Digital Winding Tester
DX4, DX6, DX6HO, DX12, DX12HO

User Manual Part No. 71-030E-EN

User Manual

⚠ *Read this manual before using this product. Failure to follow the instructions and safety precautions in this manual can result in serious injury, damage to the product, or incorrect readings. Keep this manual in a safe location for future reference*

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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 if it 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 is required to correct the interference.

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

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INTENDED USE OF INSTRUMENT

This motor analyzer is offered by Baker Instrument Company, a standard products division of SKF Group. This machine is intended to be used to detect weak or defective 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 operations of instrument.

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If the UNIT fails, whether it is under warranty or not, call the Baker/SKF 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/SKF 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 phone number:
(970) 282-1200 or toll free at
(800) 752-8272.

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Preface

⚠ Important Safety Information

General Safety Precautions

- The general safety information presented here is for both operating and service personnel. You will find specific warnings and cautions throughout this manual where they apply.
- If using the equipment in any manner not specified by Baker Instrument Company, an SKF Group Company, the protection provided by the equipment may be impaired.

Safety Term Definition

DANGER: This notification indicates a hazardous situation that, if not avoided, will result in death or serious injury.

WARNING: This notification indicates a hazardous situation that, if not avoided, can result in death or serious injury.

CAUTION: This notification indicates a hazardous situation that, if not avoided, can result in minor or moderate injury.

NOTICE: "NOTICE" is the preferred signal word to address practices not related to personal injury.

Danger

High Voltage

To prevent serious injury or death:

- **Do not use in explosive atmospheres.**
- **Do not contact test leads or the device being testing while a test is in progress or during the discharge period.**
- **Do not connect test leads to live circuits.**

Read and follow safety precautions and safe operating practices in the operator manual. Do not exceed maximum operating capabilities of this instrument.

Other Important Safety Warnings

Failure to follow these precautions can result in severe electrical shock or death.

1. **Never** attempt a two-party operation. Always know what test is being performed and when. For example, **do not** adjust test leads when operating a footswitch. Leads will have live voltage and severe electrical shock may result.
2. For capacitor-started motors or systems with surge arrestors/power factor capacitors, be sure to **disconnect** all capacitors from the test circuit **before** testing.
3. Upon completion of a DC High Potential (HiPot), Megohm, Polarization Index (PI), Step Voltage, Dielectric Absorption (DA), or Continuous Ramp Test, before disconnecting the test leads, short the winding, motor, etc., to ground and allow time for discharge. If this is not complete, voltage may still be active on leads and tested components.
4. Make sure to disconnect the tester leads before energizing or powering up the motor.
5. **Do not** remove the product covers or panels or operate the tester without the covers and panels properly installed. Components on the inside of the tester carry voltage for operation and can render a shock if touched.
6. Use appropriate safety equipment required by your organization, including high voltage gloves and eye protection.
7. **Repair parts warning:** You must replace defective, damaged or broken test leads with factory-authorized parts to ensure safe operation and maintain performance specifications.
8. **Ground the product:** This product is grounded through the power cord's grounding conductor. To avoid electrical shock, plug the power cord into a properly wired/grounded 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 cause an electric shock!
9. This instrument is **not** waterproof or sealed against water entry.
10. The unit is for indoor use. If using it outdoors, you must protect the unit from rain, snow, and other contaminants.

Symbols on Equipment

	Protective conductor terminal. Located beside black ground test lead on front panel of instrument.
	Earth (ground) terminal.
	Frame or chassis terminal. Located on rear panel of instrument by ground terminal.
	Warning about hazardous voltage and risk of severe electrical shock or death. Located beside each red test lead on front panel of instrument.

Other Information

Cleaning and Decontamination

Keep the unit clean and in a dry environment. To clean the unit, power down and unplug the instrument. 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.

Technical Assistance / Authorized Service Centers

See our website at www.bakerinst.com for technical assistance / authorized service center information. This information will be marked with an asterisk.

Intermittent Operation Limits

At this time, there are no intermittent operation limits to the use of the unit.

Installation Requirements

You may operate the unit:

- Flat, on the bottom of the unit
- Flat, on the back of the unit
- 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 you may encounter occasional non-conducting condensing pollution.

Unpacking the Unit

Carefully remove the following items from the shipping box:

- Baker DX
- Power cord
- Operation manual (soft copy only)

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 100-240 V AC, 50-60 Hz, 2 amps AC maximum current draw. An auto-reset circuit breaker protects the unit.

Environmental Conditions

- The unit has been tested for use up to 2,000 m *(6,500 ft.)*.
- Only operate the tester in temperatures ranging from 5 to 40 °C *(41 to 104 °F)*.
- This unit is for use at a maximum relative humidity of 80% for temperatures up to 31 °C *(88 °F)*, decreasing linearly to 50% relative humidity at 40 °C *(104 °F)*. This unit is intended for Installation Category II in a Pollution Degree II environment.

1
Instrument Overview

Baker DX Series testers provide a comprehensive, yet modular set of high voltage motor testing tools in a compact, lightweight, easy-to-use system. These testers perform Surge, Insulation Resistance (IR), Inductance, Capacitance, Megohm, Dielectric Absorption (DA), Polarization Index (PI), and High Potential (HiPot) tests. These units also perform coil and DC motor tests, and have low-voltage circuit resistance, impedance, capacitance, phase angle, and dissipation factor/quality factor testing capabilities.

Baker DX testers are compatible with the Baker PP24, PP30, and PP40 power pack systems for very high voltage testing, and with the Baker ZTX for armature testing. The DX family is also compatible with external safety lights and emergency stop boxes.

Front Panel Controls

All Baker DX Series testers feature a large, 8-inch touch screen with a graphical user interface. Designed for rugged use in shop or field environments, the interface features a logical layout of large touch icons that improve ease of use, even with electrical gloves. The units come with a push-to-test (PTT) lock button that conveniently holds voltage during DC tests, a variable voltage knob to quickly apply voltage during coil and DC motor tests, and an easily accessible push-button emergency power shut-off switch.

