakened dielectric strength of the turn insulation, one or more turns may be shorted out of the circuit. In effect, the number of turns in the coil is reduced. Fewer working turns reduce the inductance of the coil and increase the frequency of the ringing pattern from the surge.

The voltage or amplitude of the surge wave pattern is also reduced due to the decrease in inductance of a coil with a fault between turns. It is determined by the following formula:

$$Voltage = L\frac{di}{dt}$$

When the insulation between turns is weak, the result is a low energy arc and a change in inductance. When this happens the wave pattern becomes unstable – it may shift rapidly to the left and right, and back to the original position.

## The Error Area Ratio

When testing three phase motors, the waveforms of the three phases can be compared to each other. They should all be virtually the same: same shape, same zero crossings, and same amplitude. In practice; however, the three waveforms won't be exactly the same. There will be slight differences in the physical windings themselves as one phase is wound over another. However, how different should two waveforms be to identify a bad coil? The Error Area Ratio (EAR) was developed to answer that question. The EAR values give a quantitative number to how different two waveforms are. EAR is defined as:

$$EAR_{1-2} = \frac{\sum_{i=1}^{Npts} Abs(F_i^{(1)} - F_i^{(2)})}{\sum_{j=1}^{Npts} Abs(F_j^{(1)})}$$

Where:

$F^{(1)}$ = Data points representing waveform 1.

$F^{(2)}$ = Data points representing waveform 2.

$EAR_{1-2}$ = error area ratio of waveform 2 with respect to waveform 1.

If two waveforms are exactly the same, the EAR value will be zero. Two waveforms that are almost exactly the same will have EAR values of 3-4%. Waveforms with obvious separation will have EAR values greater than 10%. This application of comparing one phase of a winding to another is called a line-to-line EAR (ll-EAR).

The application of the EAR above is used to compare two waveforms from two leads or two phases of a motor. A second application is to use the EAR formula as a way to compare the surge waveforms from a single lead or phase to itself. This application of the EAR is called the pulse-to-pulse EAR (abbreviated ppEAR).

To explain the ppEAR, recall that the arcing turn-to-turn short is identified by a shift to the left of the surge waveform as the test voltage is slowly increased. On a good coil, the waveforms from consecutive pulses would appear almost the same – the only difference being the increases in amplitude as the test voltage increases. On a faulty coil, the consecutive pulses would look nearly the same until the arcing short occurred. At this voltage, the whole waveform shifts to the left and possibly drops in amplitude.

Consider what an EAR calculation of two consecutive pulses could look like as voltage increases. Since the amplitudes of the two waveforms are different, there would be some EAR value calculated, possibly around 4-7%. Now consider doing the EAR calculation on the pulse just before breakdown and again on the pulse just after breakdown. The EAR value would jump to a significantly higher value (10 to 100%).

# Chapter 3 Instrument overview & Setup

**Inside this chapter**

- AWA startup
- Printer configuration
- Provided memory key
- Use of footswitch

## AWAIV-2 & AWAIV-4 (AWA) startup

The AWA requires adequate ventilation. Place the unit where air can circulate freely around it and avoid locations in direct sun or near heat sources. Do not stack objects on or near the AWA. To prevent shock hazard, do not expose the AWA to rain, snow, or moisture. Avoid locations with high levels of dirt or dust.

1) Place the AWA on a large table or bench. Check the AWA power switch and make sure it is in the off position.
2) Plug one end of the AWA power cable to the line connector on the left side of the AWA and plug the other end of the power cable into a grounded wall socket. The unit will operate between 85-264 VAC 50/60Hz.
3) Locate the keyboard/pointer USB unit. Plug into one of the USB ports.
4) If a CD-ROM, disk drive needs to be used, plug it into one of the USB Ports for the AWA.
5) Power up the AWA by turning the power switch to the **On** position.
6) As the AWA powers up, various BIOS messages will appear on the screen.
7) The AWA will automatically log into the AWA Software with the associated serial number information. **Note:** An Administrator can change this to log into the Windows Desktop; however, Baker Instrument Company, an SKF Group Company, recommends this be unchanged. If passwords are changed and the instrument is returned for service without the passwords, the instruments hard drive will be reformatted and any data may be lost.

### Printer configuration

The AWA comes with a set of printer drivers installed. More printer drivers may be added if necessary. To install a printer, follow the instructions provided in the Windows® manual. In order to print, the AWA must be connected to the printer and the proper printer driver must be selected.

### Provided memory key

An external, USB memory key is shipped with the unit for data storage, backup or transfer.

To enable the CD-ROM driver, have the devices plugged in upon boot-up. The devices will be automatically recognized at this point and ready for use.

### Use of footswitch

On the rear of the instrument a Cinch® four pin connector is available to plug in the footswitch to operate the instrument for span testing of armatures. The footswitch allows the operator to continue testing the entire armature easily and quickly.

# Chapter 4
# Software navigation

**Inside this chapter**

- Database management
    - Starting the software
    - Creating a new database
    - Opening an existing database
    - Multiple databases
    - First time version 4 software is used
- The motor tree
    - Motor ID field
    - Motor location fields
- Finding motors
    - Explore tab
    - Motor ID tab
    - Route tab
        - Adding a route
        - Renaming a route
        - Deleting a route

The AWA software works by performing pre-configured tests, automatically, on pre-configured motors. The pre-configured tests are called Test ID's. A pre-configured motor is called a Motor ID. The Motor ID is stored in the AWA's database along with the Test ID to be used when testing that motor. Additional information about the motor such as the manufacturer, serial number, horsepower rating, frame size, speed, operating voltage and current is also stored in the Motor ID. New motors can be entered into the database or existing motors can be edited, corrected, or updated.

To view test results for a given motor or to perform a test on a motor, it must first be selected from all the other motors in the AWA's database. The left side of the AWA software display is used to find and select a motor. The right side of the screen is used to view test result data and run tests.

The Test ID consists of all test parameters to be used when performing tests on a motor. Details such as test-voltages, pass or fail criteria, and test times are contained in a Test ID. These Test ID's are named and defined by the user. There are already several Test ID's created by Baker Instrument Company, an SKF Group Company, for several different machines. Usually, the most important parts of a Test ID are the test voltages. Therefore, a Test ID is named after the operating voltage of the motor. Several motors can share a single Test ID. For example, all 480-volt motors can use the same Test ID.

## Database management

Database management is a highly important feature of a good predictive maintenance-testing program. It facilitates organization of periodic maintenance data. The database section of the AWA software allows the entry of identifiers to help clarify the location of specific motors, along with the use of multiple databases to help organize overall program maintenance. The user will need to develop a best practice in keeping the data collected, easily accessible and meaningful. The discussion in this chapter will be about the tools the AWA software provides to aid in database management. The following will be discussed:

- Motor ID
- Motor location fields
- Multiple databases
- Data transfer
- Archive
- Restore
- Conversion of older databases

## Consequences of not organizing data

Since the Baker tester can be configured to store every test it ever performs, it is recommended to establish a structure that is to be used by all persons performing tests. Consider the following example: A maintenance program is established to test motors at seven plastics production plants, each in a remote location. Each plant has nearly 1000 motors that are identified as needing periodic testing. All works well for several months until a motor that was previously tested fails. The maintenance manager wants to see all the test data. When the project supervisor looks at the data, he finds nearly 7000 tests, all in one large database, and in a random order. The manager spends about an hour looking for the last test performed and gives up. Upon investigation, the manager finds that each of the technicians using the equipment has been entering the data based upon what made sense to them at the time. Because of the disorganization, important test data has been lost or at best difficult to locate.

The AWA's database structure is designed to facilitate data organization and to be flexible enough to allow the user to uniquely plan for specific needs.
The Motor ID, two location fields, and the multi-database abilities are the tools for you to use to organize the data so that the above scenario does not happen.

## Starting the Software

To start the AWA, locate and double click the AWA icon on the Windows® desktop. The AWA software will start and present a window with two options: to create a new database or open an existing database. AWAIV-12 units built since late 2007 will automatically start the software.

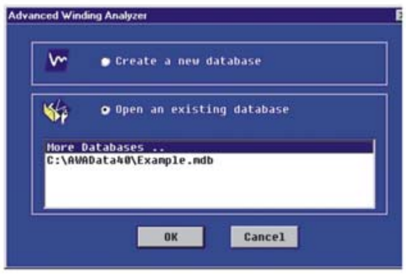



Fig 4-1: Opening software from desktop

## Creating a New Database

There are two ways to create a new database. Click on the radio button upon entering the AWA software. The second way is after the user is already using the software.

To create a new database from the first screen presented click on the radio button in front of the **Create a New Database**. Type the name of the Database and click on **Save**.


Fig 4-2: Create new database

If the software is already running, create a new database by, selecting the **New** from the **File** menu item or the new database icon on the toolbar. The same **Create New Database** dialog will be displayed. The **Save in** folder is the default folder, navigate to another folder if desired, enter the name of the new database in the box next to the file name and click on the **Save** button. A database will be created and opened that has one default motor and the Baker default Test ID's. At this point begin entering new motors using the **Data-Nameplate** tab.

## Opening a Existing Database

There are also two ways to open an existing database. Upon opening the software, click on the radio button for the Open an existing database. To open a database

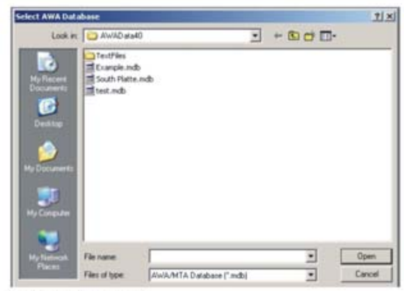



Fig 4-3: Select database

after the software is running, select the **Open** option under the **File** menu or click on the open database icon on the toolbar. An open file dialog box will pop up and allow the selection of a database to use as shown. It will default to the folder that has been selected in **View-Option-File Locations** menu item. In this case the default folder is AWAData40. By selecting a database (.mdb) and clicking the **Open** button or by double clicking the desired database the AWA application will open the database.

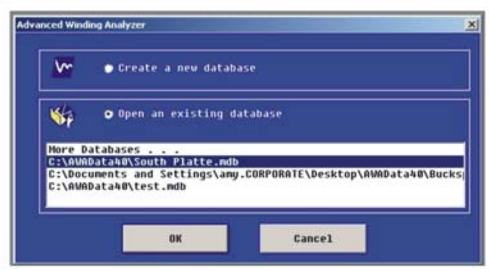



Fig 4-4: Open existing database

## Multiple Databases

The AWA software allows the use of multiple databases. Split data between different databases, grouping motors in whatever way that is beneficial to the application. For example, motor shops might want to use different databases for each customers. A preventive maintenance department could use a different database for each part of their plant. There may be a need to keep the data in a centrally located database on a network and have databases locally on each AWA, which are used to update the main database.

It is important to establish best practices for database organization early and maintain adherence to the establishment's practices to avoid loss of data or data duplication.

**Note**: Manipulation of the database may be useful for management and auditing purposes. Do not delete records associated with Motor IDs. Proceed with caution when manipulating data from the AWA. Always backup a database before deleting records or manipulating the database in any way.

## The First Time Version 4 Software is Used

The first time the AWA software is used, the **Enter Test Equipment Information** dialog will be displayed. Select the tester type, serial number (found on a sticker on back of unit), and customer's tester ID (can be an asset ID). If the software is being installed on a desktop computer all other fields will be gray.

This information will be used to track each data record to identify which AWA acquired the given record. It is usually entered at Baker, before the AWA is shipped. It may be changed though calibration, which can be invoked from the **Tests Tab**, **Enable Calibration** check box.

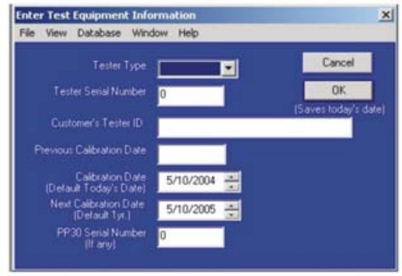



Fig 4-5: Dialog box

**Note**: Test results from a converted database (databases from a pre-4.0 version) will not have this information. Converted records will contain the tester type of AWA converted. Subsequent test results will be stamped with machine information, which can be viewed in the application view at the bottom of the pane.

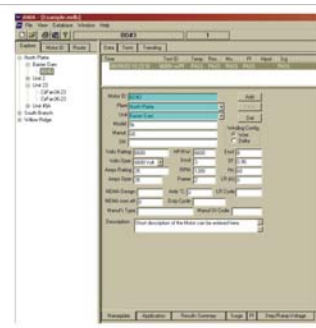


Fig 4-6: Selected database

## Motor tree

After selecting or creating a database, the above window appears.

The main AWA window is split into two panes. The left pane contains three different tabs that facilitate browsing through the motors in the database: the Explore tab, the Motor ID tab, and the Route tab. The right pane contains three more tabs, which allow the viewing of test data, performance of set tests and any trending mechanisms.

## Motor ID field

The records that are stored by the AWA are linked to each other hierarchically. The principle field, which serves as the base for linking associated records, is the Motor ID. The Motor ID is also the main means of locating and interacting with a motor's data. Therefore it is important to develop a naming scheme that will facilitate the location and retrieval of information. Case in point, it is not uncommon for a plant to have duplicate processes, with identically named motors in each process. This can cause confusion, since the motors have the same Motor ID, but are in different locations. Take steps at the start to ensure that Motor ID's are unique.

Example: Two identical intake pumps are present in duplicate processes. It makes database management easier if these two motors can be uniquely identified. One way to solve this problem is to include in the motor ID the process ID as in the following: The motor ID for process 1 could be intake pump P1 while the Motor ID for process 2 could be intake pump P2.

## Motor location fields


Fig 4-7: Changeable labels

The Motor ID is the primary identifier of a motor by which it can be located. There are two other fields that are used to help in locating a motor in the database. The location fields have default field names of Location and Building. If these labels do not make sense for the situation then change them. (Choose **View-Options-Changeable Labels** menu item from the AWA software.) For instance, for a plant maintenance program with several plants, the label of the location fields may be renamed to Plant and Unit. These location fields along with the Motor ID are entered as part of the nameplate record and are used to make up the tree structure of the **Explore** tab. In the example **Explore** tab to the right, motors have been organized by location in Plants and Units. North Platt and South Branch are Plants and Unit 23, Unit45A, Unit 17C are all units.

## Finding motors


The left side of the opening screen is used to navigate through the motors within the opened database. Three methods are provided. An **Explore** tab where the motor location is shown in a three level tree view, a **Motor ID** tab where a alphabetical list of Motor ID's can be used to locate a motor by typing the first few characters of the Motor ID, and a **Route** tab where predefined lists of motors can be used, much like a route often used in the predictive maintenance business.

## The Explore tab

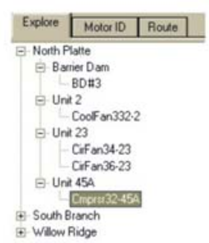



Fig 4-8: Explore tab

The **Explore** tab offers a tree structure to assist selection of a particular Motor ID. The two upper levels of the tree correspond to the location and building that the physical motor is housed. Location and Building are the default tree labels but are changeable labels for the motor location fields. The lowest level is the Motor ID. For example, in the view below the selected Motor ID, Cmprsr32-45A, is at the North Platte plant, Unit 45A. By clicking on Motor ID, a motor and its associated data is recalled. It becomes the current motor. Expand a motor location by clicking on the plus sign or contract a location by clicking on the minus sign.

## The Motor ID tab

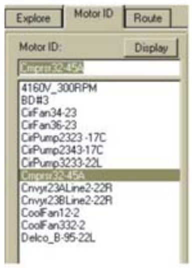



Fig 4-9: Motor ID tab

The Motor ID list box contains all motors from the database in alphabetical order. In the edit box, located above the list, will be the currently selected Motor ID. Locate a Motor ID two ways within this tab. The first method allows the user to begin typing the Motor ID needed into the edit box. The list will automatically scroll to the nearest Motor ID that begins with those characters. For example if the letters Cmp are typed, in the example to the left the Cmprse32-45A Motor ID would be highlighted. If this is the Motor ID in question, double click on that Motor ID (or click the **Display** button) and it would become the currently selected motor. The second method is to simply scroll down in the list until the Motor ID is found and double click or highlight it and click the **Display** button to select the desired Motor ID.

## Route tab


Fig 4-10:Route tab

The Route tab allows the user to construct individual lists of Motor ID's for routing purposes. As seen in the example Spring Outage list is selected. This list has four motors associated with it. The electrical technician does not have to search the entire database for these four motors to be tested during the spring outage. This tab also allows editing and printing of these routes. Click on the Edit Route button to start the editor. The editor allows the user to Add, Rename, and Delete routes. It also allows addition, removal and changing of the order of the Motor ID's on a list. See example dialog box Fig 4-11.

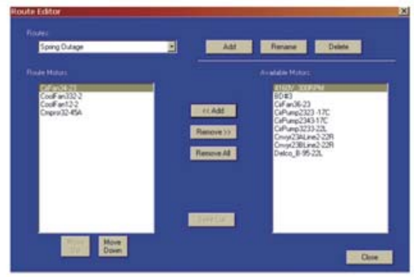


Fig 4-11: Route

## Adding a route

1) To add a new route, click on the **Add** button at the top of the dialog. The Route ID's edit box will be blank in order to enter a new Route ID. After entering the new ID, start adding Motor ID's from the **Available Motors** list box on the right to the **Route Motors** list box on the left.
2) To add a motor, select the Motor ID on the right and click on the **<<Add** button. The Motor ID will be moved from the **Available Motors** list to the **Route Motors**. Continue adding all necessary motors.
3) When completed, click on the **Update** button at the top of the dialog.

**Note:** The **Update** button appeared when the **Add** button was clicked.

### Renaming a Route

1) Select the Route in the Route ID's combo box to rename.
2) Click on the **Rename** button.
3) The Route Id will be highlighted. Edit the Id to the desired change, and click the **Update** button.

**Note:** The **Update** button appeared when the **Rename** button was clicked.

### Deleting a route

1) Select the route in the Route Id's combo box to delete.
2) Click on the **Delete** button. The selected route will be deleted.

**Note:** Deleting a route does not delete the Motor IDs from the database.

### Editing Motor ID's on an existing route

1) Select the route in the Route ID's combo box to edit. The Motor ID's associated with that route will appear in the **Route Motors** list box on the left. On the right, in the **Available Motors** list box, will appear all Motor ID's not on the route.
2) To add Motor ID's, select the Motor ID's in the **Available Motors** list box that need adding and click on the **<<Add** button. Select one motor at a time or use the control/shift keys to select a group of Motor ID's.
3) To remove unwanted Motor ID's from the route select the Motor ID's in the **Route Motors** list box and click on the **Remove>>** button. The Motor ID's will be removed from the **Route Motor** list and be added back to the Available **Motors** list.
4) To change the order of the Motor ID's in the **Route Motors** list, select the motor or group of motors to move and click on the **Move Up** or **Move Down** buttons at the bottom of the list.
5) When finished editing a route click on the **Update List** button to save changes.

# Chapter 5 Viewing data – the data tab

**Inside this chapter**

- Nameplate view
    - Adding a motor
    - Updating an existing motor
- Application view
- Results summary grid view
- Surge view
- PI view
- Step/Ramp Voltage test view

# Viewing data

## The data tab

The right pane of the AWA software has three tabs at the top of the screen. They are Data, tests and trending tabs. The Data tab contains two windows one above the other. The top window shows the date and time for the test result data and whether or not the motor passed the specific test. By clicking on a date/time, view test result data for that specific date within the application, Surge, PI, or Prg HiPot, tabs in the lower window. The lower window's view changes depending on which tab at the bottom of the panel is selected. These views include Nameplate, Application, Results Summary, Surge, PI, and Step Voltage Test (Prg HiPot).

Fig 5-1: Data tab

## Data tab, nameplate view:

The Nameplate view contains the nameplate data on each motor in the database. The first field is the Motor ID, which is used by the AWA program to uniquely identify the motor. Required fields are the Motor ID, and the two motor location fields. In the example, the location fields are plant and unit. The labels of these two fields are user definable. The default values are location and building. If changing the field descriptions is needed, select the **View-Options-Changeable Labels** menu item. The location fields are used in the Explore tab to help locate a motor. All other fields in the **Nameplate** view are optional.

**Note:** Many of Baker's industrial customers have found having all nameplate fields filled in greatly helps their preventive maintenance programs, by providing one place where their plant's motor data is kept. Likewise, Baker's motor shop customers find recording the complete nameplate information is a required task when working with their customer's motors.

The **Nameplate** view allows for the adding of new motors, updating existing motors and deleting motors from the database.

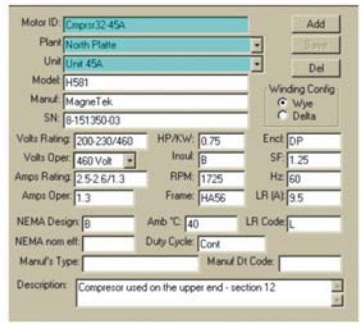



Fig 5-2: Data Tab Nameplate view

## Adding a new motor

1) Click on the **Add** button and the Motor ID and SN fields will be blanked out.
2) If needed, click on the **Clear** button to blank out all fields.

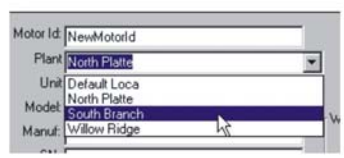



Fig 5-3: Location

Enter the new Motor ID by filling in the location fields. If more then one location exists, click on the down arrow of the location boxes. If entering a new Plant location, type the new name in the field.

1) Enter any other information needed for tracking. When finished, click on the **Save** button. When Voltage Class restriction is enabled, the

appropriate voltage class is a required field to enter.

2) Enter the Test ID to be used when testing the new motor.

**Note:** Clicking the **Reset** button will redisplay the previously motor and nothing will be added.

### Updating an existing motor's nameplate information

1) Make sure the Motor ID is selected and move the cursor to the field to update and make required changes. The **Save** button will be enabled as soon as changes are started.
2) When finished, click on the **Save** button and these changes will be committed to the database. If these changes are not needed, click on the **Reset** button instead of the **Save** button. All fields will be reset and no changes will take effect.

### Deleting an existing motor from the database

1) Make sure the Motor ID is selected and click on the **Delete (Del)** button.
2) A dialog will be displayed asking if this request is appropriate. If it is, click on the **Yes** button and the motor and all of its test results will be deleted.

### Data tab, application view:

Fig 5-4: Data Tab, Applications view

The Application view provides a place to enter data about a particular test. Such information as who did the test, who the test was done for, which MCC the test was performed from, and a general memo are fields that can be filled out at the time of testing or at a later date. The general memo field is a good place to put such information as humidity, any noticeable vibration of the motor before it was tested, etc.