Figure 1. Front Panel Controls.

	Description
1	Start, or push-to-test (**PTT**) button
2	USB port
3	High-resolution touch screen with graphical user interface
4	Emergency power shut-down button
5	Resistance, inductance, and capacitance lead port
6	Resistance, inductance, and capacitance test leads
7	Variable voltage control knob
8	Unit kV capacity
9	High voltage leads (three red, one black)

1. Start, or "Push-to-Test" (PTT) Button

The start test button (also known as the "press-to-test" or **PTT** button) works whether the Baker DX is in standalone mode, attached to a power pack, or operated with an auxiliary ZTX unit. With the Baker DX, the PTT operates with a single button press. A second press of the PTT ends a HiPot test when the PTT lock is active. When high voltage testing is underway, the PTT conveniently enables voltage discharge of the high voltage leads. For tests that require repetitive starts or long duration, a foot-operated floor switch (footswitch) is available as an option.

2. USB Printer Port

The industry standard USB port is accessible from the front panel for connections to a printing device, and may also be used as a port for data storage and retrieval devices.

3. Touch Screen Interface

A high resolution VGA color touch screen on the DX is the main user interface. Large, intuitively laid-out icons allow users to select and configure all test types and display and store test results. This screen also presents instrument configuration and report printing menus.

4. Emergency Power Shut-Off

This large, highly visible red button is easily depressed on the front panel for emergency shut-downs, and cuts all power to the unit swiftly and safely.

5. Resistance/Inductance/Capacitance Lead Port

Full Kelvin connection resistance/inductance/capacitance leads are used for testing. Both sides of the connection clips must be in contact with the terminal of the motor being measured.

6. Resistance, Inductance, and Capacitance Test Leads

Three test leads (red) and a ground lead (black) are provided for motor test connections.

7. Voltage Control Knob

Turn the knob clockwise to increase the applied voltage or counterclockwise to decrease the voltage. The rate of voltage increase or decrease is set via the touch screen interface. Do not force the knob; turning the knob harder does not cause voltage to ramp any quicker and may damage the instrument.

8. System Unit kV Capacity

Each Baker DX system is clearly marked on the front panel with its voltage capacity.

9. High Voltage Test Leads

The Baker DX uses high voltage test leads for surge, ZTX, and DC testing. You must keep the leads clean and dry for best measurement performance.

Rear Panel Connections

Figure 2. Rear Panel Connections.

	Description
1	Unit on/off switch
2	AC power cord port
3	Remote footswitch cable port
4	Power pack, ZTX port
5	External emergency stop/light connector port

Configuration Options

The Baker DX host series includes five base models: DX4 (4 kV), DX6 (6 kV), DX6HO (6 kV), DX12 (12 kV), and the DX12HO (12 kV). They have common base functions that vary by capacity. These models' capacity and capability can be augmented with easily-attached auxiliary units, such as Baker power packs that extend the output capacity up to 40 kV (PP30, PP40). You can add low impedance coil testing to the host with the Baker ZTX 101, or through a Baker power pack with built-in ZTX capability (such as the Baker PP85). Additional modularized configurations are covered in subsequent sections of this manual (see *Supplements 1* and *2*).

Optional Footswitch

You may connect the optional footswitch to the Baker DX host or to auxiliary units, and it serves to override the start (**PTT**) button on the unit. This footswitch enables greater hands-free use of the Baker DX and gives users additional operating position options during a given test.

Carrying Case

The optional carrying case provides durable protection for the Baker DX. The case has a convenient storage pocket for storing test leads and a reinforced top cover to protect the instrument front panel. The case design allows using the Baker DX while still in the case.

User Interface

The touch screen interface of the Baker DX family provides a logical, easy-to-navigate layout to conduct all tests with a minimum of user interaction. A light touch on the screen is all that is required to select an item. (**Note:** Pressing harder or rubbing on the screen will not make it respond any faster, and may even damage or place unnecessary wear on the screen.) The function icons are large enough to operate while wearing electrical gloves.

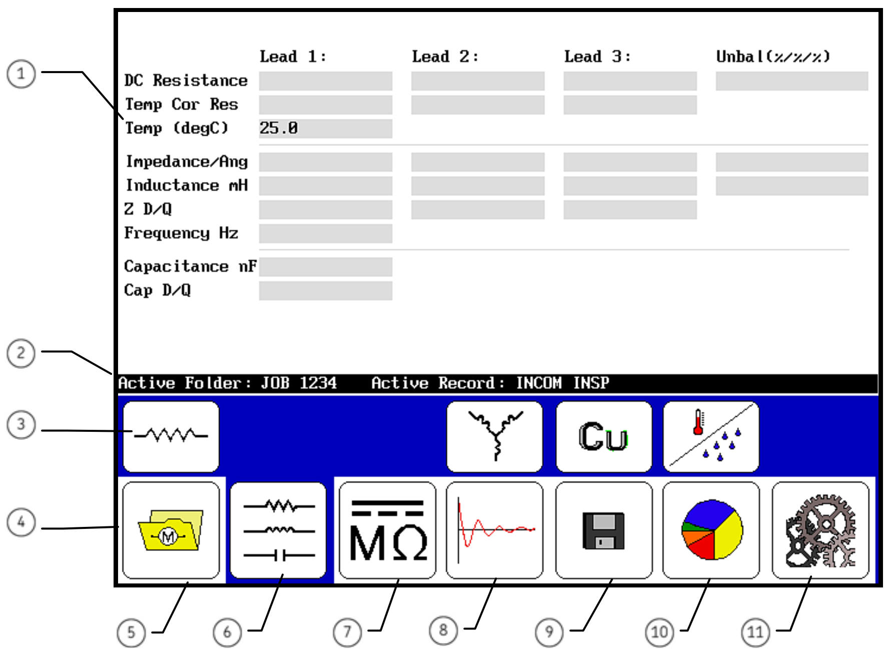


Figure 3. User Interface (Touch Screen) Orientation.

Description

1. Measurement results
2. Status bar
3. Mode submenu
4. Mode menu (always available)
5. Data folders
6. Coil Resistance/Inductance/Capacitance tests
7. DC tests
8. Surge tests
9. Data storage
10. Results/Reports
11. System settings

The large icons in the mode (main) menu at the bottom of the touch screen represent the primary test modes. The mode menu is always visible on the screen during normal operation. When a mode menu icon is selected, it will appear to lose its border (i.e., the icon will be surrounded by the blue background of the submenu above); this tells you which mode the unit is in. The control icons for each mode appear in the submenu just above the mode menu. Note that the mode submenu icons only correspond to the selected mode menu item.

2
Data Management Operations

Modes of Operation

Data Folders

Moving from left to right on the mode menu, the first mode is the data folders  icon. This section describes the data folder mode and each of its associated submenu icon functions.

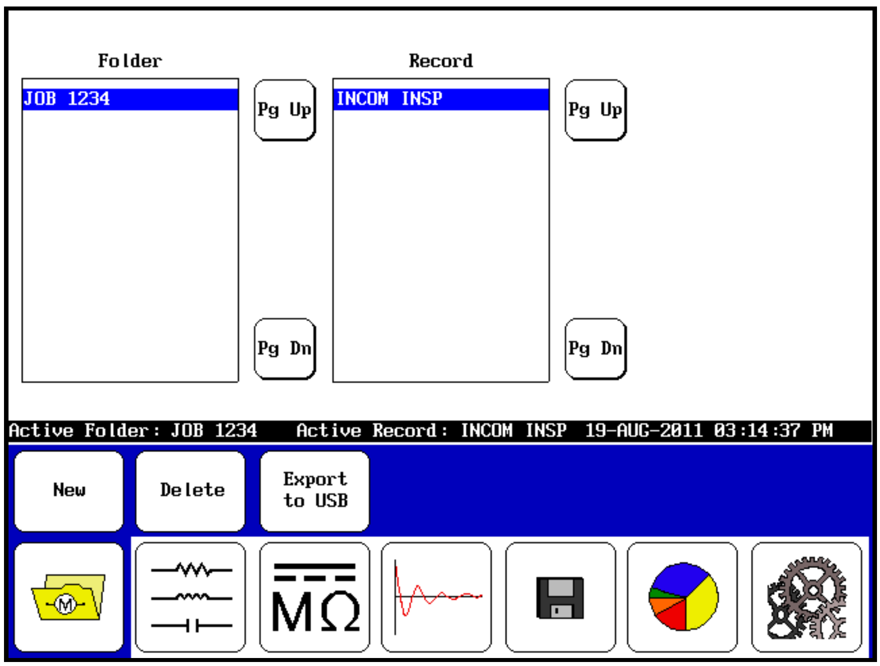


Figure 4. Data Folder Mode.

Managing Test Data

Data management functions for a given test are broken down into three areas:

1. New data
2. Existing data
3. Storage and print

Management of New Data

1. The Baker DX stores test information using a system of folders and records. To create new folders, and then the records that are stored in folders (test results), select the main mode folder icon . A set of three buttons will appear in the submenu: **New**, **Delete**, and **Export to USB**.

2. From the folder icon's submenu, press the **New** button. Two new button icons appear: **Folder** and **Record**. Folders hold records, and you cannot save records without a folder. You must create a new folder or have an existing folder highlighted in order to create and store a new record.
3. Select whether you wish to create a new folder (**Folder**) or a new record (**Record**). You can only create a new record within the active or highlighted folder if multiple folders exist.
4. In each case, a touch screen keyboard will appear to enable you to type in the folder or record name you wish to create.

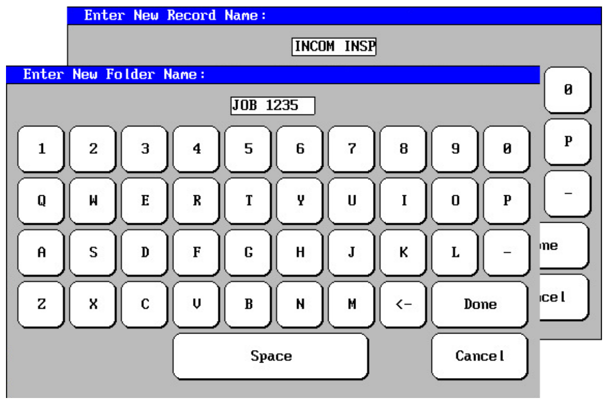


Figure 5. Touch Screen Keyboard.

5. You may name a given folder using up to 10 characters per name. After entering the folder name, press **Done**. The folder panel will then show both the newly named folder and any record you created within that folder. All records will be time stamped upon saving, so you have a record of when a given test was performed.

   Again, note that active folders and records are highlighted and that current test results are always saved in highlighted (selected) folders and records.

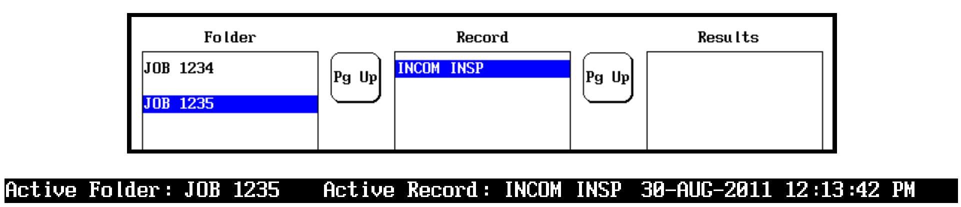


Figure 6. Active Folder and Record.