**Note:** The tester type, tester serial number, and calibration date are stamped on this record, to indicate what tester performed the test.

Add new application records (which add an empty test record), update existing information, and delete test results from this view. To change what test result is being displayed, click on the date/time in the top window of the **Data** tab and this will change the **Application** view to the selected data/time's information.

### Data tab, results summary

Fig 5-5: Data tab, Results summary

The results summary view displays the test results data summarized in a grid or spreadsheet form. Each column represents one test result. Displayed, as a heading for each column is the date and time the test was performed. If all tests performed were passed, then the date/time will be displayed as a green cell. If one or more tests fail, the date/time will be displayed in a red cell. If no tests were performed then the cell will be gray. Use the scroll bars to the right and bottom to scroll through the results for each test category. The side-by-side nature of this view allows comparisons to be made easily  by allowing all test results for a motor to be seen.

To print a copy of this view, right mouse button click anywhere on the grid and a dialog will appear allowing the chose of a printer and the printing of the grid.

### Data tab, Surge views:

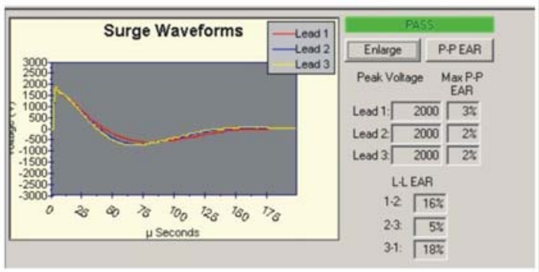



Fig 5-6: Data tab, Surge results

The Surge view shows the surge waveforms for a particular test. The surge waveforms can be viewed in two ways. As a comparison, all waveforms for each lead are superimposed on each other or a nested view where waveforms for each lead at the 1/3, 2/3 and full voltage are superimposed. Additionally, if the test failed, the previous to fail and the failed waveform will be displayed with the failed waveform being drawn in red.

The Surge view not only displays the surge waveforms for all leads but also renders a view of the pulse-to-pulse Error Area Ratio's (EAR). Click on the **pp-EAR** button to view the pulse-to-pulse EAR graph. The graph displays the EAR percent between successive pulses per test lead and the tolerance used during the test.

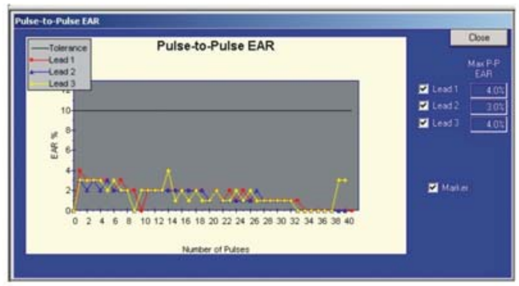
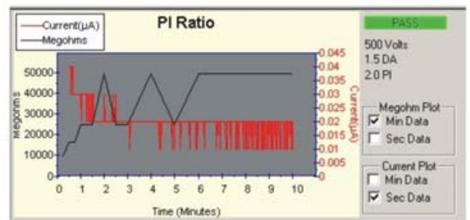



Fig 5-7: Pulse-to-pulse EAR

### Data tab, PI view




| Time (Min) | Current(μA) | Megohms |
|---|---|---|
| 0:15 | 0.05 | 10000 |
| 0:30 | 0.03 | 16666 |
| 0:45 | 0.03 | 16666 |
| 1:00 | 0.02 | 25000 |
| 1:30 | 0.02 | 25000 |
| 2:00 | 0.01 | >50000 |
| 2:30 | 0.02 | 25000 |
| 3:00 | 0.02 | 25000 |
| 4:00 | 0.01 | >50000 |
| 5:00 | 0.02 | 25000 |
| 6:00 | 0.01 | >50000 |
| 7:00 | 0.01 | >50000 |
| 8:00 | 0.01 | >50000 |
| 9:00 | 0.01 | >50000 |
| 10:00 | 0.01 | >50000 |

Fig 5-8: Data tab, PI view

Pressing the **PI (Polarization Index)** tab displays the PI view, which contains the PI/DA graph and the data table. The PI graph charts the current vs. time and the Meg-Ohm reading vs. time. Under the PI graph are selected data points that are used in the graph. On the right side will be the following: PASS/FAIL, Test Voltage, DA/PI ratios, and four check boxes. Choose the graph plot Meg-Ohm/Current data in one second or one-minute increments.

## Data tab, Step/Ramp-Voltage test view

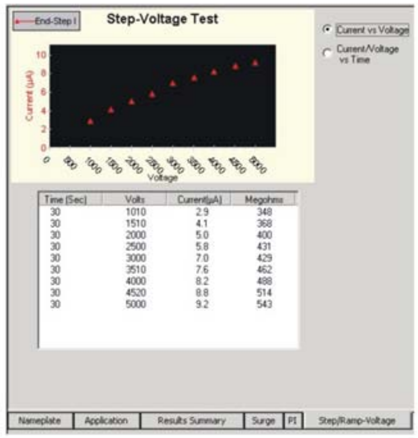



Fig 5-9: Step Ramp-voltage current vs. Voltage

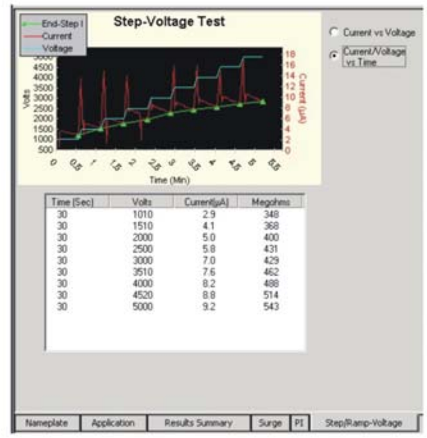



Fig 5-10: Step Ramp voltage current vs. Time.

Pressing the **Step/Ramp-Voltage** tab displays the Step Voltage test data in both graphical and tabular form. The graph defaults to plotting current vs. voltage.
The red triangle indicates the current at the end of the step. Clicking on the current/voltage vs. time radio button will cause the data to be plotted accordingly. The voltage in blue, the real time current in red and the green line with triangle markers indicates the current at the end of the step.

**Note:** The large excursion of the red real time current line shows the motor's charging current while ramping up voltage. The large swings of this value do not indicate an insulation problem.

Most concern is the current at the end of the voltage step. These end step currents should be linear. If not linear, there may be an insulation problem. The data in the table below the graph shows the test time per step, the voltage of each step, the measured end point current and the Meg-Ohm value at each end point.

# Chapter 6 Setting up – Tests tab

**Inside this chapter**

- Temperature/Resistance test screen
  - Manually entered Resistance measurements
  - Wye wound Resistance measurements
  - Delta wound Resistance measurements
  - Coil Resistances
- Meg-Ohm/PI/HiPot test screen
- Step Voltage test screen
- Surge test screen
  - Reference motors

## Tests tab

Pressing the **Tests** tab displays the screen in Fig 6-1. This is the main testing screen of the AWA. Each of the tests the AWA performs is indicated by several columns of buttons that show the status of each test.

In the left most column are On/Off buttons that show if the test is active. Press or click on the button to turn the test on or off.

The center column buttons can be pressed from this view to perform the particular test. This is known as a semiautomatic test.

The right column of buttons configures each test. If one of these buttons is pressed, the test configuration screen pops up. The description on these buttons gives an idea how each test is setup, how many leads will be used, the test voltage, etc. Each test's configuration screen will be described below.

A fourth shaded column appears at the end of testing. It indicates in red or green the pass or fail status of a test. The reason the test failed will be displayed on the red indicator.

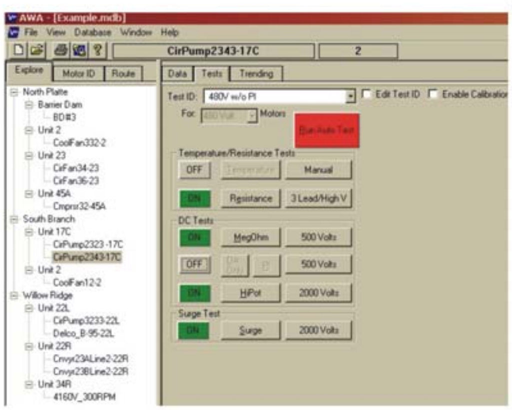


Fig 6-1: Test view

To run an automatic test, click the **Run Auto Test** button. Each test that is turned on will be performed in the same sequence as the tests appear on the tests tab view.

To edit Test ID's click on the **Edit Test ID** check box. The user will be prompted for a password. If this is the first time to edit a Test ID since the AWA software's installation, press the **Change Password** button and enter the password then press the **Set Password** button. If this is not the first time to edit Test Id's, simply enter the password and press **Ok**. Three new buttons will appear below the Test ID. Use the **Save** button to save changes that are made to the selected Test ID. Use the **Add** button to add a new blank Test ID or to copy the selected Test ID. Use the **Delete** button to delete the selected Test ID. When finished editing Test ID's click on the **Edit Test ID** check box to disable the editing of Test ID's.

**Note:** Leaving the tests view will also disable the editing of test ID's and all changes will be lost if they have not been saved.

## Test configuration

The three major setup screens for configuring AWA tests will be described below. The specific choices made in the test setup screens define the Test ID. Before editing test parameters make sure to check the **Edit Test ID** box and enter the password. This will allow updates to the test parameters and saving the changes when finished editing.

## Temperature/Resistance test screen

When one of the temperature or resistance test configuration buttons is pressed, the Temperature/Resistance Test screen pops up. The resistance and temperature test screens are combined into one and are shown in Fig. 6-2. This screen is also used during testing. The Resistance test and the temperature test can also turn on or off using the check boxes on the left side of the window.

The temperature test is used to acquire the temperature of the motor. The temperature is entered manually. Temperature can be entered in either °C (Celsius) or °F (Fahrenheit).

The temperature that acquired at test time is used later on to temperature correct coil resistance values per IEEE 118 and insulation resistance values per IEEE 43/95.

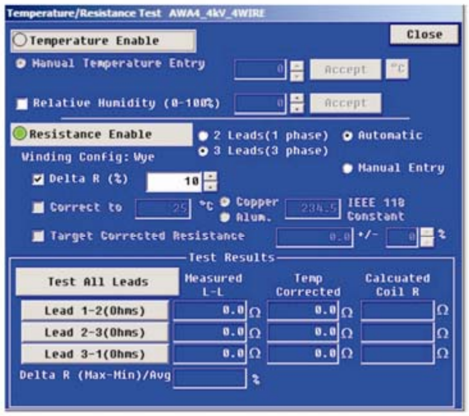



Fig 6-2: Temperature/resistance test screen

The Resistance test has several options. The test can be performed on a two lead device such as a single coil or a three lead device such as a 3-phase motor. The motor may have Wye or Delta winding configurations. The Wye or Delta configuration is entered in the nameplate window.


Fig 6-3: Resistance enable

The resistance values may be automatically acquired by the Baker tester or acquired by some other means and manually entered into the AWA software. The method for entering or obtaining resistance data will be discussed later in this chapter.

By checking the **Delta R (%)** box, the resistance values will have their percent spread calculated at the end of the test. If the percent spread is outside the number entered in the edit box, the AWA will fail the resistance test.

Resistance measurements can be influenced by humidity. To set the relative humidity, click on the


Fig 6-4: Max Delta R (%)

check box to enable and enter the humidity present. Click on **Accept**. .


Fig 6-5: Relative humidity

The acquired resistance values may be temperature corrected by checking the **Temperature Enable** check box.


Fig 6-6: Temperature correction

The temperature the resistance value is corrected to is set to 25°C or can be changed to another value. IEEE 118 recommends 25°C. The constant used to convert resistances at one temperature to another is known as the IEEE 118 constant and is 235.4 for copper or 224.1 for aluminum.

**Note:** Enable the temperature radio button and enter temperature into the software to obtain corrected resistances.

A motor that does not have a resistance reading within a Target Resistance range, may also be failed by checking the **Target Corrected Resistance** check box and entering appropriate resistances.


Fig 6-7: Targeted corrected Resistance

**Note:** Only temperature corrected values will be used in determining if values are within tolerance.

At the end of the test the AWA will compare corrected resistance readings to the target corrected resistance to determine if the motor will pass or fail.

The lower portion of the Temperature/ Resistance test window consists of, the test radio buttons, measured resistance values, temperature corrected resistance values and the fourth column is the calculated coil resistance.

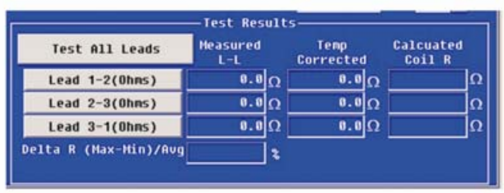



Fig 6-8: Resistance test results

As mentioned previously, there are two ways to obtain resistance data. In automatic mode the AWA will measure the resistance. Select the automatic radio button shown in Fig 6-2. The second way to determine resistance data is to enter it by hand using measurements made with a precision resistance bridge.

There is another key differenced between the automatic and manual modes. The automatic mode will make a resistance measurement per the users specifications between a lead with the other two leads held at ground as described in Chapter 2 Principles of offline testing.  A resistance value that is manually entered will be different: a measurement made with a bridge will be between one Lead and another lead with the third lead allowed to float. Due to this difference, the winding configuration becomes even more important. The AWA software will assume that manually entered data will be made with a two lead precision bridge and that the 3rd lead is allowed to float. Clearly, a Wye motor's lead-to-lead measurement will be different from a Delta lead-to-lead measurement.

Regardless of how the resistance measurements were acquired, once the measurements are obtained, the AWA software will calculate the temperature corrected resistances and display them as shown in Fig 6-8. Additionally, if possible, the AWA will calculate the individual coil resistances. If not, the AWA software will display a message indicating a solution to the coil resistance that could not be found.

While the Temperature / Resistance screen is open, there are several ways to start an Automatic measurement:

1) Press the **Test All Leads** button shown in Fig 6-8. The AWA will then measure each lead's resistance sequentially.
2) Press on of the **Lead** radio buttons also shown on Fig 6-8. The AWA will measure the resistance of that lead only and display the results.
3) Press one of the **Lead** buttons on the front panel of the AWA as shown in Fig 3-1. The AWA will then measure the resistance of the pressed lead only and display the results.

## Manually entered Resistance measurements

Resistance measurements from high precision resistance bridges can be manually entered instead of having the AWA run an automatic resistance test.


Fig 6-9: Automatic and manual entry radio buttons

Manually entered data should be of the line-to-line type of measurement. To enable the manual data entry, press the **Manual Entry** radio button as shown.

When the Manual Entry radio button is enabled, the results section of the resistance test screen shows measured L-L above the lead resistance column (see Fig. 6-10). In this column of three edit boxes, the lead resistances for the manual measurement should be entered as described below for the either the Wye wound motor or the Delta wound motor. When finished entering data, press the **Accept** button.

### Wye wound Resistance measurement

Using the NEMA nomenclature for a Wye wound motor, the resistance measurement for lead 1 should be made between terminals 1 and 2 with terminal 3 left floating. This measurement will consist of coil 1-4 in series with coil 2-5. Likewise, the lead 2 measurement should be made between terminal 2 and 3 with terminal 1 left floating. The lead 3 measurement should be made between terminal 3 and 1 with terminal 2 left floating.

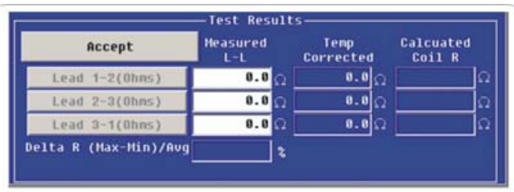



Fig 6-10: L-L manual Resistance

### Delta wound Resistance measurement

Using the NEMA nomenclature for a Delta wound motor, the lead resistance measurement should be made between terminals 1-6 and 2-4. This measurement will be of coil 1-4 in parallel with the series combination of coils 2-5 and 3-6. The lead 2 measurement should be from terminals 2-4 and terminals 3-5. Likewise, the lead 3 measurement should be made between terminals 3-5 and terminals 1-6.

Once all data is entered, and the **Accept** button is pressed, the measurements will be temperature corrected and displayed in the **Temp Corrected** column. The coil resistances will also be calculated for the individual coils and displayed in the Calculated Coil R column.

### Coil Resistances

As discussed above, the resistance measurements made by the AWA are a user configured series or parallel combination of coils. At the end of a resistance test, the AWA will the coil resistances and if a temperature has been entered it will also report those values. These are the values found in the right hand column of numbers on the resistance screen. The calculation involves numerically solving for the coil resistances given the type of winding (Wye or Delta) and the measured Balance values.

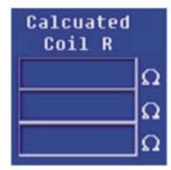



Fig 6-11: Calculated coil R

There are occasions when the algorithm fails. In these cases, the AWA will indicate that it can't find a solution given the balance resistance values.

### DC Tests: Meg-Ohm/PI/DA/ HiPot/Step or Ramp Voltage test screen

The DC tests screen is displayed when the Meg-Ohm, PI, DA, or HiPot voltage buttons are pressed on the **Tests** view. All of these tests should be thought of as a single type of test. The Meg-Ohm test is the first test to be run, followed immediately by a PI test, and then a HiPot test. There are two drop down lists for PI and HiPot. This is where the DA only, Revert DA, Ramp-Voltage and Step-Voltage tests are located. Therefore, a single setup screen for these three tests is used to configure each test.

The left half of the screen is where test voltages, minimum Meg-Ohm readings, voltage ramp rate, test times; current trip settings, discharge times and minimum PI values are all entered. The PI has two extra options: 1) default to the Dielectric Absorption if the IR=5000MÙ at 1 minute and 2) the Dielectric Absorption test only. As mentioned in an earlier chapter, the PI test has many subtleties. These two options let the test be setup so that no unnecessary time is spent on the PI test.

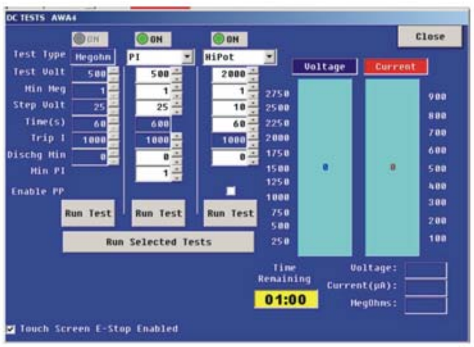



Fig 6-12: DC tests

Each test may be run individually by pressing the appropriate **Run Test** button. Alternatively, all selected tests can be run by pressing the **Run Selected Tests** button.

The right side of the screen is a display of the real time voltage, current, and the insulation resistance reading during the Meg-Ohm and HiPot tests. The voltage and current will be displayed as slider bars. Below the slider bars, are real time numerical outputs of the voltage and current.

## Ramp Voltage test

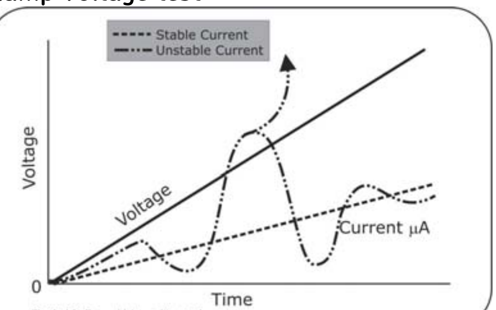



Fig 6-13: Ramp Voltage illustration

The Ramp Voltage test is used mostly for generators. It gives information on the contamination level with the winding. The Ramp Voltage test is performed for a predetermined length of time to a specific voltage level. The voltage increases linearly on a specific time scale. As the test is operating, the key is to watch the current. If it remains linear with the voltage the winding is in good condition; however, if the current waves up and down the winding may be contaminated. Fig. 6-13 gives a graphical representation of this test. In the illustration the unstable line make a sudden increase in voltage and current. If this occurs, it may mean an imminent overcurrent trip and a problem within the winding.

## Step Voltage test screen

The third type of HiPot test is the Step Voltage test. This test is also called a step test and is described in detail in IEEE 95. Clicking on the drop down arrow on HiPot reveals the Step Voltage test. By clicking on the Step Voltage test it will start the wizard for setting up the test.

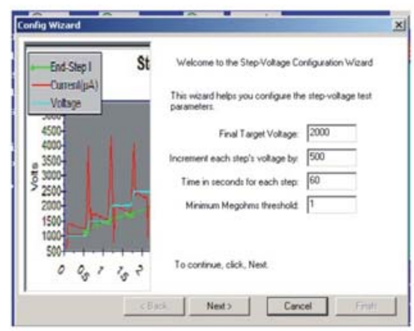



Fig 6-14: Step Voltage test wizard

Fill in the appropriate information for the steps that are needed. Make sure the steps are appropriate to the application being tested.

The seconds screen is used to enter up to 30 voltage steps or test intervals for each step. This screen will also appear when the Step Voltage test runs and will show a real time graph of the voltage and current during the test. After this test has been set up it can be edited prior to running the test. Click on **Config** on the test screen and the second or step page is viewed.

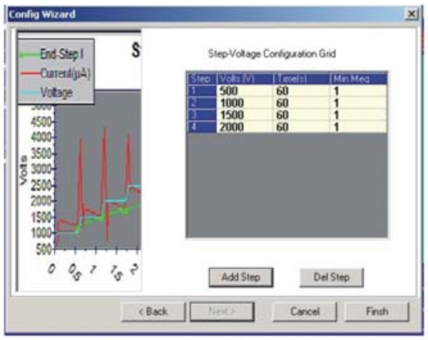



Fig 6-15: Step Voltage wizard steps

## Surge test screen

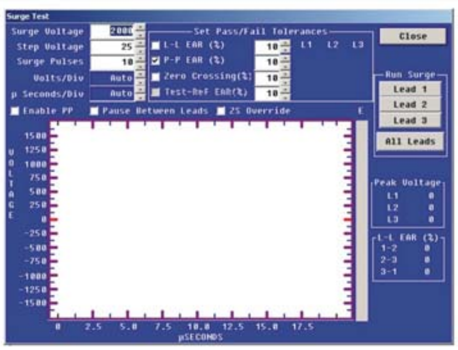



Fig 6-16: Surge test

The **Surge** test screen (Fig 6-16) will appear when the button with the surge voltage, to the right of the **Surge** button on the **Tests** tab is pressed.

In the upper left corner of the screen the **Surge Voltage**, **Step Voltage**, and the number of **Surge Pulses** are entered. Baker recommends the **Surge Voltage** to be 2V+1000. The **Step Voltage** controls the rate at which the voltage increases during the test and is set to a default rate of 25 volts per step. Finally, the **Surge Pulses** is the number of pulses that are applied to the winding after the full test voltage is reached.