- Users should have a clear plan or policy in place before naming folders and records for test activities. A clear file naming policy makes file identification, organization, and searches much easier, and helps to avoid any potential confusion that can occur with redundant or forgotten file names.

Viewing Existing Data

1. To view any existing data, first select the folder icon  in the mode menu.
2. When you touch a highlighted folder JOB 1234, it will show all associated records within that folder in the record field.
3. Touch the report icon  and the results associated with the highlighted record display in the *Results* field.

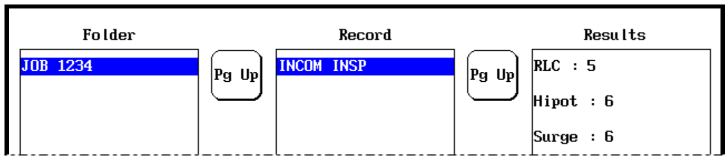


Figure 7. Record Results.

4. When you select the display icon , it displays submenu items that allow data in the results panel to be viewed according to a test, or be printed. Touch the **Done** button to return the display to the report panel as viewed in Step 3.

Figure 8. Display Submenu Items.

Deleting Data

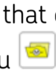
You may delete old data, but you cannot delete individual test results within a record. However, you can delete an entire record that contains the old data. Start by selecting the folder icon in the mode menu . Next, press the **Delete** button and then the **Record** button to delete the record selected. A pop-up window will prompt you to confirm your wish to delete the record.

Figure 9. Delete Record Confirmation Window.

WARNING! Deletion is immediate and permanent. Always double-check to make sure you really wish to delete **all** data within a given record.

To delete a folder, follow a similar procedure: select the folder icon in the mode menu . Next, press the **Delete** button and then the **Folder** button to delete the selected folder. A pop-up window will prompt you to confirm you wish to delete the record.

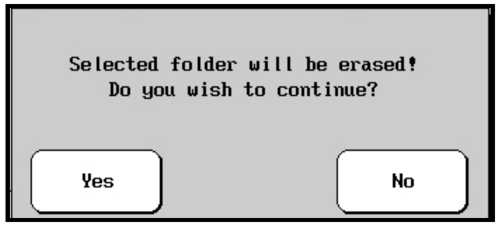


Figure 10. Delete Folder Confirmation Window.

Data Storage and Printing

1. To save data after a test, press the save icon , and then respond **Yes** to the prompt. Data always saves to the active folder and active record, or the folder/record combination that is highlighted at the time you save your data. Test results from the most recent test are protected by a prompt to save the test data, including any time a completed test is abandoned to run another test.
   - ➢ If you power off the unit before saving data, any unsaved test results will be permanently lost.

2. If printed reports are required, press the report header icon . This invokes a template or form you will use to describe the test data to be printed (see example of a completed form below). If a customer logo is required for the printout, insertion of a logo is possible; refer to the section on logo insertions below.

   a) A simple touch on any of the highlighted fields produces a touch screen keyboard. Use the keyboard to enter or edit the information fields in the form. The image below shows an image of the screen to input the *Company Name* field, using the example "Motor Rebuilders Inc." When finished typing the company name in the field, press **Done** on the keyboard and you will return to the report screen.

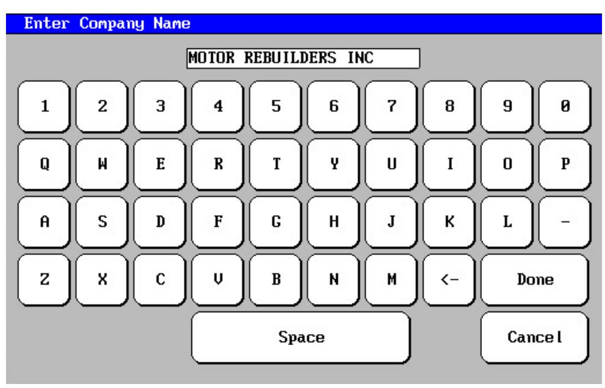


Figure 11. Touch Screen Keyboard.

   - ➢ This report header information remains unchanged as long as one remains in the report area, even if other folders or records are opened.

   b) Click **Done** on the submenu bar when the form is completed.

- **Note:** When moving to different records or folders, be sure to press the **Clear All** button to ensure the report header field is not populated with old or inaccurate information.

3. **Inserting a customer logo in reports:** The Baker DX can store a customer's logo for printing on test reports. When a customer requires a logo on a test report, use the form described above and insert an "X" in the **Include Logo** box. If a customer does not wish to have a company logo on the report, simply leave the box unchecked and skip to Step 4 below.

   a) Acquire the customer logo file and save it on a PC. It must be 100 pixels wide by 100 pixels high, so you may need to resize your logo before you proceed. You can resize or edit a logo image using the photo editor of your choice, but it may also be resized by simply using Microsoft Paint. On a Windows PC, open **MS Paint > Image > Stretch &/or Attributes > Save *.bmp**.

   b) Next, if you haven't done so already, load the utility software **DXUtility** (which you can obtain from the Baker DX documentation CD, or from the SKF website: http://www.bakerinst.com) and save it in an easily accessible location on your PC. Once you have loaded and opened the utility program, connect a USB flash drive or other portable USB memory device to your PC.

   c) Click the **Load Logo Bitmap** button. Browse to and select the logo file from your PC, click **Open**, and then click the **Create DX Logo** button.

Figure 12. Load Logo Bitmap Button.

   d) The file will be named "Logo" and stored in the root directory on your PC's C:/ drive. Copy or move the image file to the USB drive, then remove the device and insert it into the USB port on the front panel of the Baker DX. Wait for the transfer to complete.

   e) Now press the report icon, select display, remove the USB drive and connect a USB printer to the port. Click the **Print** icon, then check the printout to see if the logo was correctly installed (Step 4 below).

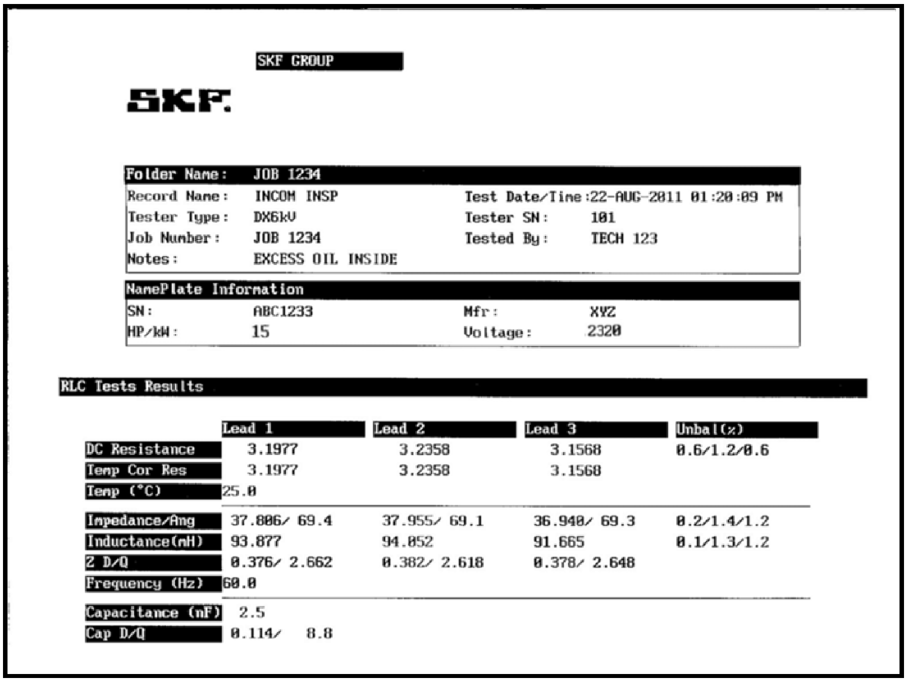
      - Any time the new information is reentered, be sure that the logo box is checked before clicking **Done**.

4. To print data, select the folder and record that is to be printed (remember, selections are highlighted).

   a) Once the data is loaded, press the report icon and then press the display icon.

b) Connect a USB printer to the USB port (installation of a printer driver is not necessary). When the printer is powered on and ready, press the **Print** button.

c) The report will print with an SKF logo just to the left of the company name, as illustrated in the following printed report example.



SKF GROUP

SKF

Folder Name:	JOB 1234		
Record Name:	INCOM INSP	Test Date/Time:	22-AUG-2011 01:20:09 PM
Tester Type:	DX6kV	Tester SN:	101
Job Number:	JOB 1234	Tested By:	TECH 123
Notes:	EXCESS OIL INSIDE		

NamePlate Information			
SN:	ABC1233	Mfr:	XYZ
HP/kW:	15	Voltage:	2320

RLC Tests Results

	Lead 1	Lead 2	Lead 3	Unbal(%)
DC Resistance	3.1977	3.2358	3.1568	0.6/1.2/0.6
Temp Cor Res	3.1977	3.2358	3.1568	
Temp (°C)	25.0			
Impedance/Ang	37.806/ 69.4	37.955/ 69.1	36.940/ 69.3	0.2/1.4/1.2
Inductance(mH)	93.877	94.852	91.665	0.1/1.3/1.2
Z D/Q	0.376/ 2.662	0.382/ 2.618	0.378/ 2.648	
Frequency (Hz)	60.0			
Capacitance (nF)	2.5			
Cap D/Q	0.114/ 8.8			

Figure 13. Report Example.

- For users of Hewlett-Packard printers, support includes those HP printers that use the Hewlett-Packard PCL 3 printer language/ command set. Any printers purchased for export outside the U.S. should be purchased as an export printer, to ensure they come with HP's international warranty.

How to Export Screen Captures

When viewing results after pressing the report icon, screen shots of the display can be saved to a USB drive inserted into the USB port. To do this, view the subject result screen and then:

1. Press the red Emergency Stop button and rotate it to release. Wait for the file to save, and then press **OK**.
2. When you finish collecting desired screen shots, remove the USB drive and insert it into a PC. Acquire the utility **DXB Viewer** from the Baker DX product documentation CD or the SKF website (http://www.bakerinst.com) and install it on your PC where you can easily access it.
3. Execute the **DXUtility**, click the **Load DX Image** button and browse to the USB drive where the screen shots are stored (they should be identifiable as "dated and serialized .dxb" files). Next, select the **Save Image As** button to rename the file and store the file where you wish to on your PC.

3
Performance of Tests, Sequences and Applicable Standards

Tester Initial Operation/Overview

Positioning of Equipment

- ➢ Do not position equipment in such a way that it is difficult to operate the device itself, the equipment being tested, or any nearby equipment.

Safety Precautions for Setup

- There are no specific ventilation requirements for the Baker DX. 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.
- Never stack objects of any kind on or near the Baker DX.
- Avoid placing the unit on other items; use a level, clean, empty shelf, bench, or table space.
- To prevent shock hazard, do not expose the Baker DX to rain, snow, or moisture. Avoid locations with high levels of dirt or dust.

The unit may be oriented for operation in the following positions:

- Laid flat, with the bottom of the unit to a flat, level bench, cart, or table surface.
- Upright with the front panel facing upward.
- Held at an angle using the rotating handle with face panel upright (not upside down).