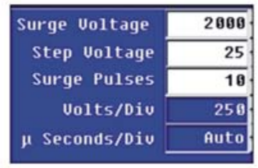



Fig 6-17: Surge voltage

The other two fields, **Volts/Div** and **µS(Seconds)/Div**, are related to the x- and y-axis of the surge waveform graph located in the middle of the screen. The **Volts/Div** field usually is automatically set by the AWA, but may be overridden by the user. This field determines the y-axis scale on the surge waveform graph. The µS/Div x-axis field can also be set to automatically capture the waveform in time. It can also be manually overridden in a specific setting.

The top center of the screen shows a series of checkboxes that determine Pass/Fail criteria for the Surge test. The **L-L EAR (%)** checkbox sets the maximum Lead-to-Lead Error Area Ratio (EAR) that is allowed between the different leads. This is usually set to 10%; however, some people have found settings as low as 4% are useful.

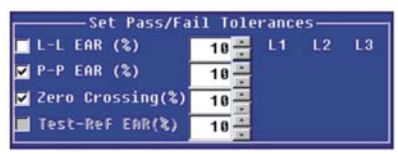



Fig 6-18: Pass/Fail tolerances

**Note:** This option should not be set if testing a motor with a rotor installed. If it is absolutely necessary to use the L-L EAR with the rotor installed, increase the tolerance to avoid nuisance trips. The increase in

EAR tolerance with installed rotors makes the use of this feature a poor detector of a turn-to-turn insulation problem.

The **P-P EAR (%)** sets the maximum Pulse-to-Pulse Error Area Ratio that will be allowed for the test.

The **Zero Crossing (%)** option determines how much a waveform must shift to the left (compared to the width of the screen) during the surge test before the AWA fails the test. Recall from previous chapters, a turn-to-turn fault is identified by a sudden jump to the left of the surge waveform. If a waveform jumps more that the percentage indicated the AWA will fail the surge test. The remaining three columns (L1, L2, and L3) will show real time numbers for the specific lead while the test is running. These numbers, which will be explained later, will become visible during the test.

The **Test-Ref EAR (%)** edit box is used to set a pass/fail criteria when comparing the surge waveforms from the test to a previously stored Reference Test. Use of the Reference Test will be discussed later in this chapter.

The four buttons on the right side of the screen will run a Surge test if pressed. Pressing the **Lead 1** radio button will start a manual surge test on lead 1 only. Likewise for the buttons that read **Lead 2** and the


Fig 6-19: Run Surge buttons

**Lead 3.** The **All Leads** button will start a manual three lead surge test. A surge test can also be started by pressing one of the test buttons on the front panel of the AWA.

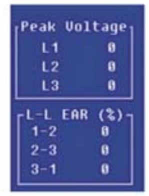



Fig 6-20: EAR ratios

The final voltage reached for each lead tested is displayed in the text boxes on the middle right of the screen. The EAR values shown correspond to the measured L-L EAR between the three leads during the test.

The surge waveform graph is shown on the next page. The vertical or y-axis shows voltage while the horizontal or x-axis shows time. The surge waveform is a plot of the voltage across a coil versus time. On the right side of the graph is a slider bar with an E label at the top. This slider bar will rise as the energy is increased by the tester to create the displayed waveform.

In effect, this slider bar shows how far down the pedal must be pressed to obtain the surge waveform. Low impedance coils (those with few turns) will require more energy in the surge pulse to develop a given voltage than will a higher turn count coil. The energy slider bar gives the operator an idea how hard the AWA is working.

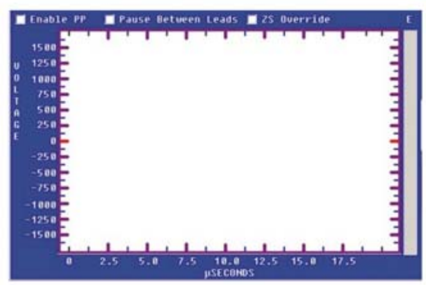



Fig 6-21: Surge waveform graph

## Set-up Test Parameters for Reference Waveform


Fig 6-22: Set up test procedures screen

To acquire a reference waveform enable Edit Test Id on the main screen. Turn on the Surge test and set the desired voltage, Zero Crossing, and both L-L EAR and P-P EAR tolerances. The Micro sec/div parameter defaults to auto. If this setting is known, it is better to enter that setting than leave it at **Auto**. However, if the setting is unknown, leave it at **Auto** and run a test. Then select that setting to run further tests. Once the test parameters have been modified press the **Update** button to save the parameter changes.

**Note:** It is important when comparing waveforms that all settings are the same. If the scales are different then a comparison cannot be made.

## Testing reference motor


Fig 6-23: Edit test ID

While in edit mode, the **Edit Test ID** check box is checked. Directly after setting up the test parameters, hook the AWA to the reference motor, and confirm the Motor ID displayed on the toolbar is the reference Motor ID. Press the **Run Auto Test** button. Upon completion of the test, the tester will prompt to save the results as a reference. If the results are good, press **Yes.** If the test needs to be run again, press **No**.

Multiple tests can be run in order to obtain the necessary standard. In automatic mode, test results are always saved. Reference waveforms will only be part of the Test ID when **yes** is pressed on the **Use as Reference** dialog. Continue to add or update Test ID's. Once finished editing, unselect the **Edit Test ID** check box to turn off the edit mode.

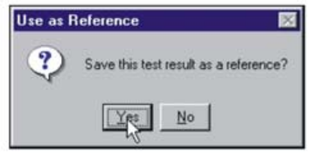



Fig 6-24: Use as reference

## Testing a production motor using comparison with a standard motor

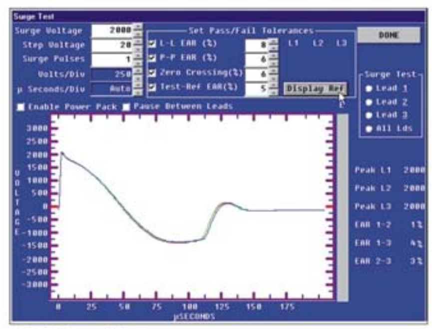


Fig 6-25: Display ref button

If a motor does not exist, add it via the **Nameplate** tab. From the **Test** tabs, select the Test ID to be used. Determine if the selected Test ID has a waveform attached by viewing the Surge configuration screen. The **Test-Ref EAR (%)** will be checked and a **Display Ref** button will be visible. Click on the **Display Ref** button and the reference waveform will be displayed.

**Note:** If the reference waveform is no longer needed or if by accident the reference waveform has been made, uncheck the **Test-Ref EAR(%)** and press the **Done** button, then update the Test ID and it will detach the reference waveform from this Test ID.

In order to begin testing, press **done** to return to the **Tests** screen. Press the **Run Auto Test** button to begin the test. If the motors have passed all other tests and there is a reference waveform, the AWA application will calculate the Error Area Ratio (EAR) at the end of the surge test. The EAR is calculated between leads of the motor under test and the reference motor. (Reference motor's Lead 1 and motor under test lead 1, reference lead 2 and lead 2 and reference lead 3 and lead 3.) The software will then compare the EAR values with the tolerance entered as part of the surge test parameters. If the EAR's are within tolerance, the motor passes. Likewise, if an EAR value is outside the tolerance the motor fails. After the test is performed and saved, surge waveforms can be examined from the **Data - Surge** tab.

### Viewing Surge Results

To examine surge results go to Surge view. If the Test ID used has a reference motor attached to it, the AWA application will display the selected motor's surge waveform (solid lines) and the overlaid reference motor's surge waveforms (dashed lines).

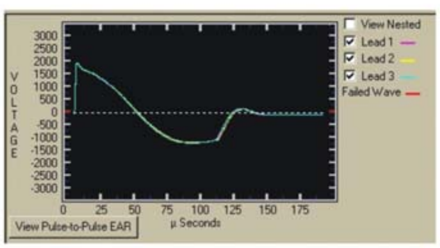



Fig 6-26: Surge results display

**Note:** If the reference waveform is very close to the selected motor's waveform, it will hide the dashed waveform so only the solid lines are viewed. To see one lead at a time, check or uncheck the desired lead's check box.

# Chapter 7 The Trending tab

**Inside this chapter**

- Max Delta R%
- Resistance
- Insulation Resistance/Meg-Ohm
- PI
- HiPot
- Relative humidity
- Special features for trending

## The trending tab

Opening the **Trending** tab brings up a graph that charts acquired data. Trending information such as Max Delta R%, Balance Resistance, L-L Resistance, Coil Resistance, Meg-Ohm (correct or not corrected), PI and HiPot leakage currents can be graphed over time in order to get an idea of the long-term status of a motor's insulation. These graphs can be reset, are selectable by dates, and have several printing options.

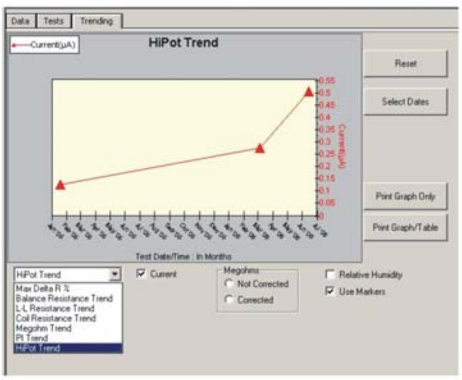



Fig 7-1 Trending graph

### Max Delta R% Resistance

There are three different types of Resistance data that can be trended. Balance, Line-to-Line, and Coil. Selecting one will bring up a graph similar to the main trending graph. Resistance measurements are against time and show very little variation over the test interval. Each of the three leads is shown in its own color. Each data point is indicated by a square, diamond or triangle markers. Hovering over a data point will show a date/time stamp and give the value of the test. This feature allows for easy identification of the test record for that point. By clicking the **Reset** box the markers will be returned to the first trending screen.

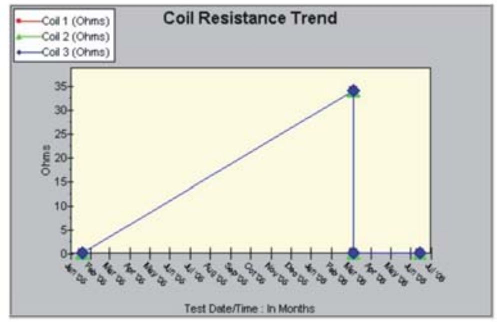



Fig 7-2: Resistance trending graph

### Insulation Resistance/Meg-Ohm

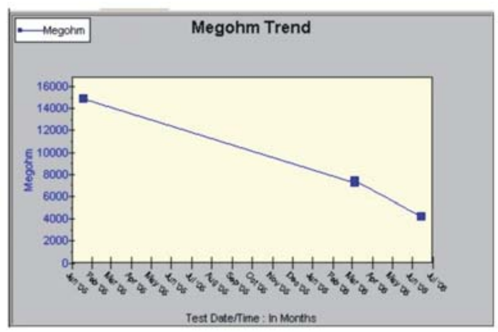



Fig 7-3: Meg-ohm trending graph

Meg-ohm data is graphed by checking the **Meg-Ohm** button. Hovering over a data point will show a date/time stamp and give the value of the test.

**Note:** When trending Meg-Ohm values, the temperature corrected values should be used and not the uncorrected values. Both values are available in the software. Sometimes it is not possible to acquire the temperature of a motor when testing due to inaccessibility of the motor.

## PI

Pressing the **PI** button displays the graph trending the PI ratio versus time, and has similar features to the other trending graphs.

## HiPot

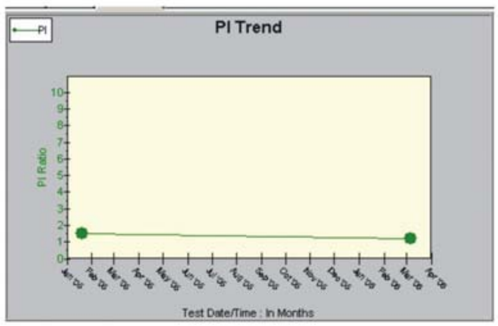



Fig 7-4: PI Trending graph

Clicking on **HiPot** in the drop down box brings up a graph of the HiPot leakage current data. This has the same features as the Meg-Ohm trending graph.

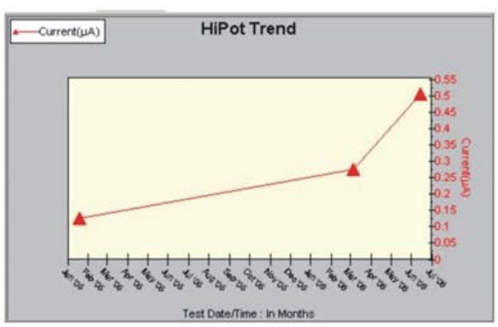



Fig 7-5: HiPot trending graph

## Relative humidity

Checking Relative Humidity (RH%) will cause the tool tips to display the RH% entered at test time. Hover over a data point will cause the tool tip to display the Time/Date stamp value of the point and RH%.

## Special software trending features

There are occasions when only a certain time period of data is desired or some invalid points need to be excluded. There are two ways in which to select specific data points. The first method is when the trending graph is displayed. Hold the left mouse button and drag and draw a box around the points you wish to see displayed. When you release the left button the graph will automatically re-scale and display the points inside of the box you drew. To reset the graph click on the Reset button and all points will be displayed.

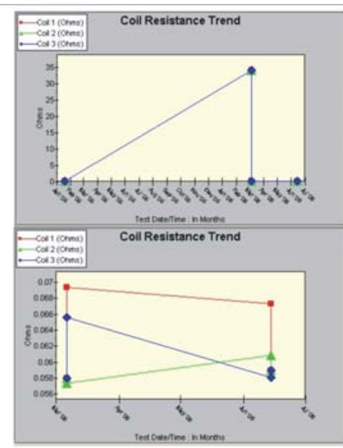



Fig 7-6: Special trending features

The second method is to choose points from a list of all test dates/times. By pressing the **Select Dates** button, a window pops up showing all test dates and times as well as a spreadsheet style view of the data. All of the data can be selected or just specific tests selected. Most often, this feature will be used to exclude a test that contains known bad data that for example, might be acquired in a test that was aborted. To select or deselect dates, use the same type of selection techniques used to select files in Windows Explorer.

1) Left click to select a single record
2) Left click the first record
3) Press the shift key and click on the last record to select a range
4) Within a selected range, press the ctrl-key and click to remove an unwanted record from the selection.

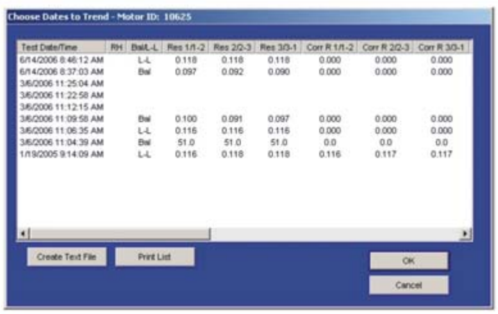


Fig 7-7: Dates to trend spreadsheet

Additionally, all of the records on this window can be exported to a comma-delimited file for later importing into a spreadsheet. In this manner, data can be analyzed using the customers tools in any way desired. To create the comma delimited file, select the test date/time to export or select none and all will be exported. Click on the **Create Text File** button, enter a file name, and the application will create a comma delimited file that can later be imported to a spreadsheet. This dialog will also allow printing of all the data see in the list box to a printer. Click on **Print List** to print all selected data.

# Chapter 8 Performing an example test

**Inside this chapter**

- Creating a motor ID
- Creating a test ID
- Configure Temperature/Resistance
- Configure Meg-Ohm/PI/HiPot tests
- Configure Surge tests
- Generic test ID's versus specific test ID's
- Running an automatic test
- Reviewing test results/data
- Printing reports

The following chapter will go through an example setup just as an operator would if a motor was to be tested for the first time. The first thing to do is create a Motor ID that uniquely identifies the motor – this example will use a 460V Delco motor. Next, a Test ID will be created for this motor and assigned to the Motor ID. Then tests will be ran and the results reviewed. Finally, reports will be printed.
The motor for this example is a Delco 460V, three phase, Wye wound, induction motor and has the following data on the nameplate:

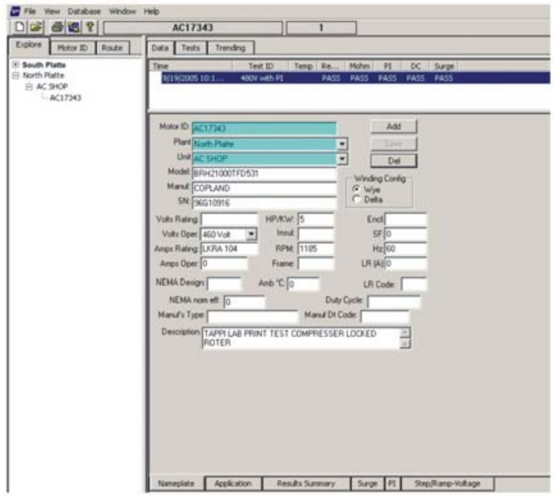


Fig 8-1: Motor ID's

Model: 2G2104
Frame: 213
SN B-95
Insulation: B
Amb °C: 65degC
V: 460V
A: 4.2A
HP: 3
RPM: 1765
Hz: 60
LR Code: J
SF: 1.0
Des: B
NEMA nom eff: 84
Duty Cycle: Cont

From this information, we will fill out the Motor ID Nameplate form.

## Creating a motor ID

Under the **Data** tab - **Nameplate** on the right half of the screen, the Motor ID information is displayed for the selected motor from the left hand **Explore** tab.
In this case, the AC17343 is chosen. Pressing the **Add** button clears the Motor ID and SN fields of the **Nameplate** view. In these data fields, the nameplate information for the motor is entered. See Fig. 8-1.

If needed, click on the clear button to clear the rest of the nameplate form. The reset button will restore the previous motor's information to the form.

**Note:** There are more data fields available than are contained on the nameplate. Only those items that are on the nameplate are filled in.

Enter a unique identifier for the Motor ID. For this example, use Delco_B-95-ACS as the Motor ID. Pant location is North Platte and Unit location is AC shop. Fill in the rest of the fields from the nameplate data previously given. After all data is entered click on the **Save** button to add the new Motor ID to the database. After the **Save** button is clicked, a **Select Test ID** dialog will appear. At this time, assign a Test ID to the newly created motor. In this example, select the **480Vw/o PI** Test ID. Next, create a new Test ID and assign the new Test ID to this Motor ID.

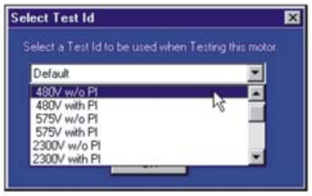



Fig 8-2: Test ID

Once the Test ID is selected, click on the **OK** button. The new Motor ID, Delco_B-95-22L, is now in the left hand screen along with all the other motors.

At this point the Motor ID, Delco_B-95-22L, has been created. The next step is to create a Test ID and assign it to this motor.

## Creating a test ID

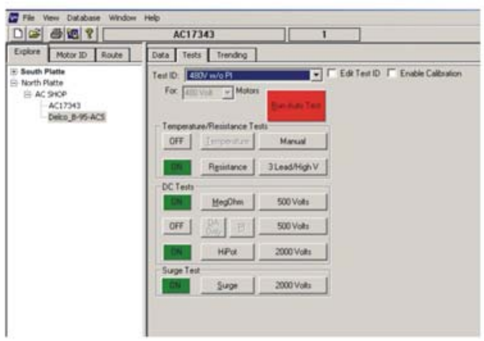


Fig 8-3: Creating a test ID

Press the **Tests** tab. Notice there is already the Test ID that was assigned in the **Test ID** drop down box when the Motor ID was created. However, for this example, we will add a new Test ID.

**To add a blank test ID:**

1) On the **Tests tab**, check  the.

2) Enter the password. (Note: If this is the first time to edit the Test ID's the password will need to be set. To do this click on the **Change Password** button and entering a password then click on **Set Password**.) Click **OK**, once the application has accepted the password, the **Update**, **Add**, and **Delete** buttons will appear and the voltage class dropdown list will be enabled.

**Note**: The Edit Test ID area will be red when in edit mode.

3) Click on the **Add** button, the **Create New Test ID** dialog box appears.
4) Click on the **Add Blank Test ID** radio button.
5) Enter the Test ID, Delco_460/wPI, for this example.

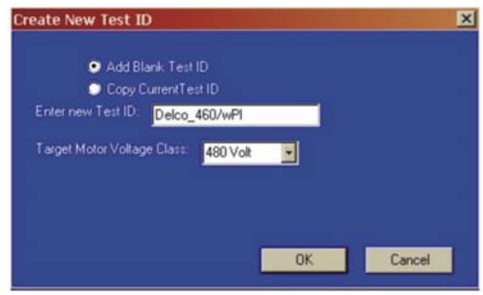



Fig 8-4: Test ID input

6) Using the dropdown box select a **Target Motor Voltage Class**. For this example, choose the existing voltage class of 460. If it does not exist you can create a new one by typing 460 in the edit box of the dropdown list.
7) If a new voltage class type has been entered, enter a description and click on the **Add Voltage Class** button. A dialog will appear asking if this action is correct. If it is, click **Ok**. This will close the **Create New Test ID** dialog.
8) The new Test ID will be displayed and all tests are turned off. The Test view will resemble Fig 8.5.

9) Turn on all required tests by clicking the left most column of **ON/OFF** buttons. When on, the button will turn green.
10) Proceed to the next section.

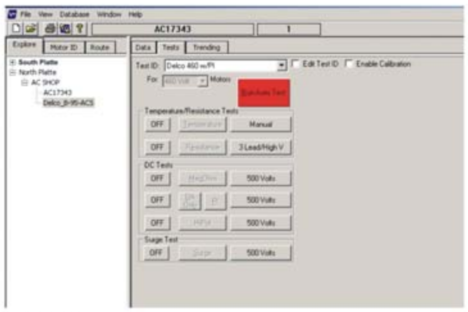


Fig 8-5: New test screen

## Configure Temperature/Resistance

1) The Temperature and Resistance tests share the same setup screen. Click on either of the two buttons to the right of the **Temperature** or **Resistance** buttons, by default; they are labeled **Manual** or **3 Lead/High V**. The **Temperature/ Resistance Test** dialog will be displayed.
2) If the test has been selected the **Temperature Enable** radio button will be green. Select the **Manual Temperature Entry** radio button. Note: The AWA will accept both °C (Celsius) or °F(Fahrenheit) temperatures and a temperature range of range of -32°C to 250°C. To unselect the test, click on the radio button and it will gray out.

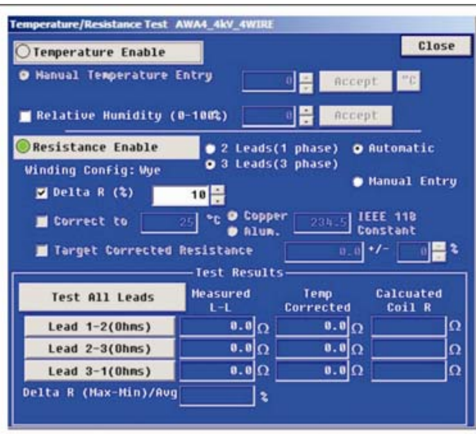



Fig 8-6: Temperature/resistance test parameters

3) If the Resistance test was chosen the **Resistance Enable** radio button will also be green. The Delco motor in this example is Wye wound, which is indicated on the screen and can be changed on the motor's **Nameplate** Tab.
4) The 3 **Leads and Automatic** radio buttons will be selected by the software for the 3-phase motor. The AWA will automatically acquire the resistance readings.
5) Leave the **Res Leads** check box unchecked. The AWA is equipped with a separate set of Resistance Test Leads to perform a lead-to-lead low voltage resistance test. Resistance values must be greater than 0.500 ohms for high voltage leads. If the high voltage leads are used on a motor with resistances less than 0.500 ohms, the AWA will prompt the operator to switch to the low voltage leads.
6) Check the **Max Delta R (%)** check box, setting it to 10%. If the spread of resistance readings are more then 10% the AWA will fail the motor.
7) Since temperature is enabled, the **Correct to** check box is checked and defaults to 25°C and the copper's IEEE 118 constant.
8) **Target Corrected Resistance** is another tool which further refines the pass/fail criteria. If checked, the AWA will fail a motor if the readings are not within the tolerances. For the example motor, its resistance reading, using a DVM, is 3.1 ohms. Therefore, it would be possible to check the **Target Corrected Resistance** check box and enter the value of 3.1 +/- 10%. Enabling target corrected resistance makes this Test ID specific to the example motor. If resistance data is not available, do not enable this.
9) Click on the **Done** button.

## Configure Meg-Ohm/PI/HiPot tests

1) To configure the Meg-Ohm/PI/HiPot tests, press one of the three buttons to the right of the **Meg-Ohm/PI/HIPOT** buttons to bring up the **DC Tests** screen. For this motor, the Meg-Ohm and PI tests will be run at 500V while the HiPot test will be run at 2000V. Consult IEEE 43/95 or another appropriate standard to determine test voltages.
2) Since this is a small motor, the PI test will be ran as a DA test only by selecting the **DA Only** box.

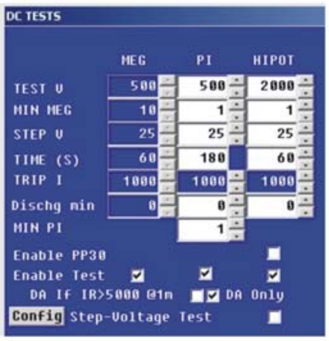



Fig 8-7: DC test parameters

Doing a full PI test will possibly not yield any useful information.

The other option, **DA If IR>5000 @1m**, sets up the AWA to automatically skip the PI test in favor of the DA test, at three minutes if the insulation resistance (IR) is greater than 5000 Meg-Ohms at the 1 minute mark. Insulation resistance readings 5000 Meg-Ohms or greater at one minute is the generally accepted criteria for aborting the PI test. Once the DC Tests are configured as shown above, press the **Done** button to return to the main test screen.

## Configure Surge test

1) Press the **500V** button next to the **Surge** button to open the surge test setup.
2) Configure the surge test as shown. Select the **Surge Voltage** to be 2000V which is approximately 2*V + 1000. Step Voltage of 25V/step is a typical ramp rate. If the test should run faster, increase this number to 50V or 100V.

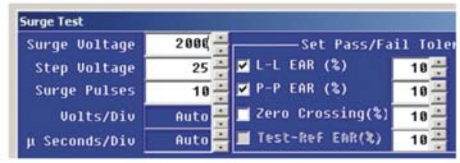



Fig 8-8: Surge test parameters

3) The **Surge** pulses number is set to 1 which means just one pulse will be applied to the windings after the tester reaches its maximum test voltage of 2000V.
4) Set the **Volts/Div** and the **µSeconds/Div** to Auto. The AWA will automatically scale the waveform to fit the graph.
5) The **L-L EAR** (Line-to-Line EAR) has been turned off since this motor will be tested with the rotor installed. If this option were left selected, a nuisance trip could occur as the rotor coupling is different for each phase winding unless the pass/fail value is set to a high number like 50%.
6) The **P-P EAR (**Pulse-to-Pulse EAR) is set to 10%. This means a pulse-to-pulse EAR value greater than 10% will cause the AWA to stop testing and fail the test. This number can be reduced as long as the step voltage is also reduced.
7) The **Test-Ref EAR(%)** is set to 10% which means that if a test is run, and a reference test exists, the reference waveforms will be compared to the acquired waveforms. Should the EAR values between reference waveforms and acquired waveforms be greater than the value shown, the AWA will fail the motor. If this option is not checked and is greyed out, no reference waverform is associated with this test.

8) Press the **Close** button in the upper right corner of the **Surge Test** screen to return to the **Tests** view.
9) On the **Tests** view click on the **Update** button to update the database with the new test information. From this point, the Test ID called Delco_460V/wPI will be used to test the Delco motor or any other motor that has this Test ID assigned to it.

### Generic Test ID's versus specific test ID's

The Test ID just created above is specific to the Delco 460 V motor of this example. This Test ID should not be used for another 460 V motor such as a 100 hp/460 V motor. The reason is that a Target Resistance value of 3.1Ω (ohms) which it is specific to this 3 hp Delco motor was entered. If this Test ID were used to test a 100 hp motor, the resistance test would fail because the 100 hp motor will have a much lower winding resistance than 3.1Ω (ohms). Therefore, if a Test ID is to be used for many motors, the Target Corrected Resistance option should not be used. Without a Target Corrected Resistance, there is no specific or unique information that ties the Test ID to a specific motor. Baker has already provided several Test ID's based on machine voltage in the database. These are generic Test ID's. (Target Corrected Resistance checking is disabled.)

## Running an automatic test

Once a new Motor ID has been created, and a new Test ID for this motor has been created, a fully automatic test can be run. An **Automatic Test** will test the motor in the following sequence:

1) Temperature
2) Resistance
3) Meg-Ohm
4) PI/DA
5) HiPot/Step Voltage
6) Surge

At the end of the sequence, the test data will automatically be saved to the database.

For completeness, it must be mentioned that tests can also be run from the test screens themselves – a process called semiautomatic testing. Additionally, tests can be run manually using the controls on the front panel of the tester. A semi-automatic test can be run by pressing the desired test's button on the tests view.

1) To start an automatic test, make sure the motor is selected from the Explore Tab.
2) Next, press the **Tests** tab to get to the main testing screen. If the Motor ID setup and the Test ID setup procedures were just followed above, the AWA is at the correct place to begin the automatic test.
3) To start the test, press the red **Run Auto Test** button on the **Tests** tab screen and follow the directions.
4) The **Safe to Turn On** dialog appears, which instructs the user to verify that the correct set of leads is properly connected. If the resistance test is turned on and the **Res Leads** is not checked this dialog will direct the operator to attached the High Voltage leads. If the **Res Leads** is checked, the displayed dialog will request that the Low Voltage Leads be attached.

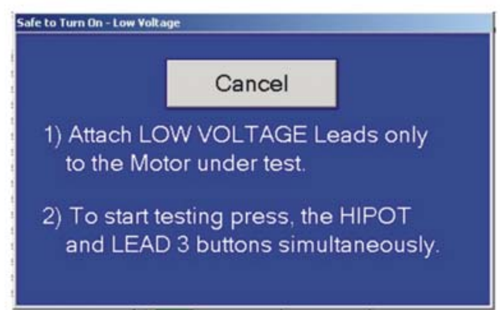



Fig 8-9: Test verification

The following sequence of tests will be run automatically:

Fig 8-9: Test verification



- **Temperature–**This test dialog will be displayed ready for the temperature reading to be entered from a third party temperature device. Enter the temperature reading, click the Accept button to acknowledge the temperature being entered, and indicate to proceed with the next test. Automatically, the AWA will proceed with the remainder of the tests.
- **Resistance–**If the readings pass per the requirements of the Test ID, the **Temperature/Resistance** dialog will close. If low voltage leads were used then a dialog will appear to instructing the operator to switch to the high voltage leads.
- **Meg-Ohm –**starts by ramping up all test leads to 500V. This voltage will be held for 60 seconds during which the AWA watches for HiPot trips or insulation resistance values below the minimum Meg-Ohm setting. Should a failure be detected, all testing will stop; leads will be discharged and grounded. The operator will be given the choice to repeat the test, stop all testing, or continue to the next test.

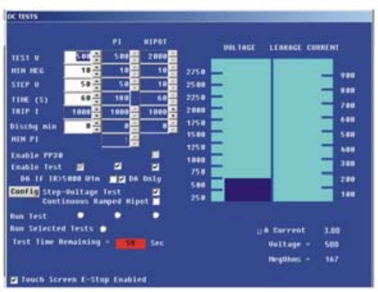


Fig 8-10: Megohm test screen

- **PI/DA –**test dialog will appear. Since the Test ID was setup for a Dielectric Absorption (DA) test, the duration of the test is three minutes (180 seconds). At end of the PI test, if no failures occur the **PI/DA** dialog will close.
- **HiPot –** test will automatically begin. Preset by the example Test ID, the voltage will be ramped up to 2000 V and held for 60 seconds. If the AWA detects a low Meg-Ohm reading or a HiPot trip, the testing will immediately stop; the leads will be discharged and grounded. The operator will be given the choice to repeat the test, stop all testing, or continue to the next test. If no failures have been found during the HiPot test, the AWA will continue to the next test.
- **Surge –** test will automatically start. The Surge Test Screen will be displayed and the test voltage will be slowly ramped up on lead 1 to 2000 V as specified by the Test ID. If no pulse-to-pulse EAR failures have been detected, lead 2 and lead 3 will likewise be tested. If no failures have occurred, the data from all tests will be saved to the database and the main test screen will re-appear.

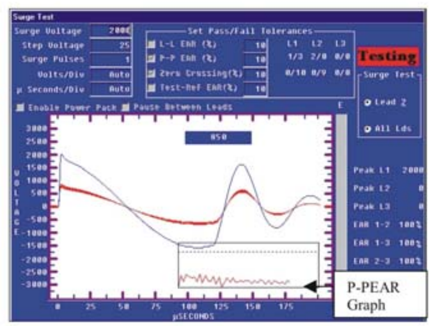



Fig 8-11: Surge test screen

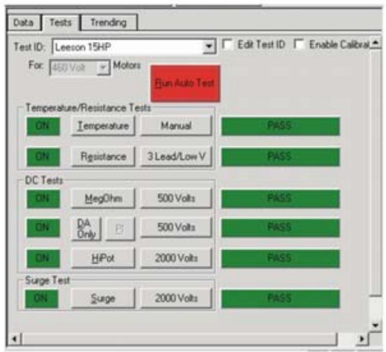
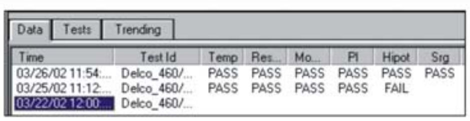



Fig 8-12 Main test screen with passed results

## Reviewing test results/data

After the test results have been saved to the database, they can be reviewed using the **Data** tab on the right hand pane of the AWA main window. The **Results Summary** tab shows a **Date/Time** window on the top part of the screen and a spreadsheet style view of the data on the bottom.

The **Date/Time** window shows a quick summary of the time and date of tests and whether the tests passed or failed. Double click on a test date and time to move to a new record.



| Time | Test Id | Temp | Res... | Mo... | PI | Hipot | Srg |
|---|---|---|---|---|---|---|---|
| 03/26/02 11:54:... | Delco_460/... | PASS | PASS | PASS | PASS | PASS | PASS |
| 03/25/02 11:12:... | Delco_460/... | PASS | PASS | PASS | PASS | FAIL | |
| 03/22/02 12:00:... | Delco_460/... | | | | | | |

Fig 8-13: Date/time results summary

The spreadsheet style of results view shows the actual test data as acquired. The test date and time is shown across the top of the window and the specific measurement results are shown in each column.

The PI test can be reviewed by pressing the **PI** tab. PI view will display the PI/DA graph along with a table of the current and Meg-Ohm readings gathered at specific times. The PI voltage, DA ratio and PI ratio are displayed on the right side. Since this test was a DA, only the PI ratio has **I=0 No PI** indicating there is no PI value because the current was zero.

| Test Date | 03/28/02 | 03/19/02 |
|---|---|---|
| Test Time | 14:51:34 | 14:21:52 |
| Temp Status | PASS | No Test |
| Winding Te... | 46.0 | |
| Resist Status | PASS | PASS |
| Bal L1 | 6.107 | 3.175 |
| Bal L2 | 6.093 | 3.210 |
| Bal L3 | 6.096 | 3.150 |
| L1-L2 | | |
| L2-L3 | | |
| L3-L1 | | |
| Coil 1 | 4.079 | 2.116 |
| Coil 2 | 4.061 | 2.162 |
| Coil 3 | 4.065 | 2.082 |
| Delta R Max | 0.200% | 1.900% |

Fig 8-14: Test results spreadsheet

The surge test data can be reviewed by pressing the **Surge** tab.

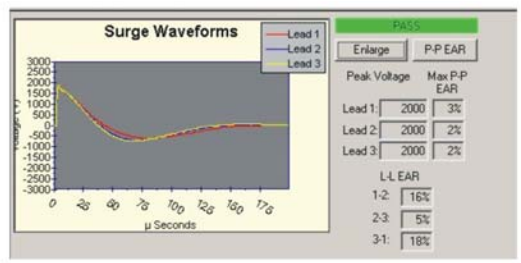



Fig 8-15: Surge test data view

## Printing reports

The AWA software comes with a complete set of report generation features to facilitate the requirement that test results be made available to managers, owners, and repair personnel. Reports containing test data, nameplate data, application data, etc., can be printed to a physical printer or can be exported to a desktop computer. Microsoft Word 2000/XP/2003 can be used as the file generator if installed on the desktop computer. For convenience, it is recommended that reports be printed from a desktop computer, instead of the tester itself.

There are three ways to invoke the **Report Generator:** click on **File – Print** menu item, holding down the **Ctrl** key and pressing the **P** key, or pressing the printer icon on the upper left of the main screen. The top section of the Report Generator, called **Select Filter(s)**, contains the filters by which tests results are chosen to print. Select the current motor and test result, or use any combination of the other filters, such as, a date range and all motors that fail any test during that given test range. The bottom section of the Report Generator dialog is called **Select Reports**. This section is where reports are chosen to print.

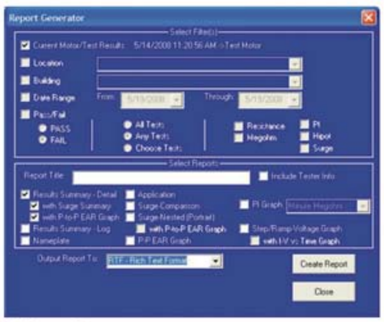



Fig 8-16: Report Generator

The Report Generator can look a bit intimidating, especially when the only test result needed to be printed is the one being reviewed.

This is the simplest case. The motor and test result that is selected in the main program will appear to the right of the checkbox titled **Current motor/test.**


Fig 8-17: Current motor/test results in select filters section of report generator

**Results** as seen in Fig 8-17. Click on that box and select which report is to be printed. In the lower part of the window, press the **Print** button. Select the printer to be used and the selected report will be sent to that printer. In Fig 8-18, the **Results Summary with Surge Summary** has been selected.

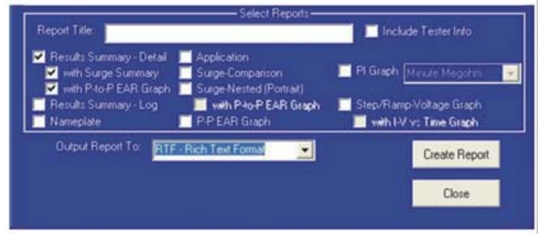



Fig 8-18: Print selected reports

If several motors' data needs to be printed, instead of selecting one at a time to print, the AWA software provides a more elegant solution. The Report Generator can select all records that match a certain criteria. Those items used to filter the data are the Motor's location fields, date range, or pass/fail criteria. Different combinations of the above options can be used, such as any motor at a given location, within a given date range, or any that failed a Surge test.

Once the selected test results have been determined, there are several choices for what reports to print. Nameplate, Application, Summary, Surge, PI, or Step Ramp Voltage test reports can be chosen. Use the Selection Filter (top part of the dialog) along with the Selected Reports section (bottom part of the dialog) to create reports. For instance, if the filters are set to all test records that failed the PI, but only one surge report is needed, the information won't be displayed correctly. The process should be thought out thoroughly in order to produce the results required. The filters can easily be set up, but the results are only as good as what is put in.

Consider the situation where an electrician tests many different motors during the day and needs to print reports for those motors that failed before going home. In this case, the Report Generator should be configured as shown in Fig 8-20. The **Select Filter(s)** section of the window has the **Date Range** selected and set both dates as 3/29/2007. This will cause the application to look for all test results that took place on 3/29/2007. Next filter selected is the **Pass/Fail**. Select the **FAIL** radio button. This will cause the application to print results for motors that have failed one or more tests on this date. Passed tests will not print. In the bottom **Select Reports** section, the **Results Summary with Surge Summary** is selected. When the **Print** button is pressed, the Report Generator will go through the entire database, looking for any failed tests that occurred on 3/29/2007. Once it is done searching a dialog box will appear showing how many records were selected. Choose to cancel or continue and print the selected reports.

**Note:** The Report Generator can be set up so that a large number of reports are created. Printing out a large number of reports can be very time consuming, especially when going to Microsoft Word. The Report Generator will show how many test results are chosen; however, this is not the number of pages that will be printed. That depends on the number of reports chosen.

The program can also print reports to Microsoft Word, (see Fig 8-20) if it is installed on a desktop computer running the software. This feature provides a way to annotate reports by adding text to the Word® document as required. For example, a comment regarding the vibration level of the motor before it was turned off can be added to the Word document. This feature should also be used with caution because printing reports to MS Word takes some time – selecting a lot of records to print means the system will be tied up for a long period of time before all records can be transferred to the Word document.

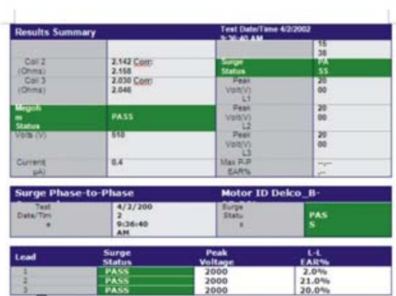
A typical Word report looks like the figure on the following page. Each of the sections is a Word table, except the surge waveform which is a bitmap. The reports can be modified by adding text between the tables or the data tables can be cut and pasted into other documents.

As of Version 4.4.7, the AWA software will be able to create Rich Text Format or RTF reports. This file type is a native file format of Microsoft Windows®. Both MS Wordpad®, MS Word® as well as many other applications can read and display RTF files. The RTF report will look substantially the same as the MS Word® reports.

| Nameplate Information | | Motor ID Delco_B-95-22L | |
|---|---|---|---|
| Plant | Willow Ridge | Unit | Unit 22L |
| Model | 2G2104 | Manufacturer | Delco |
| Serial Number | B-95 | HP/KW | 3 |
| Volts-Rating | 460 | Volts-Operating | 460 |
| Amps-Rating | 4.2 | Amps-Operating | 4.2 |
| Insulation | B | Enclosure | |
| RPM | 1765 | Service Factor | 1 |
| Frame | 213 | Freq-Hz | 60 |
| LR Code | J | LR Amps | 8 |
| NEMA Design | B | Max Amb °C | 65 |
| NEMA nom eff | 84 | Duty Cycle | Cont |
| Manufc Type | | Manuf Dt Cd | |

| Results Summary | | Test Date/Time 4/2/2002 9:36:40 AM | |
|---|---|---|---|
| Test ID | Delco_460/wPI | Repair/Job # | |
| Tested By | | Tested For | |
| Room # | | MCC | |
| Plant | Willow Ridge | Unit | Unit 22L |
| Temp Status | Tested | PI Status | PASS |
| Temp | 23.0°C 73.4°F | Volts (V) | 510 |
| Resist Status | PASS | DA Ratio | 1.0 |
| Bal L1 (Ohms) | 3.137 Corr: 3.161 | PI Ratio | DA Only |
| Bal L2 (Ohms) | 3.172 Corr: 3.196 | HiPot | PASS |
| Bal L3 (Ohms) | 3.088 Corr: 3.111 | Volts (V) | 2000 |
| Max Delta R % | 2.600% | Current µA) | 0.4 |
| Coil 1 (Ohms) | 2.096 Corr: 2.112 | Resist (Mohm) | 5000 At 40°C |

Fig 8-19: Sample report



| Results Summary | | Test Date/Time 4/2/2002 9:36:40 AM | |
|---|---|---|---|
| | | | 1538 |
| Coil 2 (Ohms) | 2.142 Corr: 2.158 | Surge Status | PASS |
| Coil 3 (Ohms) | 2.030 Corr: 2.046 | Peak Volt(V) L1 | 2000 |
| Megohm Status | PASS | Peak Volt(V) L2 | 2000 |
| Volts (V) | 510 | Peak Volt(V) L3 | 2000 |
| Current µA) | 0.4 | Max P-P EAR% | --.-- |

| Surge Phase-to-Phase | | Motor ID Delco_B- | |
|---|---|---|---|
| Test Date/Time | 4/2/2002 9:36:40 AM | Surge Status | PASS |

| Lead | Surge Status | Peak Voltage | L-L EAR% |
|---|---|---|---|
| 1 | PASS | 2000 | 2.0% |
| 2 | PASS | 2000 | 21.0% |
| 3 | PASS | 2000 | 20.0% |


Fig 8-19: Sample report

# Chapter 9 Data Transfer / database maintenance

**Inside this chapter**

- Data transfer
    - Transferring motor & test results data
    - Transferring test ID's
    - Transferring nameplate data
- Archiving a database
- Restoring a database
- Converting an older database

## Data Transfer

The Data Transfer tool offers a way to transfer motor and test information from one database (source) to a second database (destination). The transferred information is not deleted from the source database, but only copied to the destination database. The Data Transfer can be used to combine two existing databases into one centrally located database. It can also be used to re-organize existing database into more convenient groupings. When motor data or Test ID's need to be moved, the Data Transfer provides this functionality.

### Transferring motor and test result data

Two databases need to be open in order to transfer motor information, test result data and Test ID's: a **source** database to transfer information from and a **destination** database to transfer information to. Both databases must exist before beginning the transfer. If the transfer is to a new destination database, it will need to be created prior to beginning the data transfer. Select the **File-New** menu item or click on the new button on the toolbar in the AWA software.