Setup Requirements

- Place the Baker DX directly on a large table, bench, or cart (do not place atop other equipment, paper, books, etc.). Prior to attaching a power plug to any power source, check the power switch at the rear of the unit and make sure it is in the **Off** position.
  - ➢ The power switch and cord connector are located on the instrument's rear panel.
- Plug the female (device) end of the Baker DX power cord into the connector on the rear of the unit. Next, plug the other end of the power cable into a grounded wall socket. The unit operates between 85 and 264 V AC, 50/60 Hz.
- Switch the unit on by turning the power switch at the rear panel of the unit to the **On** position. The device will then boot to the main operations screen and be ready for use.

Recommended Testing Sequence

In order to test motors adequately and to have effective predictive maintenance programs, SKF recommends the following test sequence to achieve the best results. The general idea is to perform a sequence of progressively more rigorous tests, adopting 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 recommended testing sequence is:

- Resistance, inductance, capacitance/impedance test
- DC (insulation resistance, insulation parameters, DC-HiPot) tests
- Surge tests

Performing Coil Resistance, Inductance and Capacitance Tests

Background

This unit performs coil resistance tests using low voltages (with low voltage leads). A coil resistance test looks for resistance imbalance between phases, discrepancies between measured resistance values, previous measurements, and nameplate values. Further DC-HiPot or surge testing is not necessary until the coil resistance measurement is acceptable.

With coil inductance tests, the Baker DX looks for imbalances between the coil phases and variations from previous values. The analyzer performs these tests at multiple frequencies. Note that in an assembled motor, the rotor's position will influence the stator coil inductances. When looking for imbalances and comparing to previous values, be sure to take into account the rotor position, or remove the rotor to eliminate the effect.

This analyzer also performs capacitance readings at multiple frequencies, and measures the capacitance and impedance of the stator coils to ground across the ground wall insulation. With the Baker DX, you can compare the capacitance value to previous values, and the impedance's phase angle can provide an early indication of insulation degradation if the phase angle deviates too much from 90 degrees.

For more information, refer to *Chapter 4* of this manual, which goes into much greater detail about this unit's resistance testing capabilities and methods.

Resistance, Inductance, Capacitance Testing Procedure

Resistance Test

WARNING! You can damage resistance test circuitry if resistance test leads are connected to a line voltage, connected to high voltage, or element exposed to a DC or surge test. **Disconnect and lay aside the high voltage test leads when performing any RLC tests.**

Before you begin to connect leads to a motor for any test, collect information about the motor you wish to test (e.g., motor plate information). We highly recommend you do this in order to efficiently set up the test and to ensure you compile accurate test records.

We recommend the following test sequence for the RLC (resistance, inductance and capacitance) mode:

1. Connect the RLC test leads to each of the motor leads; motor lead No. 1 connects to test lead No. 1, etc.

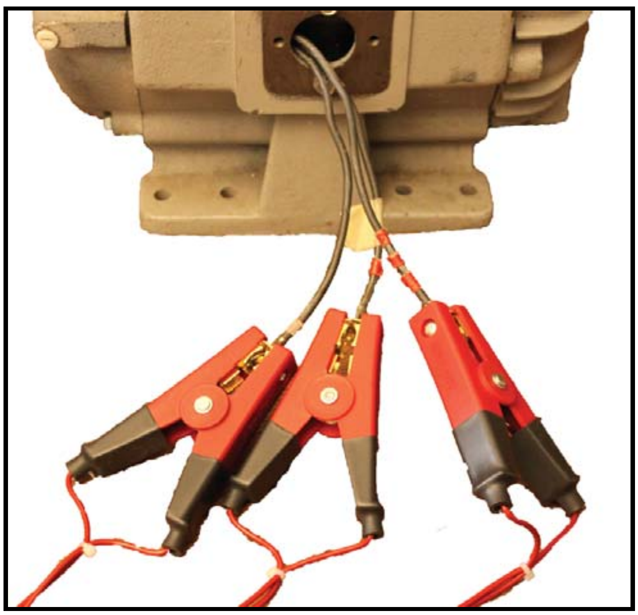


Figure 14. Connect RLC Test Leads to Motor Leads.

2. Highlight/Click on the folder and record to use and check the status bar to ensure that it is the **Active Folder** and **Active Record** intended for the subsequent RLC tests.

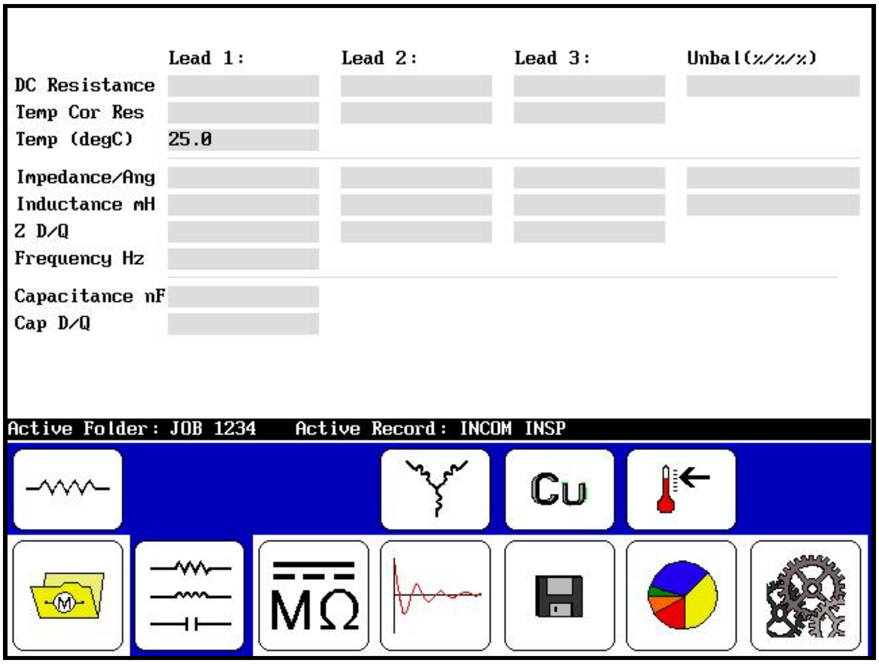


Figure 15. Active Folder and Active Record Displayed.