There are two ways in which to start the Data Transfer. The first method is to choose the **Database-Data Transfer** menu item from the AWA software menu. Alternatively, click on the Data Transfer button on the toolbar.

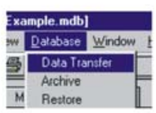



Fig 9-1: Data transfer button

Once the Data Transfer is started, it will open a source file dialog box and will default to the folder in which the currently open database resides. For example, in Fig 9-2 the example database is open in the main program, so when the data transfer button is clicked the open source file dialog defaults to the AWAData40 folder with the Example.mdb for the file name. Pick the default database or choose another database to transfer data. This is the source database.

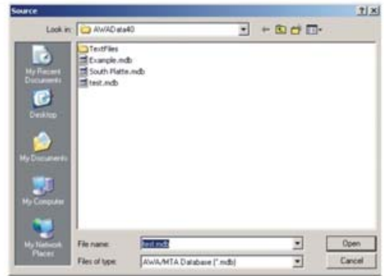


Fig 9-2: Select source AWA database

Once the source database has been chosen, click the **Open** button. The following dialog will be displayed with the source database opened on the left side. This is the same Motor ID tree structure as used elsewhere in the software.

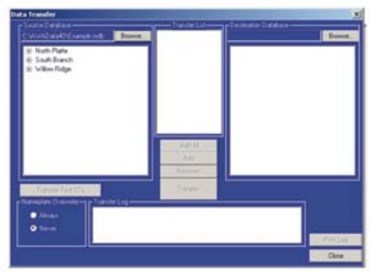


Fig 9-3: Data transfer select screen

After the data transfer dialog is displayed, click on the destination database **Browse** button, in order to open the destination database. A destination file open dialog will be presented. It will default to the same folder as was used to open the source database. Choose a destination database to open and press the **Open** button. The Data Transfer dialog will return with both databases open.

If either database is not the desired database, choose the databases by clicking on the **Browse** button next to the wrong database and choose another. When both the source and destination databases are open the **Add All** and the **Add** buttons are enabled. The application is ready for motors to be selected from the source database to be added to the **Transfer List**. The **Transfer List** is the list of motors that will be transferred when the **Transfer** button is pushed. The **Add All** button adds all the motors in the source database to the **Transfer List**. The following gives two ways to add selected motors to the list.

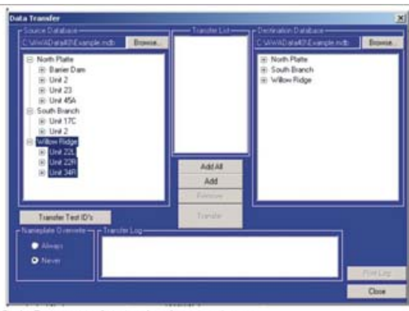


Fig 9-4: Data transfer destination database

1) Highlight the motors needed and press the **Add** button.
2) Double click on the motors to add.

If there are motors on the **Transfer List** that do not need to be transferred, remove them by selecting the motor(s) and pressing the **Remove** button. When the **Transfer List** is finalized, press the **Transfer** button.

The method the Data Transfer application uses to transfer the data is as follows. The data transfer runs through the **Transfer List** adding the motor (Nameplate) information if the motor does not exist in the destination database. If the motor does exist, no motor information will be added. Next, the data transfer adds any test records that do not exist in the destination database. It compares the time/date stamp with existing test result records and if the source time/date equals a test result record in the destination database, it does not transfer the record. If the application does not find any matching time/date then it adds the source test result record to the destination database.

The Data Transfer creates a log during the transfer process. Information logged is source/destination database names, Motors ID's added, and number of records updated. If the transfer encountered any problems, it also logs the Motors ID and reason the transfer failed. You can print this log by clicking on the **Print Log** button.

## Transferring test ID's

**Note**: Test ID's are transferred separately from the Motor ID's.

To transfer Test ID's follow the method described in the Transferring Motor and Test Result Data section above on how to open a source and destination database. The source and destination database both must be open before any transfer can be performed. Once both databases are open, the **Transfer Test ID**'s button will be enabled. Press this button to display the dialog below.

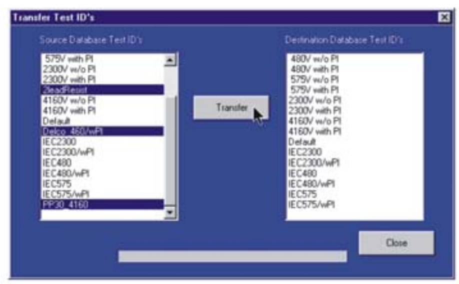


Fig 9-5:Transfer test ID's

The dialog displays all Test ID's in the source database, as well as the Test ID's of the destination database. Choose the Test ID's to transfer by highlighting the source Test ID's to transfer. Use the shift and control keys while clicking on the Test ID's to select more than one. With the desired Test ID's highlighted, press the **Transfer** button to start the transfer. The data transfer will transfer (copy) the requested Test ID's to the destination database. If the Test ID exists in the destination database then it will not transfer the Test ID and will display a message stating there cannot be duplicate Test ID's. If this message appears, click on the **Ok** button and the transfer will continue. As in the motor and test result record transfer, the application writes to the **Transfer Log** as to what action has been taken. When finished transferring Test ID's, press the **Close** button to return to the main Data Transfer dialog.

## Archiving a database

Along with the **Data Transfer**, **Archiving** (compact/zip) is a tool to help move data.  This functionality exists for backup and shuffling of whole databases from one computer to another as oppose to the Data Transfer which moves motors/test information from one database to another database.  It is important to retain a current backup copy of database(s) on some persistent storage medium, such as floppy diskette, CD, or a backed up network drive. The archive provides an easy means to backup AWA data. Use the archive option for more than just a backup. It is the best way to put a database on a floppy drive to move it from one computer to another. If the archive option is used to copy and compress a database to a floppy, then use the **Restore** option, discussed next in this chapter, to extract the database from the floppy back to a hard drive.

To archive a database, it must be opened in the AWA application:


Fig 9-6: Archive

1) Choose the **Database – Archive** menu item.
2) The application will display a **New Archive** dialog box, in the default folder, with a default zip file name. The **Look in** folder defaults to the path that has been entered in the **View – Options – File Locations** menu item.  Accept the default or browse to the folder where the archived file is to reside.

**Note:** If the default is the floppy drive or CD-Rom drives make sure there is a diskette/CD in the drive before archiving.

The default name of the archived (zip) file will be a combination of the database name and the time/date of the archive. For example, if the database name is Example.mdb then the archived file name will be: Example_YYYYMMDDHHMMSS.zip. The YYYYMMDDHHMMSS indicates the year/month/day/hour/minute/second when the file was archived.

When the archive is finished, the following message will be displayed.


Fig 9-7: Archive complete

It is important to note the location of the archived file (.zip or .cab). Press the **OK** button to return to the AWA application.

### Restoring a database

In order to view archived data with the AWA software, the database must be restored first. To restore an archived database, WinZip will need to be installed. (See Archiving a Database.)

1) Choose the **Database – Restore** menu option.
2) The **Select archived database** dialog box will be displayed. Choose the database (.zip  or .cab file) to restore and open it.
3) After choosing the archived database to restore, choose the folder to extract the archived database into.  If the database is to be restored to a different folder, browse to that folder. When the appropriate folder is located, click the **OK** button.

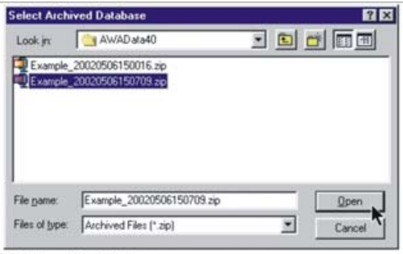



Fig 9-8: Select archived database


Fig 9-9: Browse for folder

The application will extract the archived file. If a database with the same name exists the user will be prompted with the following.

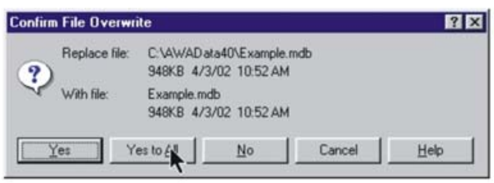



Fig 9-10: Confirm file overwrite

Choose to overwrite the existing database by choosing **Yes** or **Yes to All,** or choose **Cancel** if the database should not be overwritten. If the archived database is still needed, rename the existing database through Windows Explorer then restore again, or restore using another folder that does not contain the same named database.

Once the archived database is extracted, the software will return to the AWA application's main screen. Choose **File – Open** menu item to open the newly restored database.

## Converting an older database

Version 4 of the AWA software uses a different database structure than prior versions. The test results data are arranged differently, the database keys are different, and several tables have been combined or added in addition to many other improvements. One of the major changes is that the surge data is no longer stored in a separate set of files in a Srg folder – all surge waveform data is now stored in the database.

Care needs to be taken when upgrading to this new version of the database. After installation of the new software, the old databases as well as the old AWA software executable will still be on the AWA. It is left to the user to insure a smooth transition to the new database and software. Here are a few suggestions for making the change to the Version 4+ database:

1) Make a backup copy of all old databases. Use WinZip, older standalone version of the Data Transfer archive feature, or simply use Windows Explorer to make a copy.
2) Install the new AWA Version 4+ software.
3) Convert all of the old databases to the new version by opening each of the old databases with the new Version 4+ software, as described later.
4) Verify data has been correctly converted in the new databases. The old software and the old databases will still be on the machine in addition to the new versions.
5) Once confident the data is correct, remove the old databases and the old executable from the AWA, to avoid confusion as to what version to use. The older version of the AWA can be found in the C:\AWA folder with the name AWA.exe. The new AWA is in the same folder; however, the version 4+ executable is named AWA.exe. In order to remove the old software, delete the AWA.exe and all short cuts to it. The old data is in the C:\AWA Data folder. After saving data to an archived

folder the AWA Data folder can be deleted. As always, it is advisable to keep an archived copy.

If data resides on a network or desktop(s), make sure that all databases, not just those stored on the AWA, have been upgraded. This will insure the old databases do not get inadvertently used for new testing.

Remove the old AWA executable from all desktop machines to prevent old databases from being inadvertently used.

## Converting the data

Version 4+ software stores database files in a different place than prior versions: Database files are now in **C:\AWAData40**. Older versions stored database files in subfolders within **C:\AWAData**. Of course, these locations are the default locations programmed into the AWA software; databases can be stored anywhere on the machine's disk or network.

When using the Version 4+ software for the first time, the databases from previous versions will have to be converted. The conversion process happens automatically when the application opens an older database. In order to open an older database, the **File-Open** dialog will have to be used to pick the old database from the C:\AWAData folder where they are stored.

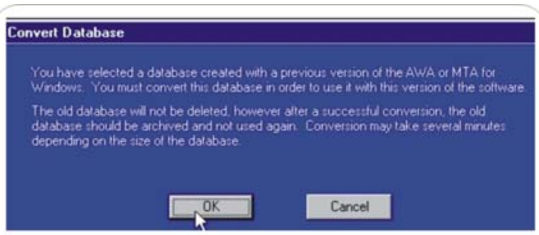



Fig 9-11: Convert database

The software will automatically identify the database as an old database and presents the operator with the above message indicating the database will be converted.

The Version 4 software will then present a **Convert Database Into** save dialog box with a new database name filled in: the new name is the old one with a **_Rev4** appended to it, see Fig 9-12. The database name can be changed to whatever is desired; however, it is recommended that a consistent naming convention and an unambiguous location be used.

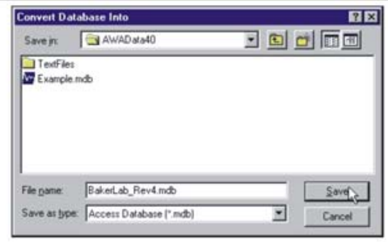



Fig 9-12: Convert database info

Once a file name is entered, press the Save button. The conversion will begin immediately. All Test ID's, Motor ID's and test result data will be converted. When the conversion is concluded the application will open the converted database.

# Chapter 10 Typical winding faults

**Inside this chapter**

- Determination of a fault
- Application notes
- Factors affecting Surge tester output

## Overview

This chapter is designed to assist with interpreting test results. Through it is not a substitute for experience gained in the field, it may assist those new to motor testing by providing examples. It will also explain each of the failure messages the software will give once a failure is found.

Both pass/fail results and quantitative data for tests are recorded by the AWA. They are stored as results records. For some testing situations, such as quality control in a motor shop, the pass/fail results may be the only data of consequence. In a predictive maintenance or troubleshooting situation, pass/fail results may be less important than the quantitative data from the test. For quality control, predictive maintenance, and troubleshooting different factors will determine the voltages used in testing and the way fault detection is handled.

Due to the wide range of motors and their test parameters, always refer to the motor manufacturer and published standards for appropriate voltage levels and acceptance limits.

## Determination of a fault

There are several basic wave patterns (for assembled motors, refer to Rotor Loading)

1) Good, stable trace, indicating turn-to-turn and phase-to-phase insulation integrity.
2) Instability and separation, indicating a fault or weakness in winding or phase insulation.
3) Open circuit, indicating an open phase or disconnected test leads.
4) Grounded phase.
5) Separated waveforms, indicating a solid turn-to-turn or phase-to-phase short (if the rotor is not in place).

The motor windings are considered good if all three leads wave patterns are the same and remain stable up to the specified test voltage.

For initial determination of winding faults, refer to the following wave patterns. These are typical wave patterns seen for three-phase, lap wound induction stators. They provide a reference for identifying a characteristic wave pattern with a type of fault.

**Note:** Variation from these wave patterns is to be expected. **Do not consider these wave patterns to be absolute**. Due to the variety of motor windings and connections that exist, each winding will have its own signature wave pattern.

### Good, stable trace

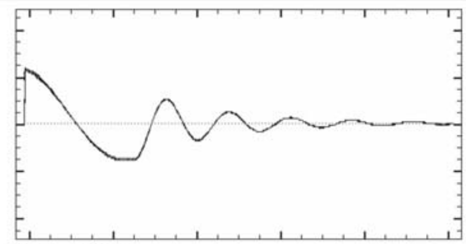


Fig 10-1: Good stable trace

### Arcing turn-to-turn short

In the waveform, the solid line represents an unstable, intermittent shorting in the windings. Notice its shift to the left of the dotted line.

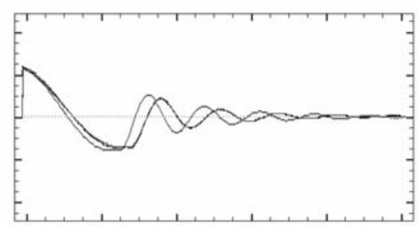


Fig 10-2: Turn-to-turn short

### Open circuit

When an open condition exists in the tested phase, a pattern resembling a ski ramp is seen. This is due to a loss of continuity throughout the tested winding. If only one phase is open, normal waveforms will appear for the other phases. This pattern is also seen when nothing is connected to the surge test leads.

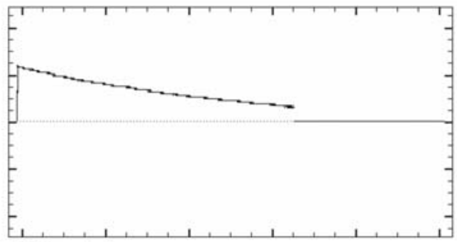


Fig 10-3: Open circuit

### Hard sort to ground

If a hard short to ground exists, the Megohm or HiPot test will detect it. It can also be detected when Surge testing. The wave pattern will appear as a relatively flat line. Fig 10-4 illustrates a grounded phase.

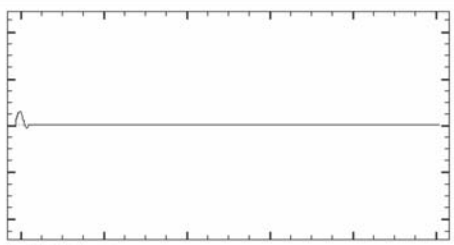


Fig 10-4: Hard short to ground

### Solid turn-to-turn short (fused or welded short)

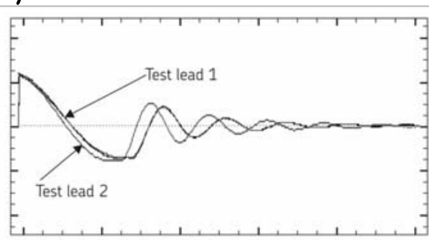



Fig 10-5: Solid turn-to-turn short

The waveform in Fig 10-5 indicates a short only in a motor without a rotor in place.

## Application Notes

- Knowledge of all types of wave patterns is not necessary when maintenance testing. It is more important to look for a stable, uniform waveform up to the specified test voltage.
- Test leads should be checked for breakage by firmly grasping the boot and clip in one hand while pulling on the lead with the other. A broken lead will stretch and a good lead will not.
- When an open circuit is indicated, check the connections between all three test leads and the winding being tested.
- Also check for open test leads at the clip end. Test leads should be checked weekly to ensure there is no breakage!
- Baseline testing can be conducted to determine appropriate DC test pass/fail tolerances. Maintenance testing should be performed using Test ID records that are kept consistent from test to test.
- Depending on the severity, motors that fail tests should be considered for service or replacement.

### Rotor loading (coupling)

When surge testing assembled motors, the rotor can influence the shape of the surge wave pattern. These influences are of two types:

- Dampening effect: The loading of the rotor dampens the ringing of the wave pattern.
- Separated wave pattern comparison for good windings: Imbalance in the inductive coupling between the rotor and stator winding causes the wave patterns of two good phases to appear separated when they are compared. By turning the rotor, this coupling effect can be eliminated and the wave patterns will be superimposed.

Rotor loading can be understood when the rotor is considered a secondary of a transformer. When one phase being surged has a different number of rotor bars under it's stator windings than the other phase being tested, a different transformer action exists for each phase. Two mismatched waveforms are seen on the display.

Rotor loading effects are most prevalent in smaller, high-efficiency motors with small tolerance air gaps. Separation of wave patterns due to rotor coupling can be determined when the wave patterns separate from the first positive peak downward, cross one another at the bottom (first most negative point) and separate again as they go upward (positive).
To compensate for rotor coupling effects, conduct a manual surge test.

> **Warning:** Wear insulated high voltage gloves and take other appropriate safety precautions.

If the rotor can be turned, surge test the first lead. While testing lead 2, carefully turn the rotor until the wave pattern superimposes over phase 1 on the display. Repeat this procedure for the third phase.
If the rotor cannot be turned, observe the wave patterns. As the test voltage is raised, watch for a sudden shift to the left or instability. This shifting can indicate a fault due to arcing. Deteriorating insulation may not be obvious until higher voltages are reached. Rotor coupling does not prevent the surge impulse from stressing the turn-to-turn or phase-to-phase insulation. It only changes the ringing of the wave pattern, decreasing sensitivity to interpretation of solid faults. Unstable wave patterns clearly indicate a fault in assembled motors whether or not rotor coupling is present.

## Factors affecting tester output

Sometimes full output of the AWA may be below its rated maximum output voltage. This occurs on low impedance devices or devices which exceed the AWA's capability.

For example, the horsepower of a motor may be too high for the AWA. If this is the case the 12,000V AWA may only apply 4000 V when the output is set halfway between min and max . At this mid-point 6000V is expected. The AWA may then only give a maximum output of 7000V, when 12,000V is expected.

The test should be considered successful if the desired test voltage level can be reached. For the example above, if the motor was 3000 horsepower and operated at 2300V, an appropriate test voltage would be 2 x 2300V + 1000V = 5600V. The size of the motor may limit the AWA's output to a level below its rating.

- Adjacent windings, such as a start winding, part winding, high or low voltage winding, should be jumpered together and possibly grounded while doing the test. This procedure may eliminate incorrect test results caused by inductive coupling.

| Factor | Effect |
| --- | --- |
| Motor larger than recommended max size to test | Capacitance and inductance of motor windings can load the AWA output down. The voltage output is reduced below maximum output, which can damage the AWA if the test is applied for an extended period.<br>**Note:** The test is considered successful if the test voltage 2E + 1000V is achieved. |

| | |
| --- | --- |
| Motor RPM is slow. | For each reduction of the motor's RPM, (i.e. 3600 -> 1800) the effective horsepower of the motor that the AWA senses is doubled.<br>Example: A 500 hp/3600 RPM motor = 500 hp.<br>A 500 hp/1800 RPM motor = 1000 hp.<br>A 500 hp/900 RPM motor = 2000 hp, etc. |
| Motor has high number of poles | Same condition as comment above on motor RPM. |
| Feeder cable length | Distributed capacitance of the feeder cable loads down the test according to the formula:<br>$V \max capable = \frac{V\, tester \times tester\, cap}{Tester\, Cap + Cable\, cap}$<br>The AWA may be unable to generate the desired test voltage. It is observed that the closer the motor is to the recommended maximum motor size to test, the shorter the feeder cables must be. If the motor is very small compared to the maximum recommended motor to test, the AWA may have sufficient energy such that longer feeder cables, as well as the motor windings, can be tested. |
| Shielded feeder cable | The above condition becomes extreme. Shielded feeder cables have very high capacitance. |
| High horsepower motors at Low Operating Voltage | The characteristics of these motors are such that the winding impedance is low, requiring high AWA output energy to surge test the windings. If the AWA output is insufficient to test a motor, then a Power Pack option may be necessary, OR, if testing at the motor or the MCC, very short feeder cables lengths will be needed. |
| Motor assembled with rotor in place | The presence of the rotor will load the AWA by drawing energy from the AWA like the secondary of a transformer. |

## Software fault messages

| Status | Failure Type | Why Failed Message |
|---|---|---|
| PASS | | No failure was detected according to the Test Model given. |
| FAIL | USER ABORT | USER ABORT. An User abort has been detected. |
| FAIL | EMERGENCY SHUTOFF | EMERGENCY SHUTOFF. Emergency Shutoff has been detected |
| Tested | Tester | No message, cannot determine Pass/Fail because no test criteria was turned on. |
| FAIL | CANCEL | USER CANCELLED TEST |

## Resistance failure types

| Status | Failure Type | Why Failed Message |
|---|---|---|
| FAIL | DELTA R | Resistance test result: Fail – DELTA R. Delta R percent is out of tolerance. |
| FAIL | OPEN LEADS | Test results: Fail-OPEN LEADS. Open Leads Detected. |
| FAIL | TOLERANCE | Test Results: Fail-TOLERANCE Resistance(s) outside of user defined targeted range. |
| CAUTION | Resistance Out of Range | Resistance values must be greater than 0.500 ohms for HIGH VOLTAGE LEADS and greater than 0.001 for the RES LEADS. You may stop Testing, reconfigure Test ID with the appropriate leads, and repeat the test OR continue with the remaining tests. |
| CAUTION | MAX R Range Exceeded | Test Results: Caution – MAX Resistance Range Exceeded. Possible Open lead(s). |
| FAIL | No Resistance Solution | Resistance values do not have a solvable solution. See software manual. |
| FAIL | Noisy ADC | Instrument detecting excessive electrical noise. Resistance measurements are unstable. Check for noise sources nearby (welders, VFDs, etc.) or a free wheeling rotor. |

## DC tests failure types

| | | |
|---|---|---|
| FAIL | OVER VOLTAGE | OVER VOLTAGE. Over Voltage Condition has been detected |
| FAIL | OPEN GROUND | An open ground has been detected. Check power cord outlet ground for continuity |
| FAIL | MIN MEG-OHM | Test Result. Fail – MIN MEG-OHM. Meg-Ohm value is less than the minimum tolerance |
| FAIL | MIN PI | PI test results: Fail – Min PI. PI Ratio is less than minimum tolerance. |
| FAIL | OVER CURRENT | Test result: FAIL – OVER CURRENT. An over current trip was detected. |
| FAIL | NO STEPS DEFINED | No steps for Step-Voltage Test exist in this Test ID. |
| FAIL | LOW PRG HPT VOLTAGE | The last step voltage is below the previous Meg-Ohm/PI test voltage. |

## Surge Test Failure Types

| | | |
|---|---|---|
| FAIL | OPEN LEADS | Test Results: Fail – OPEN LEADS. Open leads detected. |
| FAIL | OVER VOLTAGE | OVER VOLTAGE: Over Voltage Condition has been detected. |
| FAIL | OPEN GROUND | An open ground has been detected. Check power cord power outlet ground for continuity. |
| FAIL | ppEAR LIMIT | Surge test results: Fail – ppEAR LIMIT. Pulse-to-Pulse EAR%. |
| FAIL | L-L EAR | Surge Test Result: Fail – L-L EAR Lead- to-Lead EAR % is out of tolerance. |
| CAUTION | Unequal Zero Crossings | Test results: Caution – UNEQUAL ZERO CROSSINGS Waveforms do not have the same number of zero crossings. |

# Chapter 11 Applying the AWA

**Inside this chapter**

- Predictive maintenance
- Quality control
- Motor troubleshooting
- Surge reference waveform
- Maintenance testing
- Single phase motors & two terminal devices
- Form coils
- Three phase motors
- Two or more single coils
- Wound rotor motors
- Synchronous motors/generators
- DC motors/generators
- Field coils
- Chiller motor testing
- Armatures
- Testing large AC stator/motors
- Rotor loading (coupling) when testing assembled motors
- Testing assembled motors from the switchgear
- Transformers

## AWA applications

### Predictive maintenance

A program of predictive maintenance testing requires that motors be periodically taken off-line and tested with the same parameters each time. This provides a picture of motor condition. Predictive maintenance allows spare parts to be stocked, rewinds or other refurbishments to be scheduled, and minimizes the likelihood of unscheduled down time.