3. Select the RLC test mode icon .
4. Select the resistance test icon .
5. Select the winding configuration icon: wye or coil .
6. If performing temperature compensation, select one or the other type of conductor metal icon: aluminum Al or copper Cu.
7. For temperature compensation, press the temperature icon (otherwise, continue to Step 9), then use the pop-up keypad to input actual temperatures.

Figure 16. Pop-up Keypad.

8. The default temperature is 25 °C; key in the actual temperature to calculate compensation and click **Done**.
9. Press and release the start button (**PTT**) to run the resistance test. The “Leads Energized” message will appear at the top of the display. When the test finishes, the unbalance will display in the results.

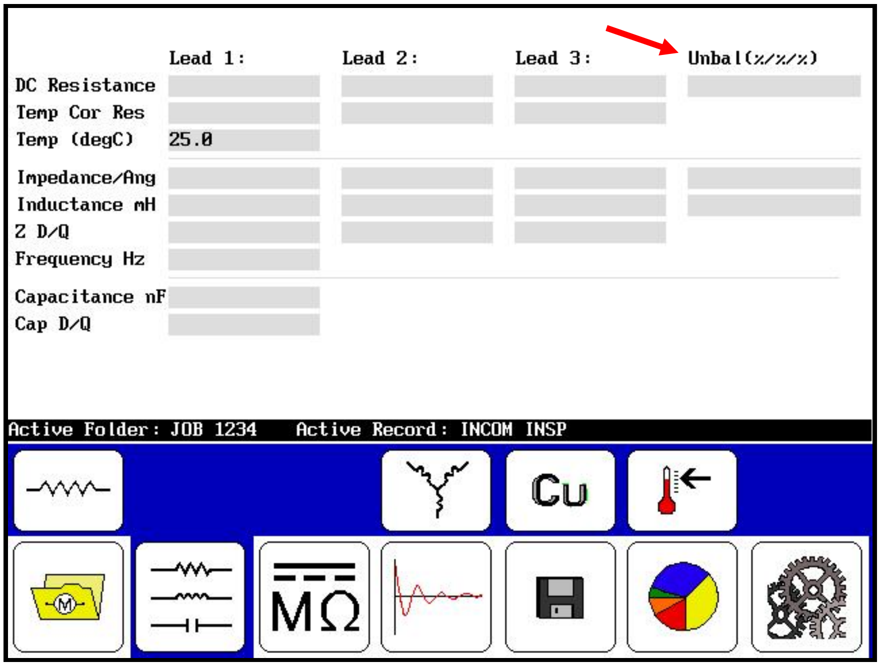


Figure 17. Unbalance Results.

10. If this resistance test was run as a standalone test, you should save the results. Saving resistance data at this time is not necessary if you are to collect inductance and/or capacitance tests data as well; then you can save all together.
    - ➢ If you require another resistance test, running this test again will overwrite the current results unless you save it.

Inductance, Impedance, Phase Angle, D/Q Tests

With coil inductance tests, the Baker DX looks for imbalances between the coil phases and variations from previous values. The analyzer performs these tests at multiple frequencies. Note that in an assembled motor, the rotor's position will influence the stator coil inductances. When looking for imbalances and comparing to previous values, be sure to take into account the rotor position, or remove the rotor to eliminate the effect. **This procedure will start from where the resistance test was completed.** Lead cautions still apply and connections must remain the same as for the resistance test described in the previous section.

1. Ensure the same connections as for the resistance test leads.
2. Highlight/Click on the folder and record to use, or check the status bar to ensure it is the **Active Folder** and **Active Record** intended for the subsequent inductance tests.

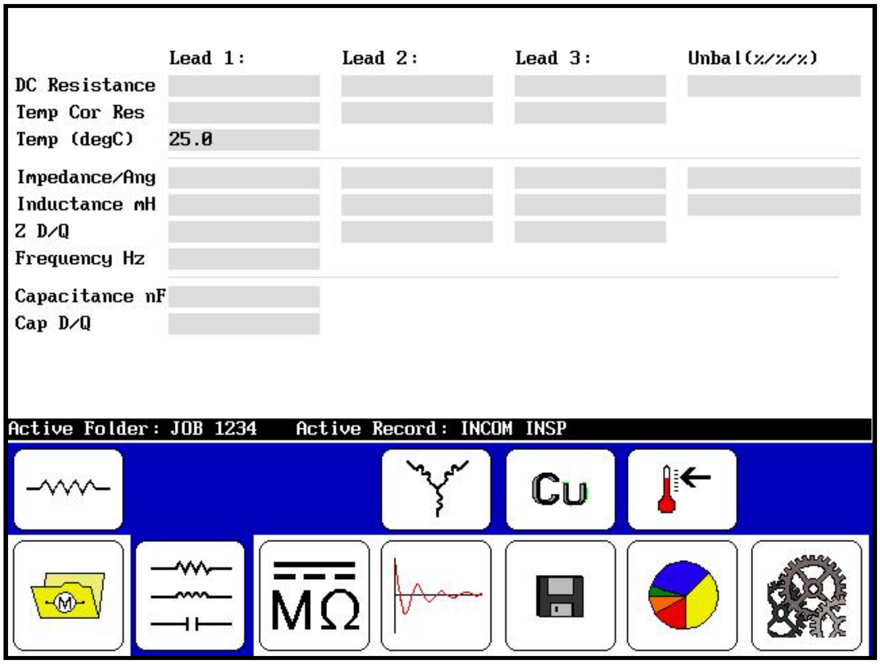


Figure 18. Active Folder and Active Record Displayed.