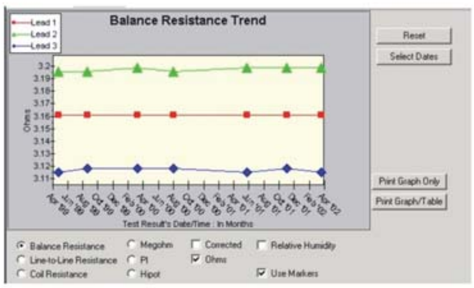



Fig 11-1 Resistance trending screen

Particularly useful for predictive maintenance is trending data collected and stored by the AWA. Test parameters must be identical for data trending to be meaningful. Tests at different voltages will render data less useful for trending. If Test ID's are programmed and used properly, and tests are conducted precisely, trending can help monitor the rate of insulation decay. Observing data over time can also help establish a schedule for motor testing.

During maintenance testing, failure of a test should be a flag indicating possible motor problems. Additional testing, e.g. visual inspection, may be warranted. The combination of tests should be determined by experienced operators. If the source of the problem is electrical, the AWA's manual mode may be employed to conduct further testing. As an example, consider the case of wet windings. The motor is likely to pass Resistance tests, fail Meg-Ohm tests, fail HiPot tests, and pass Surge tests. After the failed Meg-Ohm test, no further automatic testing will be done by the AWA unless the operator uses the continue option. Knowledge of motor behavior will help the experienced operator conduct visual tests or further electrical tests with the AWA in Manual mode to isolate the source of the problem.

### Quality control

Quality control testing done in a motor shop or production facility may use relatively higher voltages compared to maintenance testing of the same motor. In a quality control testing situation, the test results are either pass or fail. Data is not trended and diagnosis is not a goal. Rather, the insulation system of the newly rewound motor must be able to withstand test levels in accordance with IEEE and NEMA standards.

When conducting quality control tests, failures must be analyzed. For example, some winding configurations will fail a winding resistance test with seemingly reasonable test parameters even when the winding resistance is good. Knowledge of special windings is important and can only be provided by those responsible for the winding.

### Motor troubleshooting

In the case of a motor failing during service, the AWA can help determine the reason for failing and provide data that assists in making decisions about refurbishments vs. replacement. Isolation of the site of a phase-to-phase short, for example, can be done by surge testing the windings. The shorted winding will give a waveform substantially different then the two good windings.

Motor shops can use the AWA to indicate where a problem has occurred, pinpointing what needs to be repaired. AWA test results provide a tool for recommendations to the customer.

**Note**: For additional reference for fault determination see Chapter 10 Typical winding faults.

### Maintenance testing

Baker Instrument Company, SKF Group Company testers have become extremely popular for industrial maintenance programs, troubleshooting, and to ensure that replacement motors (spares, reconditioned motors, or rewinds) are thoroughly tested. The following are guidelines for performing tests on assembled motors in the field as part of maintenance testing.

Hard-shorted winding faults are rarely found in motors during maintenance testing. Solid turn-to-turn winding faults happen when the insulation on adjacent copper wires has failed to the point that adjacent wires are welded together. This is a rare condition in maintenance testing because of transformer action, which occurs within the windings and induces very high current in a hard turn-to-turn short. The high current causes heating and deterioration of the surrounding insulation systems. The single turn-to-turn short rapidly compounds until the damage causes a failure in the ground wall insulation. The high current will trip the circuit breaker and stop the motor. A solid turn-to-turn or hard-shorted winding fault is not the type of fault expected during maintenance testing. This condition is usually only found after the motor has failed.

During surge testing, steady separation in the wave pattern comparisons is most often the result of the rotor coupling with the stator. (See Rotor loading (coupling) when testing assembled motors). In this case, a consistent double wave pattern will be seen at all voltage levels. Separation due to rotor coupling should *not* be interpreted as a fault.

The key to surge testing for maintenance is to detect a fault at a voltage level above the peak operating voltage, but not above what the motor would withstand during start-up. For example, a 460V motor that shows a good trace at 500V but shows an unstable, flickering patter, (regardless of rotor coupling) at 1500V definitely contains a fault. When the fault is detected above operating voltage, time is available to schedule service for the motor before a hard short and rapid failure occurs.

Consider a 460V AC motor. The operating voltage is the root mean square, a kind of average of the AC power supply. For this motor, multiply 460V by 1.4 to determine the maximum voltage level that the coil undergoes during normal operation. It is approximately 650 volts. Suppose the motor has an insulation fault at 500 volts. This motor will probably fail while in service well before it can be surge tested because the peak of the AC voltage will continuously stress the fault under normal conditions.

The goal, therefore of the surge test is to detect weakness well above the operating voltage of the motor, as much as twice the operating voltage plus 1000 volts. Refer to recommended voltages for a thorough description of how to determine test voltages along with IEEE references that explain the reasons for these recommendations.

As shown in the following figures, a good winding will produce stable wave patterns from zero volts up to the recommended test voltage. Faults that are detected during Surge tests are unstable, flickering wave patterns that appear as the voltage is increased.

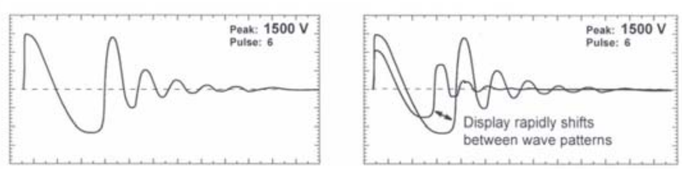



Fig 11-2: Good versus bad coil

Fig 11-2 shows how a good wave pattern (left) and a representation of how a live wave pattern may appear to move on the display for a winding or coil that contains an intermittent short or is arcing (right).

## Single phase motors and two terminal devices

Select lead 1 and connect the corresponding test lead #1 to one side of the device. Connect test lead 2 to the opposite side of the two terminal device. Connect the ground lead and test lead 3 of the tester to the frame or metal core material. On the temperature/resistance screen locate an item called 2 leads (1 phase). Select it for testing single phase or two terminal coils.

## Form coils

Form coils should be tested similarly to a two terminal device (see Single phase motors and two terminal devices). The Surge test is recommended for form coil testing because it alone can generate the turn-to-turn voltage that is required in these low impedance coils.

## Determination of a fault

Refer to the previous section on Single phase and two terminal devices to determine if a fault is present.

## Notes and tips for testing form coils

- IEEE-522-1992 recommends a test voltage for vacuum pressure Impregnation coils, before they are cured, at 60-80 percent of the test voltage of fully cured coils.
- Currents required to test form coils often limit the maximum surge voltage. Placement of the coils into the stator iron or spare laminations has the effect of enabling the tester to produce a higher voltage drop across the coil for a given current level.
- **CAUTION** should be exercised. The laminations or stator core have induced voltage on them, and can provide a path or ground.
- Many formulas are used in calculating a test voltage for AC form-wound coils. These are generally based on experience and theoretical arguments about the distribution of voltage in a coil and the entire winding. Some of these formulas are difficult to apply, because of the great diversity of coil specifications and characteristics. One popular formula based on Paschen's Law, states a minimum and maximum test voltage range:

Minimum = Number of turns x 500 Volts
Maximum = Winding operating voltage x 1.5

The minimum voltage would be necessary to show a void in the turn insulation that would result in arcing. The maximum voltage value is based on the worst-case distribution of a surge in the winding. Studies (IEEE-522-1992 and IEEE-587-1980) have shown that a very rapid surge from a lightning strike or contactor closing/opening may be distributed across the first coil of a winding.

## Three phase motors

Wave patterns for three phase windings are compared in pairs. The storage capability of the AWA allows all three phases to be compared without removing and reconnecting the test leads. Baker Instrument Company, an SKF Group Company, recommends the following procedure:

1) Connect the three numbered red test leads to the three winding legs.
2) Connect the black ground lead to the frame or core of the winding.
3) Within the software for the AWA go to the Tests Tab. Click on the third button associated with the surge test. This button displays the test voltage it is currently set.
4) Make any necessary changes prior to running the manual test.
5) A manual test can be run from here by clicking on the buttons under Run Surge. Test each lead separately or test all leads together. See Chapter 8 Performing an Example Test for more advice in setting up the tester for testing.

For each test, check the display for a wave pattern. View the results from the AWA's screen for the wave patterns of the motor for comparison. If three good wave comparisons are seen, there is every indication to believe the motor is good. If anything other than a good pattern is seen, there is a possible fault. The AWA will also prompt if results are out of set tolerances.

### Determination of a fault

If any wave pattern becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds. Separation in two of three wave pattern comparisons indicates incorrect turns count. The fault will be in the phase connected to the test lead in common between the two comparisons, which show the separation for wye-connected windings.

In the repair shop: separation of compared wave patterns on stators indicates a hard fault, such as a solid turn-to-turn or group-to-group short; an incorrect turns count, or misconnections.

In the field: In assembled motors, separation of the wave patterns is often the effect of rotor coupling, also known as rotor loading (see Rotor Loading (coupling) when testing assembled motors).

### Two or more single coils

Surge testing can be used to test two or more identical single coils separately and then compare their wave patterns against each other.

1) Connect test lead #1 to one side of coil #1 and connect the ground test lead to the other side.
2) Connect test lead #2 to the second coil or identical coils and connect test lead #3 to that coil's other side.
3) Perform the Surge test.

If the wave patterns are stable and they superimpose on the display, the two windings are identical. They have no faults and the insulation of both coils is good.

### Determination of a fault

If any wave pattern becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds.

Separation of the wave patterns when compared indicates incorrect turns count. The fault will be in the coil connected to the test lead, which produces the waveform that shifted to the left and collapsed in amplitude.

### Notes and precautions for two single coils

- All windings or magnetic material (iron or ferrite) close to the coils under test must be the same for both coils. For example, if DC field coils are being tested, both should have the pole pieces inserted or both removed. A coil on a table when compared to an identical coil in the frame will show separation of the wave patterns because inductance differs in iron and air.
- Slight variations in magnetics of the tested device can result in similar coils not comparing identically. An example of this is synchronous pole pieces, one of which is making better magnetic contact with the rotor then the comparing pole. For this reason it is recommended that devices like pole pieces be evaluated individually and not compared.
- Paschen's Law states that a voltage greater than 334 volts is required to initiate an arc between two conductors in air. This would suggest a minimum voltage for surge testing to be greater than 334 volts. Because of the sometimes non-linear distribution of the surge pulse, it is recommended that a minimum surge potential of 500 volts be used when testing a two terminal device.
- Shunt coils often have a small error in turns count. Some mismatch or separation of patterns should be acceptable. If the wave patterns are very close in shape and remain stable during the test, the coils generally are acceptable. In addition, winding tolerances on single coils may allow for

differences in turns count, which causes a slight, steady separation. The operator should investigate whether this condition is acceptable or not.

- A slight imbalance (separation) may be noticed if the windings are not correctly phased: (i.e. the winding configuration of one compared to another is clockwise verses counterclockwise). Try reversing one set of test lead connections and repeating the test before rejecting the winding.
- Many two terminal devices have very high turns count. The waveform displayed is similar to that of an open circuit. In this case, the impedance of the coil is too high to be tested. Double check for poor connections and test lead breakage to see if these conditions may be causing the apparent open condition.

## Wound rotor motors

Wound rotor motors are tested as though they are two separate three-phase windings where one is the stator and the other is the rotor. Procedures to successfully test the wound rotor motor are as follows.

1) Remove the brushes touching the slip rings.
2) Short together the slip rings with jumpers. The jumpers minimize the coupling effect between rotor and stator.
3) Surge test the stator as would be done on a three-phase induction motor. See Three Phase Motors or follow the directions in Three Phase Motor Surge Test and Setup.

**Note:** Since the rotor is shorted out there will be no chance for a high-induced voltage transformed from the stator to damage the rotor.

1) To surge test the rotor, disconnect the jumpers from the slip rings. Connect the tester test leads to the rotor slip rings.
2) Short together the stator leads with jumpers, as done for the rotor.
3) Repeat Step 3 for the rotor.

**Note:** Check the motor nameplate for rotor voltage to calculate the rotor test voltage level. Rotor Voltage is **not the same** as the stator voltage.

If the wave patterns are stable and they superimpose on the display, the windings are identical. They have no faults and the insulation of both coils is good.

## Determination of a fault

If any wave pattern become erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Arcing is often accompanied by audible sounds.

Separation of the wave patterns when compared indicates incorrect turns count. Interpret the separations as for three phase motors.

## Synchronous motor/generator

The synchronous stator is tested as a three-phase induction motor. The rotating fields should be tested individually.

1) Before surge testing the stator.
    a. Remove the DC Leads to the brush boxes or lift all of the brushes off the slip rings.
    b. Short the slip rings for the rotating fields together.
2) Surge test the stator following the procedures and steps for three phase motors.
3) Individual poles are surge tested as outlined in the procedures for testing Single-phase motors and two terminal devices. The recommended test voltage is 600 volts per pole. It is not necessary to disconnect the pole piece leads before testing.
4) The Hot and Ground leads are then reversed and the test repeated on each coil.

If the wave patterns are stable and they superimpose on the display, the windings are identical. They have no faults and the insulation of both coils is good.

**Note:** One field can be tested and its surge wave pattern can be stored for reference. The other fields can then be compared to this reference pattern in a procedure that is similar to that of Two or More Single Coils.

## Determination of a fault

Two types of faults may exist in synchronous motors and generators.

### Pole piece fault

Do not expect coils to compare exactly. Rotating fields or pole pieces are often not wound to identical, exacting standards. If a fault does exist in the pole pieces of the test, the wave pattern on the display will collapse in amplitude and a distinct shift to the left will occur, signifying an increase in frequency (a decrease in inductance). This type of fault is usually failure of the turn-to-turn insulation.

### Stator winding fault

For a stator-winding fault, if the wave pattern changes and becomes erratic during the test, then intermittent shorting or arcing is occurring in the winding under test. Steady separation of the wave patterns of the phases when recalled and compared indicates solid shorts. (See Three-phase motors).

## Chiller motor testing

Before applying any test potential to a chiller motor, please review the manufacturer's instructions. These instructions usually recommend bleeding the vessel to atmospheric pressure before applying a test potential.

Surge test procedures for chiller motors follow those outlined for Three Phase Motors.

## Field coils

When testing field coils follow the procedures outlined for testing Single Phase Motors and Two Terminal Devices and Synchronous Motor/Generator. The recommended surge test voltage for DC fields is 600 volts.

If the impedance of the coils is very low, (few turns count, generally form coils with very low resistance) the surge tester stand-alone may not adequately test the coils. A bar-to-bar, low impedance test accessory from Baker Instrument Company, an SKF Group Company, may be necessary.

### Hi L in AWA IV-2 and AWA IV-4:

"Hi L" is a technique that extends the range of use of the AWA IV-2 and AWA IV-4 tester's original surge test circuitry. This circuitry, like all electric circuits, has design and operational characteristics that can be enhanced, or fine tuned to meet specific, additional requirements. In a nutshell, Hi L technique is an example of this.

In essence, the useful range of electric coils that can be tested by the AWA tester is dictated by the "C" or capacitance supplied by the test set, and the "L" or inductance of the coil under test. The "Q" factor or loss of the test object also has a direct influence.

Per the data specifications, the AWA IV-2 and AWA IV-4 tester are supplied with a .1 microfarad energy storage capacitor. To illustrate the phenomena at work, this value (0.1) shall be the basis of the following discussion:

The sample, or data acquisition window of the AWA IV-2 and AWA IV-4 is dictated by its analog to digital converter, and the memory size assigned to it. Without going into detail about these signals, or memory depth, suffice it to say that the maximum sample time of the AWA IV-2 and -4 is approximately 2 milli-seconds ( $2/1000th$ of a second).

his illustrates the transient nature of the surge pulse. It is applied, measured, analyzed, and displayed in a fraction of a second.

Since we have a capacitor in the AWA IV-2 tester, with a value of 0.1 micro-farad:
What frequency (*f*) is generated, and therefore, the sample width needed should a 100 micro-henry coil be tested with the standard surge test?

$$f = \frac{1}{2\pi\sqrt{LC}}$$ becomes

$$f = \frac{1}{2\pi\sqrt{100^{-6} * .1^{-6}}}$$ when solved, reveals

a ringing or resonance frequency of approximately 50 kHz. The period of said 50 kHz sinusoid is equivalent to $1/f$ or approximately 0.00002 second. Well within the sample window width detailed previously.

What happens to these frequencies should the inductance of the tested coil be raised by several orders of magnitude? For example, what if the coil inductance is now 5 henry, or 50,000 times greater?

$$f = \frac{1}{2\pi\sqrt{5 * .1^{-6}}}$$ when solved, reveals a

frequency of approximately 225 hZ

The period of this signal is $1/f$ or approximately .0044 seconds. More than double the capability of the data acquisition sample width hardware to capture it!

Therefore, the question becomes: how do we capture such a signal, and display it appropriately across several orders of magnitude?

The answer is to employ the Hi L technique. The Hi L technique, in practical terms, functions as a test range extender. In other words, it allows the AWA IV-2,-4 to deliver sensitive test results when employed on much higher inductance's than the original, highly successful AWA surge test circuit.

**Using the AWA IV-2,-4, with the Hi L technique to test DC shunt or compound motor insulation, evaluate shunt fields and test inter-poles:**

Fully testing DC shunt or compound motors with the AWA IV-2,-4 requires some additional programming, and thinking of the motor in terms of its separate windings.

Knowing that the separate windings may operate at different voltages helps determine appropriate test voltages. Since there are separate windings, Test Ids need to be tailored to the windings

An effective method of performing this test sequence is to program two test ids, each being selected once during the test sequence of the DC motor.

**#1 Test ID Armature:**

Armatures may be: Low inductance, very low resistance, and also vulnerable to surface contamination due to brush carbon, or other materials. A suitable test id should include:

1) Temperature correction
2) Kelvin resistance-*with 2 leads selected*
3) Meg-Ohm, with a suitable value of pass/fail for meg-ohm value defined.
4) DA/PI test, with a suitable value of pass/fail defined
5) DC Test, such as the DC Hipot
6) Standard Surge test-*with 2 leads selected, by virtue of 2 leads resistance*

**#2 Test ID Field:**

Shunt fields are generally, high inductance, quite higher in resistance, and arranged in pairs. Hi L technique may result in more sensitive evaluation characteristics.

1) Temperature correction
2) Kelvin resistance-*with 2 leads selected*
3) Meg-Ohm, with a suitable value of pass/fail for meg-ohm defined
4) DA/PI test, with a suitable value of pass/fail defined
5) DC test, such as the DC Hipot
6) Surge test-*with 2 leads selected, by virtue of 2 leads resistance, and Hi L selected*

**Note**: Hi L technique is only selected for the shunt fields!

**AWA IV-2,-4: fine tuning the technique:**

40HP DC Motor, straight shunt, 500V armature, 300V field. Motor leads marked F1, F2 and A1, A2. These are the shunt field leads (F1,F2) and armature leads (A1,A2)

Plugging in the two sets of previously discussed sets of test ID's we could arrive at the following:


Fig 11-3: Test ID for F1-F2 300V field

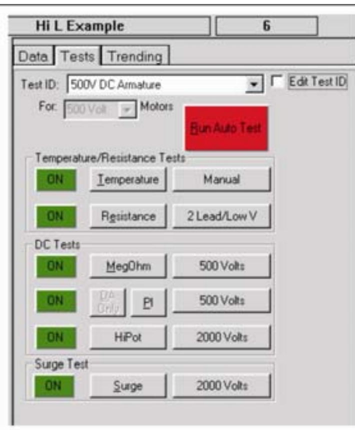



Fig 11-4: Test ID for A1-A2 500V armature

Since we know this is a DC straight shunt motor, we can further enhance the test:

We should expect DC resistance of the armature (A1-A2) to be quite low.

We should expect the potential for brush carbon contamination.

We should expect DC resistance of the fields (F1-F2) to be much greater than the armature.

We should expect the ability to employ the Hi L technique on the shunt fields.

We should employ Target Corrected Resistance detection for trending.

We should consider employment of Test-Ref, for A1-A2 and F1-F2 for trending.

We should consider steps to code, or lock the acquisition time-base for the specific motor.

Here are the steps required to fine tune the settings:

1) DC resistance of the armature is likely quite low A1-A2. This is where we employ the Kelvin Resistance Enable to ensure an accurate, repeatable measurement. Also at this stage, we should be sure to select Temperature Enable. We should also consider employment of Target Corrected Resistance (anticipating trending)

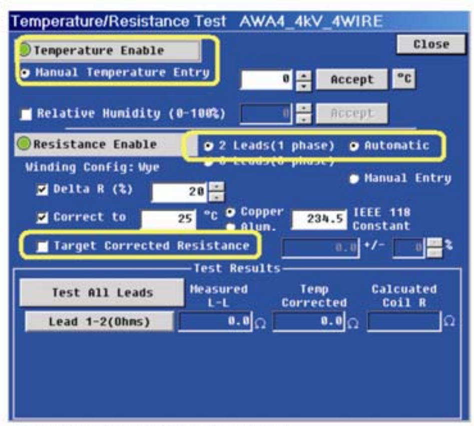



Fig 11-5: Hi-L temperature resistance

Given we are now aware of the low resistance of the armature, we should take steps to code the surge test sequence, specifically for the low resistance. This equates to a lower value of time-base, (not necessarily 10, it could be 50) and being sure to turn off the Hi L:

2) For the shunt fields, we should also employ the hard coded time-base, and the Hi L technique. Here is an illustration of steps to program the time-base, specifically for the shunt fields:

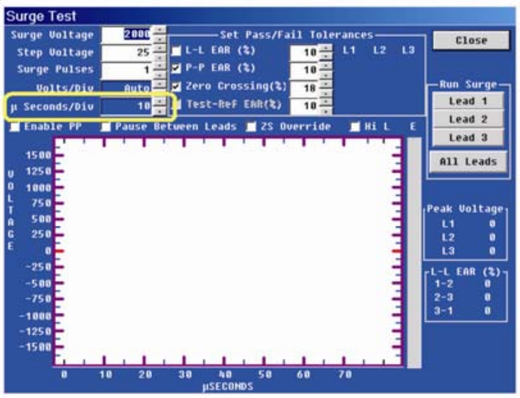



Fig 11-6: Hi-L surge test

Set micro-seconds to 200, and be sure to select Hi L, save the test ID when done.

Once we have these steps in place, we show how the successive test data would look:

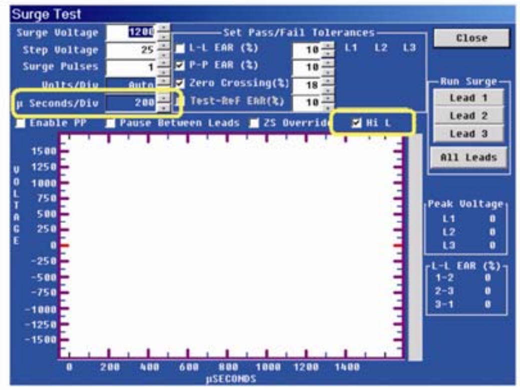



Fig 11-7: Hi-L surge test

## DC motor/generator

While the series or shunt fields of the DC motor/generator are tested as a two terminal device, the armature may be tested by three different methods.

Hi L Example | 6

Data | Tests | Trending

| Time | Test ID | Temp | Resist | Mohm | PI | DC | Surge |
|---|---|---|---|---|---|---|---|
| 7/17/2007 4:16:53 PM | 300V DC Field | PASS | PASS | PASS | PASS | PASS | PASS |
| 7/17/2007 4:08:36 PM | 500V DC Armature | PASS | PASS | PASS | PASS | PASS | PASS |
| 4/4/2006 8:01:31 AM | 300V DC Field | PASS | PASS | PASS | PASS | PASS | PASS |
| 4/4/2006 7:53:41 AM | 500V DC Armature | PASS | PASS | PASS | PASS | PASS | PASS |
| 10/13/2005 9:02:11 AM | 300V DC Field | | PASS | PASS | PASS | PASS | PASS |
| 10/13/2005 8:27:19 AM | 500V DC Armature | | PASS | PASS | PASS | PASS | PASS |

| Test Date | 7/17/2007 | 7/17/2007 | 4/4/2006 | 4/4/2006 | 10/13/2005 | 10/13/2005 |
|---|---|---|---|---|---|---|
| Test Time | 4:16:53 PM | 4:08:36 PM | 8:01:31 AM | 7:53:41 AM | 9:02:11 AM | 8:27:19 AM |
| Temp Status | Tested | Tested | Tested | Tested | No Test | No Test |
| Temp(°C) | 35.0 | 35.0 | 21.0 | 21.0 | | |
| Resist Status | PASS | PASS | PASS | PASS | PASS | PASS |
| Bal L1 (Ohms) | 40.3 Corr: 38.8 | 1.08 Corr: 1.04 | 39.0 Corr: 39.6 | 1.02 Corr: 1.04 | 39.0 Corr: 2001... | 1.08 Corr: 2001... |
| Bal L2 (Ohms) | 40.2 Corr: 38.7 | 1.07 Corr: 1.03 | 39.0 Corr: 39.6 | 1.01 Corr: 1.02 | 39.0 Corr: 2001... | 1.07 Corr: 2001... |
| Bal L3 (Ohms) | 0 Corr: 0 | 0 Corr: 0 | 0 Corr: 0 | 0 Corr: 0 | 0 Corr: 0 | 0 Corr: 0 |
| L1-L2 (Ohms) | | | | | | |
| L2-L3 (Ohms) | | | | | | |
| L3-L1 (Ohms) | | | | | | |
| Max Delta R % | 0.100% | 1.000% | 0.000% | 1.400% | 0.000% | 0.800% |
| Coil 1 (Ohms) | | | | | | |
| Coil 2 (Ohms) | | | | | | |
| Coil 3 (Ohms) | | | | | | |
| Megohm Status | PASS | PASS | PASS | PASS | PASS | PASS |
| Volts (V) | 500 | 510 | 510 | 500 | 500 | 510 |
| Current(µA) | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.6 |
| Resist | 5000 | 2550 | 5100 | 5000 | 5000 | 850 |
| At 40°C | 3535 | 1803 | 1366 | 1339 | | |
| PI Status | DA Only | PASS | DA Only | PASS | PASS | PASS |
| Volts (V) | 500 | 500 | 510 | 500 | 500 | 510 |
| DA Ratio | 3.0 | 2.0 | 2.0 | 3.0 | 3.0 | 1.5 |
| PI Ratio | 0.0 | 3.0 | 0.0 | 2.0 | 2.0 | 0.9 |

Nameplate | Application | Results Summary | Surge | PI | Step/Ramp-Voltage

Fig 11-8: Hi-L results

## Armatures

The Span surge test is used to test armatures with the AWA.

### *Span testing*

This method uses the brushes of the assembled DC motor to make the connections with the commutator for testing of the armature. Any number of bars can be used in this test. Adjacent bars can be surge tested, or a specific number or span of bars can be tested. The number of bars tested in each span for an individual motor must be the same during the entire test. In the repair shop, a fixture can be used in place of the motor's brushes (refer to Notes and Tips for Span testing an armature).

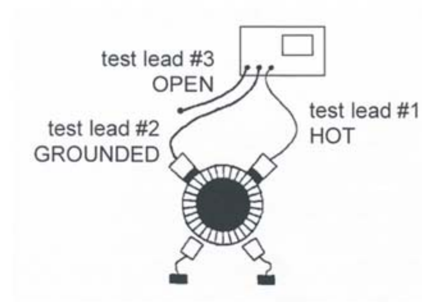



Fig 11-11-3 Span test using the motor's brushes

The wave pattern produced in this test represents the voltage oscillation between the tester and the coils for the specific number of commutator bars spanned. For example, any 10 bars spanned in series on the armature should give the same pattern as any other 10 bars spanned. As the armature is rotated, all the commutator segments and therefore their respective coils, pass into the test area between the hot surge test lead and the GRD lead.

**Note:** It is important that the same number of bars (and therefore coils) always be in the test area. The test wave pattern for each span should match a reference wave pattern on the display for the complete armature if the coils are all good.

1) Remove all brush pigtail connections from the leads at the brush rigging for all sets of brushes to isolate the armature from the power source.
2) Rotate the armature slowly through 360 degrees so that all commutator segments are tested while observing the reference wave pattern.

**Note:** It is recommended to release the Test button each time the armature is turned, but it is not necessary. Doing so minimizes the chance of marking the commutator.

If the test button is not released each time the armature is turned, the wave pattern will show regular shifts and flickers as the brushes move across one commutator bar to the next. This wave pattern movement should be ignored as long as the trace returns to the reference wave pattern and remains stable when the brushes are again centered on top of the bars.

### Determination of a fault

If the insulation is weak or failing on a particular bar or coil of the armature, the test wave pattern will become unstable and shift left when the section that contains the fault passes through the test area. The test wave pattern will no longer match the reference wave pattern. This indicates shorted windings within the span.

Usually, as soon as the bad bar is placed under the hot brush, the wave pattern will show the shift to the left as noted above, thus the bar directly below the hot brush is the faulty bar. An example of a fault found with the surge test using the motor's brushes is illustrated below.

### Notes and tips for Span testing armatures

– A test fixture can be used in place of using the motor's brushes to make contact with the armature.

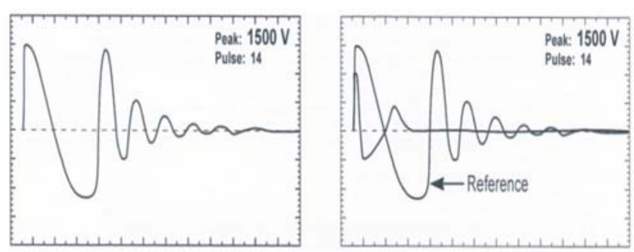



Fig 11-4: Fault located under the ground brush. Fault grounded under the hot brush or outside of the surge test span.

– Set the span between the fixture's brushes to the desired number of commutator bars. Either the fixture can be moved around the commutator during testing, or the armature can be rotated. Procedures for testing and fault determination are the same.
– First, always HiPot the armature to ground. This gives an upper limit for the maximum voltage to apply when surge testing.
– The greater the span surge test voltage is, the more adequate the stress between bars is (ideally, 335 volts according to Pashen's Law). Voltage stress is measured by the differential or drop between each bar. For example, a 10 bar span with 1000 volts applied to it will result in a 100 volt stress between bars. If the span is lowered to 5 bars, 1000 volt applied to the span will result in 200 volts between bars.
– Consider, however, that a ten bar span at 335 volts between bars would require a span test voltage of 3350 volts. This potential to ground at the first coil may be too high. A lower span test voltage is recommended if, for instance, the HiPot test was only to 2200 volts.
– It is advantageous to keep the span as low as possible to still get a reasonably good ringing wave on the display. However, lowering the span reduces the resistance and inductance of the load under test. The low inductive load may cause difficulty achieving the desired test voltage and a good ringing wave pattern on the screen.
– To simulate a fault, use an insulated screwdriver to temporarily short two commutator bars together that are in the test area. This shows the response of the wave pattern when a fault exists. It gives an indication of what the user should expect to see.
– Equalizer windings can separate the test wave pattern from the reference pattern seen during span tests. Thus, a good armature winding can appear to be bad. For example, a wave pattern for 7-bars spanned may sometimes match that for

11-bars spanned. In addition, the patterns may show a rhythmic shift consistently throughout the 360 degrees of rotation, (for instance, as the armature or fixture is rotated, every third bar shifts left a little), which is not a fault. This is due to the equalizers and does not indicate faulty windings.

– Releasing the test button before moving to the next bar during the test minimizes the chance of marking the commutator.

## Testing large AC stators/motors

Due to the physical non-symmetry of the input area, high capacitance, and inductance on some large AC high voltage machines, care must be exercised when evaluating the waveforms.

The screens below show wave pattern comparisons for a typical 4160V stator. Distortion is caused by the non-symmetrical, distributed capacitance in the input portion of the winding.

### *Notes and tips for large AC stator/motors*

– Large AC motors with parallel windings may show little, if any separation of wave patterns when shorted or open windings are present. The inductance change caused by these faults is often not detectable. Instances have been noted where an end turn of a winding has a hole blown in it, and yet surge wave pattern comparisons show no separation.
– As a result, it is critical to perform a winding resistance test with a milli-ohmmeter or micro-ohmmeter whenever evaluating the condition of a motor winding.
– The surge test must be done on each of the parallel windings individually for the highest degree of fault sensitivity.

## Rotor loading (coupling) when testing assembled motors

When testing assembled motors, the rotor can influence the shape of the surge wave pattern. These influences are as follows.

1) Loss of wave pattern amplitude: The inductive loading of the rotor causes rapid dampening (little to no cycles of the ringing pattern) of the wave pattern.
2) Separated wave pattern comparisons for good windings: Imbalance in the inductive coupling between the rotor and stator winding causes the wave patterns of two good phases to appear separated when they are compared. By turning the rotor, this coupling effect can be balanced out so the wave patterns superimpose.

Rotor loading can be understood when the rotor is considered as a secondary of a transformer. When one phase being surges has a different number of rotor bars under its stator windings than the other phase being surged and compared, there is a different transformer action existing for each phase. The wave patterns on the display indicate this difference by displaying separated wave patterns when they are compared.

Not all motors exhibit this characteristic. It is most prevalent in smaller, high efficiency motors with small tolerance air gaps. Separation of wave patterns that are due to rotor coupling can be determined when the wave patterns separate from the first positive peak downward, cross one another at the bottom (first most negative point) and separate again as they go upward (positive).

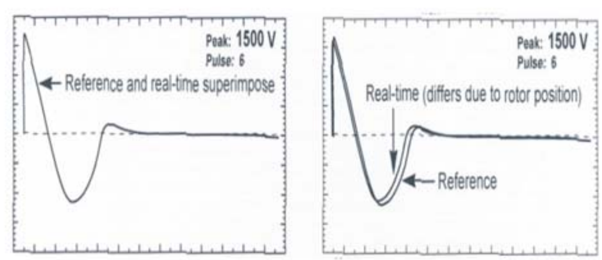



Fig 11-5: Wave pattern comparisons for motor with rotor in place.

The recommended procedure for testing assembled motors where rotor coupling may occur is as follows. Refer to Three Phase Motor Surge Test and Setup for detailed instructions for surge testing. Perform a manual surge test from the test screen within the AWA.

1) Surge test phase #1 of the motor. The AWA will perform the test and display the waveform on the screen. These waveforms will stay visible while other leads are being tested.
2) Surge test phase #2 of the motor. During the test, carefully turn the rotor until the wave pattern superimposes that of phase #1 on the display.
3) Repeat step for phase #3. All three waveforms will be displayed on the screen. Differences will be visible.

If the rotor cannot be turned, carefully observe the wave pattern as the test voltage is slowly raised. Watch for a sudden shift to the left, instability, or flickering, which could indicate a winding fault. Many winding insulation failures will not be visible at low voltages but become apparent at a higher voltage.

**Note:** Rotor coupling does not impede the surge impulse from stressing the turn-to-turn or phase-to-phase insulation. It only causes the rapid damping of the wave pattern. This rapid damping decreases sensitivity in interpretation of solid faults. Unstable, flickering wave patterns clearly indicate a fault in assembled motors whether rotor coupling is present or not.

## Testing assembled motors from the switchgear

The Surge and HiPot tests are valid tests when testing from the switchgear at the motor control center. Not only are the windings of the motor tested, but the insulation on the connections and feeder cables phase-to-phase and phase-to-ground are tested.

Follow all the procedures for surge testing. Keep in mind that different types and sizes of motors will give different traces, but the principle of testing assembled motors is still the same. When interpreting

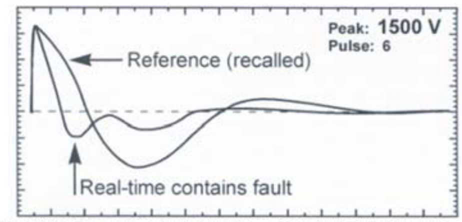



Fig 11-6: Motor with rotor in place and with faulty windings. One trace shift significantly to the left.

the wave patterns for good or bad windings, stability and symmetry are the most important factors.

## Notes and tips for testing from the switchgear

**Warning:** The motor must be de-energized before testing! Connect the test leads to only the load side of the open disconnect.

– The test motor should be properly tagged during the test as a safety precaution.
– All of the limitations and guidelines covered for testing assembled motors apply here (see Rotor loading (coupling) when testing assembled motors).
– Any power factor capacitors in the circuit must be disconnected. If power factor capacitors are present, no waveform will be observed when the voltage is raised. This will also happen if the motor was not connected to the cable. Only a rise in the trace on the far left will be noted.
– The surge test circuit will be loaded by the feeder cable capacitance as well as the motor. Significantly, higher output settings will be needed to reach the required test voltage. If the surge tester is too small to handle both the cable and the motor load, a trace will be observed but the proper test voltage will not be reached. A higher output surge tester model will be required or the motor may have to be tested while disconnected from the feeder cable.

There is no precise science to determine what size motor; with what size and length feeder cable a particular surge test model can adequately test. In general, the closer the size of the motor is to the recommended maximum motor size for a given model surge tester, the shorter the cables can be and still allow testing at the required voltage. Conversely, the smaller the motor size, the longer the cable can be.

## Transformers

Transformers contain similar insulation systems as motors: ground, turn-to-turn and phase insulation. However, the spectrum of winding characteristics for transformers is much broader than for motors.
The Surge test is only one of many tests that should be performed to properly test a transformer. If the transformer has thousands of turns, the surge tester may not be sensitive enough to detect a single shorted winding. It may also sense the high inductance of a transformer as an open.
The following procedures for single phase and three phase transformers provide the basics necessary to surge test transformers. Please call Baker Instrument Company, an SKF Group Company, at 800-752-8272 for further assistance or if difficulties are encountered when testing transformers.

### *Single phase transformers*

1) Jumper (or short out) the secondary side (low side) of the transformer.
2) Select Test Lead #1. Follow the diagram below to connect test lead #1 to H1 and to H2 of the transformer. The black GRD lead and test lead #3 go to the frame.
3) Surge test the winding following the procedures outline for Single Phase Motors and Two Terminal Devices. The discussion of determining a fault applies.

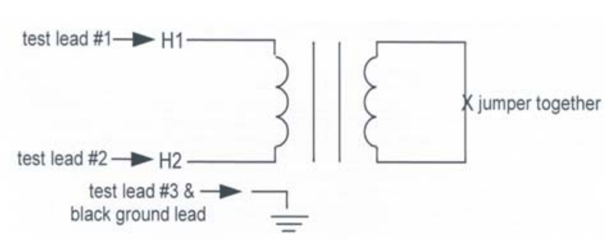


Fig 11-7: Single phase transformer connections

**Note:** Secondary winding insulation problems are reflected into the primary winding, and will be observed on the display.

1) After completing the test, reverse the tests leads (connect test lead #2 to H1 and test lead #1 to H2) and repeat the surge test. This is commonly referred to as shooting in the other direction.
2) Repeat this test process for each TAP position.

### *Three phase transformers*

It is beyond the scope of this manual to cover all possible transformer connections. It is important to remember that each line high side connection point must be surge tested to the other end of its own coil, and that the secondary side of the coil being surged must be shorted out (jumpered together and to ground).
**Note:** A wye-wye transformer with the star point internally tied can be surge tested without opening the tie point.

1) Use Test Lead position #1.
2) Connect the black ground test lead to the frame (ground) of the transformer.
3) Follow one of the charts below for connections for wye-wye or delta-wye transformers. The transformer windings should be surge tested for all the configurations shown.
4) Test procedures follow identically as for Single Phase transformer testing (refer to Single Phase Motors and Two Terminal Devices)

***Determination of a fault***

To determine a fault when surge testing a transformer winding, follow the procedure that of the two terminal device (refer to Single phase motors and two terminal devices).

Wye-Wye Transformers

| Test Lead #1 | Test Lead #2 | Jumper |
|---|---|---|
| H1 | H0 | X0 to X1 |
| H2 | H0 | X0 to X2 |
| H3 | H0 | X0 to X3 |

Delta-Wye Transformers

| Test Lead #1 | Test Lead #2 | Jumper |
|---|---|---|
| H1 | H2 | X0 to X2 |
| H1 | H3 | X0 to X1 |
| H2 | H1 | X0 to X2 |
| H2 | H3 | X0 to X3 |
| H3 | H2 | X0 to X3 |
| H3 | H1 | X0 to X1 |

# Appendix A - AWA troubleshooting

**Inside this chapter**

- Applications: What to do first
- Service: What to do first
- Precautions for proper operation
- Proper storage of leads/unit
- Checking test leads for broken sections
- Open circuit test to verify tester operation
- Third party software warning
- Warranty return
- Calibration information

Please review this section before you call Baker Instrument Company, an SKF Group Company, or return the unit.

## Self help and diagnostics

Problems in testing often crop up. If you are experiencing a problem and believe the problem might be with the Baker Instrument Company, an SKF Group Company, Surge/DC HiPot Tester, please take the following steps before calling or returning the unit.
By performing these procedures and having the requested information available, Baker Instrument Company, an SKF Group Company's Service or Applications Departments will be able to better analyze the situation and provide the appropriate response. Either department may be reached toll-free at 800-752-8272 or 970-282-1200 for assistance.

## Repair Parts

Warning: Electric Shock Hazard
During repairs, do not substitute any parts. Use only factory-supplied parts to minimize safety hazards.
Do not modify or repair test leads in any way. Defective, damaged, or broken test leads must be replaced with factory-authorized parts to ensure safe operation and maintain performance specifications.

### Step #1: Basic information

Take down all basic instrument information, including the following:

**Model number**
**Serial number**
**Product number**
**Software version number**

**Note:** All information above except for software version number is located on the rear panel product label. Software version can be found by starting the software and clicking on the **Help-About AWA...** menu item. If the tester has special options installed, please note these. Any instrument information derived is helpful! A great tool would be a printout or sketch of the waveforms displayed on the tester.

### Step #2: Applications or service problem?

Generally, if a problem is noted o*nly* when testing a specific motor/generator or other coil type, then applications would be involved. See **Applications: What to do first!** Please call Baker Instrument Company, an SKF Group Company,, sales department for applications assistance.
If the problem is not associated with any *one* type of motor/generator, or other coil type, then service would be involved. See **Service: What to do first!**

## Applications: What to do first!

Review the section on common application problems. Please have basic information about the tester and specific information about the motor being tested available when calling or faxing to assist Baker Instrument Company, an SKF Group Company, personnel in determining a solution to the problem.

Examples:

- Hp rating
- kW rating
- RPM rating
- Operating voltage & current
- How the item being tested is wound and/or number
- and type of coils
- Application of motor/generator

In short, all information from the motor nameplate would be helpful. A great tool is a printout or sketch of the waveforms displayed on the tester. If a FAX is available, send a draft to 970-282-1010, attn: Applications.

### Common application problems

There are a few common application-related problems. Please review the following cases.

1) The AWA will not give the desired output test voltage for the apparatus under test.
2) The test motor may be too large for the instrument being used. The impedance of the windings may be too low.
3) The AWA may be at fault in this case. Do not continue testing until Baker Instrument Company, an SKF Group Company, applications department is contacted.
4) Separation of compared surge wave patterns is seen when surge testing known-good coils, brand new motors or windings. Often, separation is seen in all three comparisons for three phase motors, but to varying degrees.
   a. Generally, this is caused by unbalanced impedance in windings which is inherent to the design. It most commonly occurs in basket or concentric wound motors. The phases are not magnetically balanced due to different coil lengths.
   b. When acceptance testing, waveforms that are separated because of improper turn counts, misconnections, or reversed winding groups may be seen.
   c. This condition may also be seen in DC fields or rotating poles. Coils being compared must be tested in identical configurations.
   d. On very large equipment, slight differences in capacitance to ground may be the cause. At low voltage levels, begin the test again with the black ground lead removed from the motor frame. If the separations disappear, the problem was capacitance to ground. Be sure the winding has passed the DC tests before doing the Surge test.
5) There is no dampened sinusoidal wave pattern on the display when testing a coil. The wave pattern rises on the left and then slowly drops as it trails off to the right of the screen. It may or may not cross the zero/base line.

**Precautions for proper operation**

- Never raise the output control to attain a display from a blank screen!
- Never attempt simulated problems by disconnecting the leads and positioning them to arc against each other!
- Never come in contact with the item being tested and the test leads or with the tester and the item being tested!
- Never attempt a two-party operation. Always know what test is being performed and when!
- Never attempt a Burn-Out of a detected fault with the tester!

6) The coil under test is probably too high an impedance to get a good working pattern. The coil may be very high in resistance.
7) A broken test lead may be the cause. Under heavy use, test leads should be checked weekly to ensure that there is no breakage. Grasp the boot and clip in one hand while pulling on the lead with the other hand. A broken lead will stretch, whereas a good lead will not.

## Service: What to do first!

Because history has shown that several simple solutions which do not require return of a unit may arise, please perform the following checks.

### Open condition display

Note the figures below. Is the surge waveform like this?

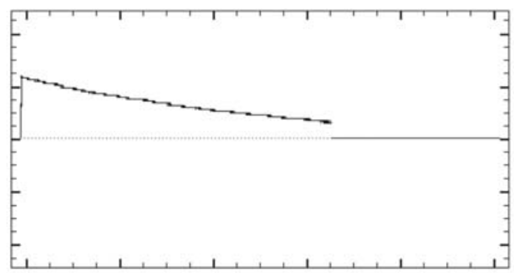


Fig A-1: Open Condition

If yes, the unit may have at least one broken test lead causing an open condition. In most cases, the test lead that is under test and gives this pattern is the broken lead.

Verify this by pulling on the book/clip assembly of the lead. A broken test lead will stretch. If it does not, repeat this procedure at one foot intervals for the length of the lead. If the leads of the tester are good, check the connections and continuity of the test winding.

## HiPot display checks

**1) The HiPot display shows only the voltage or current bar. One of three problems might exist.**

a. The item being tested is in fact faulty and has either low insulation resistance or open connections.
b. The AWA has an internal problem.
c. The tester has a test lead problem as shown above for an open condition.

Disconnect the test leads from the motor and isolate the tester from any grounded surface. Reduce the output to minimum and attempt a HiPot test with an open lead condition. Your display should indicate a rising voltage bar. The current bar may rise slightly but fall back to zero when the output increase is stopped.

**Note:** It is not necessary to run the output control at a high level to determine if the AWA is working properly.

If the display still shows no voltage bar call Baker Instrument Company, an SKF Group Company, service department. Use a meter to confirm the insulation resistance of the device being tested.

Current bar operation can be tested by shorting test lead 1 and the ground lead together. Under this condition, the voltage bar will not move off the zero line and the current bar should rise very rapidly and activate the HiPot overcurrent trip warning light (**HiPot** trip). If the HiPot Trip light does ***not*** light, check for open test leads at either test lead #1 or the ground lead (see **Open Condition Check)**. If the problem persists, contact Baker Instrument Company, an SKF Group Company, Service Department.

## HiPot over current trip check

**1. Either the HiPot trip lamp does not activate under known shorted conditions, or it will not go out when test is discontinued.**

Call the service department immediately for assistance. Please record information off the unit and the specific problem prior to calling.

## Open ground check

**2. The open ground warning prevents testing.**

Answer these questions:

1) Has the unit recently been moved to a new location with possibly an ungrounded outlet?
2) Is the unit being operated in a field where the AC power source is unknown?
3) Is the unit being operated on a scope cart that has its own outlet or power source?
4) Is the unit being operated using a two-wire extension cord?

5) Is the unit being operated on a transformer-isolated circuit?

If the answer is yes to any of these questions, the unit is probably operational and indicating that there is open AC line ground connection.

In the case of numbers 1 through 3 above, use an outlet tester to assure proper wiring connections to the outlet.

## Limited output Surge waveform

**3. The display shows a limited output (amplitude) surge waveform. The display rises normally but stops at some point. Alternatively, the user must continually increase the output control for successive tests to achieve the same output test amplitude.**

Call the service department immediately for assistance on this or any other abnormal condition noted. Please record basic information from the tester and the specific problem prior to calling.

## Proper storage of leads/unit

After the instrument has been correctly shut down, the high voltage and resistance leads can be placed back into the nylon bag with the power cord. This can be carefully placed on top of the touchscreen and the lid closed for storage. By not placing the leads in the nylon, bag and putting them directly onto the touchscreen can break or damage this screen. If the screen is damaged, the unit will not operate properly and have to be sent to Baker Instrument Company, an SKF Group Company, for replacement. Even though these units come with a comprehensive year warranty, exterior damage of this type is not covered.

Care should be taken to keep the unit dry. This instrument should not be stored in any location where water entry to the instrument can occur. Humidity will also affect the operation of the instrument.

## Checking test leads for broken sections

Either prior to using the instrument or at least once a month, each test lead should be inspected for broken sections. If the tester has a broken lead, the instrument will not work properly and give erroneous results. Within the first 6 inches from the tester panel, strain-reliefs and 12-18 inches from the clips are the typical spots where the leads are broken. There are two methods to check for breaks in the leads: a manual check and an overcurrent trip test.

## Manual break check

1. Inspect the lead wire for any cuts or nicks in the wire sheath.
2. Take the clip in one hand and grip the lead wire in the other had approximately 12-18 inches from the clip.
3. Grip the lead wire approximately 6 inches from the strain relief on the tester.
4. Again steadily, pull the lead. Again, if the lead stretches, it is broken. If it does not have any give, it is good.

***Overcurrent trip test***

The black ground lead is the most often broken lead. This is an easy test to verify if the black lead is broken.

1) Connect all leads together (clip to clip) (Three red, one black ground).
2) Place tester in either Meg-Ohm or DC HiPot mode. Initiate test.
3) If the tester immediately shows an overcurrent trip, the black test lead is good. If the tester continues to ramp up to the test voltage, the black test lead is broken.

## Open circuit test to verify tester operation

While doing periodic testing there are some instances that the tester will immediately trip when first initiating testing. When this occurs, there is generally some question by the operator if the motor is truly bad or if the tester is operating correctly. There is a simple test in order to verify the tester operation. This is called an open circuit test.

1) Unhook all leads from the motor being tested.
2) Place all leads some place safe: on the floor, over the edges of a plastic trash can, etc. The main purpose is so that the test clips do not touch.
3) Place the black lead away from the red leads.
4) Initiate either a Meg-Ohm or a DC HiPot test.
5) If the tester is operating correctly, it will ramp up to the test voltage with minimal leakage current and will not overcurrent trip. If the tester is not operating correctly, it will overcurrent trip immediately like when it was attached to the motor.
6) If the tester is operating correctly, reconnect to the possible bad motor and retest. If it is not operating correctly, contact Baker Instrument Company, an SKF Group Company, for assistance.

### Third party software warning

Even though Windows XP Embedded does not allow the installation of general software packages, do not install spy ware or spam blockers, screen savers, virus detectors or wireless Internet software to the tester. It will corrupt testing procedures and operations. Many of these types of software packages, when installed on the tester will continue to poll/use CPU resources of the computer even when not open on the desktop, creating conflicts.

## Warranty return

Please review the warranty notes and shipment sections at the beginning of this manual before sending your tester to Baker Instrument Company, an SKF Group Company, for Warranty repair.

The warranty-return form on the following page must be filled out and returned with the tester to obtain warranty service. This form will help to ensure that Baker Instrument Company, an SKF Group Company, will identify the problem, quickly repair our unit, and return it to you.

## Warranty return form

Please copy and fill out all the following information and return this form with the tester. Make a copy of all records prior to sending this to Baker Instrument Company, an SKF Group Company.

**Note:** Be sure to follow the guidelines for shipping when sending the tester to Baker Instrument Company, an SKF Group Company.

Company Name:______________________

Name: ______________________________

Mailing Address:_______________________

Shipping Address:____________________

Phone Number: _____________________

Fax:______________________________

**From the name plate on the back of the tester:**

Baker Product Number:
_________________________________

Model Number:
____________________________________

Serial Number:
____________________________________

Software Version #:
____________________________________

**Description of the problem:**
Please give as much information as possible (what is not working, when it happened, what was being tested, any unusual noises, etc.) even if you already talked to someone at Baker Instrument Company, an SKF Group Company, by phone. Use the back of the copy of this form if necessary.

Person contacted at Baker:

______________________________

Ship the Tester to: Baker Instrument Company, an SKF Group Company, 4812 McMurry Avenue, Fort Collins, CO 80525, Attn: Service Manager

## AWA calibration information

AWA calibration information and documentation can be acquired by calling Baker Instrument Company, an SKF Group Company, at 800-752-8272 or 1-970-282-1200. Please ask a service representative for document number 76-001-003.

# Appendix B Software installation/ maintenance

**Inside this chapter**

- Navigating through the software interface
- Selecting items
- Shading
- Buttons
- Text fields
- Scroll bars and Windows® icons
- Baker admin or user shell
- Software installation
- Desktop install

## Navigating through the software interface

Familiarity with Windows® and basic computer skills is assumed. For operators unfamiliar with Window®, the following texts may be helpful.

- Liming, Sean D, Windows XP Embedded Advanced, October 2003.
- Cseri, James Beau, Windows XP Embedded Step by Step, RTC Books, San Clemente, CA, January 2003.

Working with the AWA software requires that the user be comfortable using multiple windows, a variety of keyboard commands, and a pointing device (mouse). To enhance navigation, hot keys (keyboard shortcuts and toolbars) have been added to the programs.

On the AWA, one window may serve several purposes. For example, the Motor Tree View window shows the motor tree and also allows use of Routes and access to the Route Editor.

### Selecting items

As with most modern computer interfaces, the common way to select an item is to point at the item with the pointer device (mouse) and double-click with the left button while holding the device still. In many cases, a single click will not select an item, but will highlight it. The appearance of highlighted and selected items varies depending on the screen design.

Another method of selection applies to menu labels that have an underlined character. For example, on the menu bar, the **File** menu has an underlined F. Use the **Alt key** and the underlined key (F) together to perform the same function as a mouse click on the menu option. When **Alt-F** is typed, the **File** pull down menu appears.

### Shading

The shading of the images on the various screens of the programs is significant. Gray shaded fields are generally non-editable. When a field has a white background with black text, it is editable.

### Buttons

Square and rectangular buttons with labels supply commands to the AWA. For example, look at the Nameplate window to see the **Add**, **Update**, and **Del** buttons. Small square buttons such as the one next to **Edit Test ID** on the Tests tab window are called check boxes. They display a checkmark when active. Round buttons called, radio buttons, fill with black when active; radio buttons begin tests in semi-automatic mode.

### Text fields

Areas which may have text typed into them are called text fields. To edit text fields, click in them and then type. Some text fields require information and others do not. The user will be prompted to enter missing information required by the AWA if a necessary field has been left blank.

### Scroll bars and Windows® icons

The scroll bars on the bottom and right sides of the window allow the user to view parts of the window that do not currently fit on the screen. Icons in the upper right hand corner of the window allows it to be minimized to take up less computer screen space, maximize to fill the screen, or closed. The small printer icon in the upper left corner of the screen is a printing shortcut. The program icon that appears next to the AWA Software on the top of the window allows you to minimize and maximize the display or exits the program.

### Baker admin or user shell

The Windows XP Embedded operator interface offers a tamper resistant user shell that does not allow software additions or any changes to the overall operating system of the instrument. Two modes are available – the Baker admin and user shell. There are several ways to enter into these modes. The Baker admin shell can be reached from a desktop shortcut or form inside the AWA software via left **Alt** key and **F12.** The user shell can only be entered into via the left **Alt** key and **F12**. The Baker admin shell allows the addition of printer drivers, add or configure network or Ethernet support, upgrade AWA software or other basic features of Windows XP® Embedded software. When the user shell is employed the only operation of the instrument is within the AWA software. In order to switch between these two modes, the instsrument must be rebooted to activate the mode desired. Even within the admin mode of the Windows XP® Embedded software most third party software will not load onto the instrument successfully. This is employed to stabilize the testing environment of the instrument.

## Software installation

Since there are periodic upgrades and fixes to computer driven products, it makes sense to keep in touch. Contact Baker Instrument Company, an SKF Group Company, by calling 970-282-1200 or 800-752-8272 (US only) or access the website at www.bakerinst.com. There is download section, where the latest software can be downloaded.

### Desktop install

It makes sense to do a lot of the report generation on a desktop PC. Desktop monitors are larger, the AWA unit is not tied up while reports are being printed, and it is easier to share data with other people on the network, who have the desktop software present at their workstation.

When it is time to install the programs from CD-ROM or over the network, be sure to check the Readme.txt files, this is where the latest information about the upgrades can be found.

# Appendix C Technical specifications

**Inside this chapter**

- AWA IV-2, AWAIV-6 technical specifications

# Technical specifications

| **Surge Test** | **AWAIV-2** | **AWAIV-4** |
|---|---|---|
| Output Voltage | 0-2160 Volts | 0-4250 Volts |
| Max Output Current | 200 amps | 400 amps |
| Pulse Energy | .2 joules | .9 joules |
| Storage Capacitance | .1ì F | .1ì F |
| Sweep Range | 2.5-200 µS/Div | 2.5-200 µS/Div |
| Volts/Division | 500/1000/2000/ 3000 | 500/1000/2000/ 3000 |
| Repetition Rate | 5 Hz | 5 Hz |
| Voltage Measurement & Accuracy | +/- 12% | +/- 12% |
| **DC High Potential (HiPot) Test** | | |
| Output Voltage | 0-2160 Volts | 0-4250 Volts |
| Max Output Current | 1000 µ amps | 1000 ì amps |
| Current Resolution | .1/10/100/1000 µ amps division | .1/10/100/1000 µ amps division |
| Over-Current Trip Settings | 1/10/100/100 µ amps | 1/10/100/100 µ amps |
| Full Scale Voltage & Current Measurement & Accuracy | +/- 5% | +/- 5% |
| Meg-ohm Accuracy | +/- 10% | +/- 10% |
| Max Meg-ohm reading | 50,000 MΩ | 50,000 MΩ |
| **Physical Characteristics** | .001• - 100• | .001• - 100• |
| Weight | | |
| Dimensions (W x H x D) | 24 lbs | 24 lbs |
| Power Requirements | 15 x 8 x 8 in. | 15 x 8 x 8 in. |
| **Resistance Measurement** | 85-264VAC 50/60 Hz @ 500 watts or more | 85-264VAC 50/60 Hz @ 500 watts or more |

## Accuracy of measurements - Coil Resistance test

### Resistance Balance Test (High Voltage Leads)

| Range | Resolution | Full Scale Accuracy |
|---|---|---|
| *10Ù- 100Ù | .1Ù | +/- 5% |
| 2Ù - 20Ù | .1Ù | +/- 5% |
| .2 - 2Ù | .05Ù | +/- 5% |
| .05 - .6Ù | .005Ù | +/- 5% |
| .005 - .07Ù | .0002Ù | +/- 5% |
| .001 - .01Ù | .0001Ù | +/- 5% |

* Above 100Ù is reported as an potentially open circuit.

## Testing Accuracy - HiPot Measurements

| Range | Approximate Maximum Measurable Current | Resolution | Full Scale Accuracy |
|---|---|---|---|
| 100µA/Div Range | 900µA | +/-5% from 90µA-900µA | +/-5% |
| 10µA/Div Range | 90µA | +/-5% from 9µA - 90µA | +/-5% |
| 1µA/Div Range | 9µA | +/-5% from .9µA - 9µA | +/-5% |

## Voltage Measurement Accuracy - Surge

| Range | Resolution |
|---|---|
| 500V/Div | +/- 12% |
| 1000V/Div | +/- 12% |
| 2000V/Div | +/- 12% |

# Glossary of terms

## Glossary of terms

**Insulation Resistance:**
In the context of the intended use of this equipment, insulation resistance (IR) is determined by application of a known, stabilized DC voltage, and simultaneous measurement of the DC current that passes through or across insulation of the test object.
It is expressed in Meg-Ohms, or 1,000,000 ohms. Insulation resistance is a circuit parameter, that for electric machines, may exceed several Meg-Ohm's or even several thousand Meg-Ohms.

**Polarization Index:**
For the intended application of this equipment, this is fully expressed as Polarization Index Ratio. In the method used by this equipment, the duration of the test is standardized at 10 minutes. IR is compared at 1 minute and at 10 minutes. Abbreviated as P.I. This technique can provide trend-able test results for condition monitoring purposes.

**Dielectric Absorption:**
In practice, the test is performed at similar, or exactly the same voltage levels as the
P.I. The same principle of leakage measurement is used, and the times of the test is typically a total of 3 minutes. The same measurement of DC leakage current, expressed as a ratio at 30 seconds versus 3 minutes is in effect. This technique can provide trend-able test results for condition monitoring purposes

**Meg-Ohm:**
1 Meg-Ohm is 1,000,000 Ohms (1 million)

**Temperature Compensation:**
It is an established fact that the temperature of the environment has a direct influence on the measurement of both electric coil resistance, and the insulation systems used to maintain the paths where electric current will flow. In the case of electric coils, increased heating leads to an increase in the apparent measured resistance. Conversely, for insulation systems, increase in temperature leads to a decrease in the apparent measured resistance. The idea in effect is that these apparent values can be normalized by conversion factors, leading to the ability to make a more informative judgment of the measured values. This correction enhances the accuracy of trending results

**Coil Resistance:**
In the case of electric motors and generators, coiled loops of wire are used to provide the electric current path. These coils may be windings of several hundreds or more turns of small diameter wire, such as a DC shunt field, or a solenoid. Conversely, they could also be some few turns of very thick and heavy conductor, such as a DC series field or an armature. Therefore, coil resistance could measure several hundred ohms, to less than 1/1000$^{th}$ of an ohm, depending on the electric machine design. An accurate milli or micro ohm meter is essential for making adequate tests in these cases. This technique can provide trend-able test results for condition monitoring purposes.

**HiPot:**
More completely termed the High Potential test. For the intended use of this equipment, the concept is sometimes termed: Proof Test.
A high voltage potential is applied to the electric conductors, while the frame or enclosure of the equipment is held at ground potential. A successful test will pass with negligible or low electric leakage indicated. A failed test will result in a high leakage current, and often an over-current trip condition.
This test is carried out when the consequences of electric machine or insulator's failing test during an equipment outage are grossly outweighed by the severe consequences and equipment damage caused by weak or flawed insulation failure during service.

**Step Voltage Test:**
An enhanced variation of the DC HiPot. The test is comprised of a series of equally timed voltage increases. The leakage current at the conclusion of

each step is plotted. Weak or compromised insulation may be revealed by non-linear results, when plotted. By virtue of this technique, reduced risk of over-current trip and damaging apparatus under test when performed. This technique can provide trend-able test results for condition monitoring purposes.

**Ramp Voltage Test:**
An enhanced variation of the DC HiPot. The test is comprised of a smoothly rising ramped voltage. The rate of rise may be as slow as 5 volts per second. During the rise to the target voltage, the leakage current is constantly monitored and plotted. Discontinuity or non-linear responses of the leakage can reveal weak or compromised insulation.
By virtue of this technique, reduced risk of over-current trip and damaging apparatus under test when performed. This technique can provide trend-able test results for condition monitoring purposes.

**Leakage current:**
For the purposes of this equipment, leakage current is the DC current, in micro-amperes.
It is measured across, through or over the surfaces of the object under test. In general terms, properly functional insulation exhibits very small or negligible electrical leakage current.

**IuA:**
This abbreviation stands for: current (I) micro (u) Amperes (A)

**Error Area Ratio:**
This is a technique in effect during the Surge test. This technique allows a numeric value to be assigned to an electrical signal generated, and sampled by the test equipment. Since it is possible to assign a number to the signal generated, it becomes possible to make comparisons between previously sampled data, and determine the ratio of difference between the two signals. Specifically, is a very effective technique for discerning electrical differences between electric coils.

**L-L EAR**
This technique is selectable during the Surge test. Full name: Line to Line Error Area Ratio. This term is used to describe the Error Area Ratio measurement comparison between successive tests of the same test object, specifically in the case of poly-phase induction machines. It is a modern day, enhanced equivalent of the surge comparison test. A numeric value can be assigned to the instantaneous electrical qualities measured between the 3 phases, and judgments can be made about the fitness of the object under test for service/

**P-P EAR**
This technique is selectable during the Surge test. Full name: Pulse to Pulse Error Area Ratio. This term is used to describe an enhanced, real time, technique that is primarily used to detect electrical weakness in turn to turn insulation in electric coils. It functions based upon successive sampling of the measured wave shape. Variations in successive wave shapes are analyzed and the EAR between them is plotted.

**Zero Crossing:**
This technique is selectable during the Surge test. The technique looks at the zero crossing points of the voltage sinusoid signal sampled during the surge test. As this wave is typically shaped as a damped sine-wave, there are generally several zero crossings. Any shift in zero crossing, specifically in frequency, can be an indication of insulation weakness.

# Index

## *T*



## *V*