3. Select the RLC test mode icon (skip this if you just performed the resistance test described in the previous section).
4. Select the inductance test icon .
5. Select the **60 Hz** frequency icon , and then one frequency
6. Press the start button (**PTT**) to run the inductance test. The “Leads Energized” message will appear at the top of the display. When the test finishes, the results and unbalance will display on the screen.

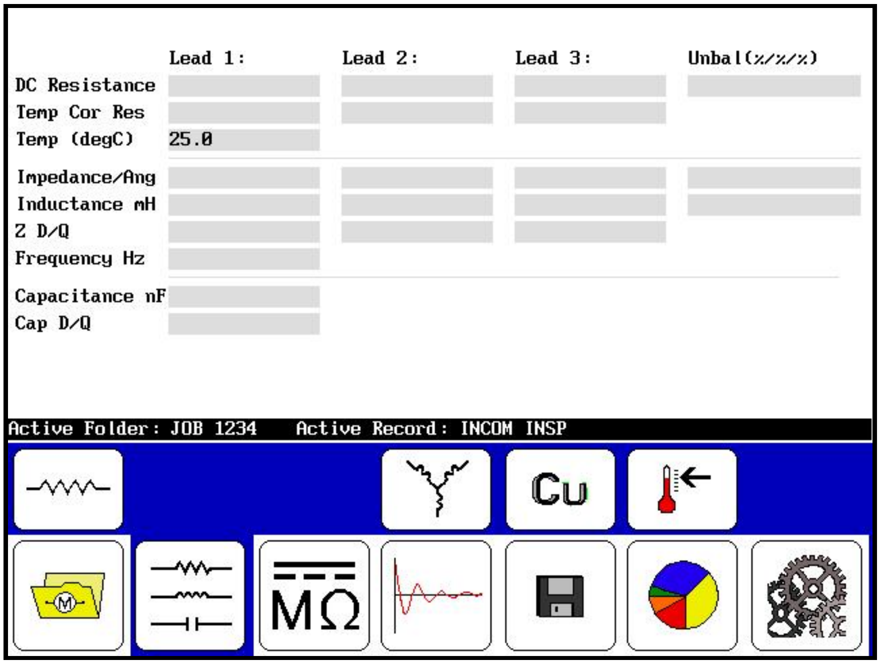


Figure 19. Unbalance Results.

- Be sure to save the tests you want to report. If you require another inductance test, running this test again will overwrite the current results unless you save it.

Capacitance Test

This analyzer also performs capacitance readings at multiple frequencies, and measures the capacitance and impedance of the stator coils to ground across the ground wall insulation. With the Baker DX, you can compare the capacitance value to previous values, and the impedance's phase angle can provide an early indication of insulation degradation if the phase angle deviates too much from 90 degrees.

This procedure will start from the end of the inductance test, but can start from the end of the resistance test as well. Lead cautions still apply, but **you must modify connections. Attach lead No. 1 to coil No. 1, and attach lead No. 2 to ground. You must disconnect lead No. 3 for this test.**

1. Connect the RLC test leads to a new configuration. Connect RLC test lead No. 1 to any motor lead. Connect RLC test lead No. 2 to ground. Disconnect RLC test lead No. 3 **and leave disconnected**.

Figure 20. Connect RLC Test Leads to a New Configuration.

2. Highlight/Click on the folder and record to use and check the status bar to ensure that it is the **Active Folder** and **Active Record** intended for the subsequent capacitance tests.

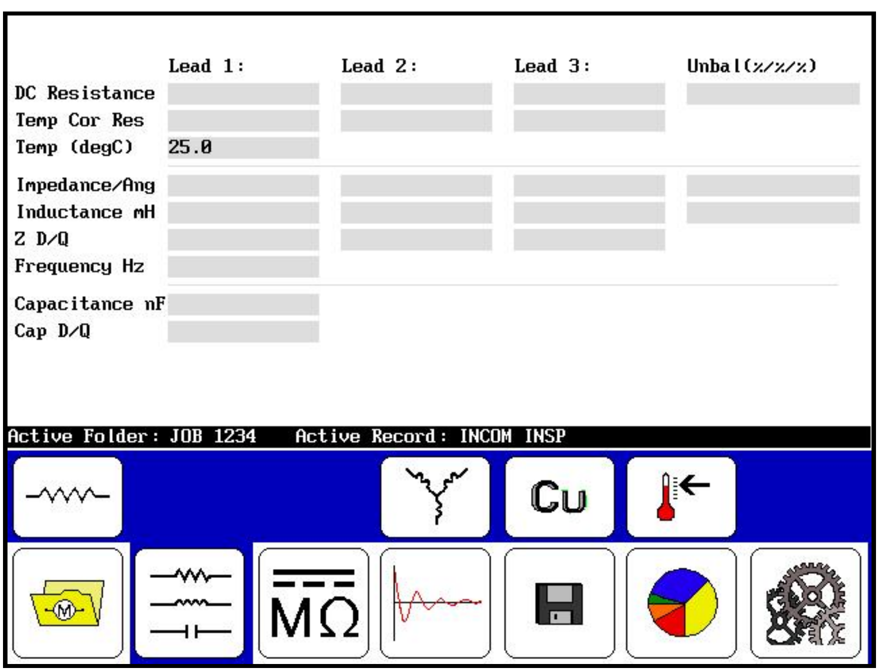


Figure 21. Active Folder and Active Record Displayed.

3. Select the RLC test mode icon .
4. Select the capacitance test icon .
5. Select the **60 Hz** frequency icon and then one frequency .
6. For temperature compensation, press the temperature icon (if neither is desired, continue to Step 8), and then use the pop-up keypad to input the actual temperature.

Figure 22. Pop-up Keypad.

7. The default temperature is 25 °C; key in the actual temperature to calculate compensation and click **Done**.
8. Press and release start button (**PTT**) to run the capacitance test. The "Leads Energized" message will appear at the top of the display. When the test finishes, the data will display in the capacitance results.

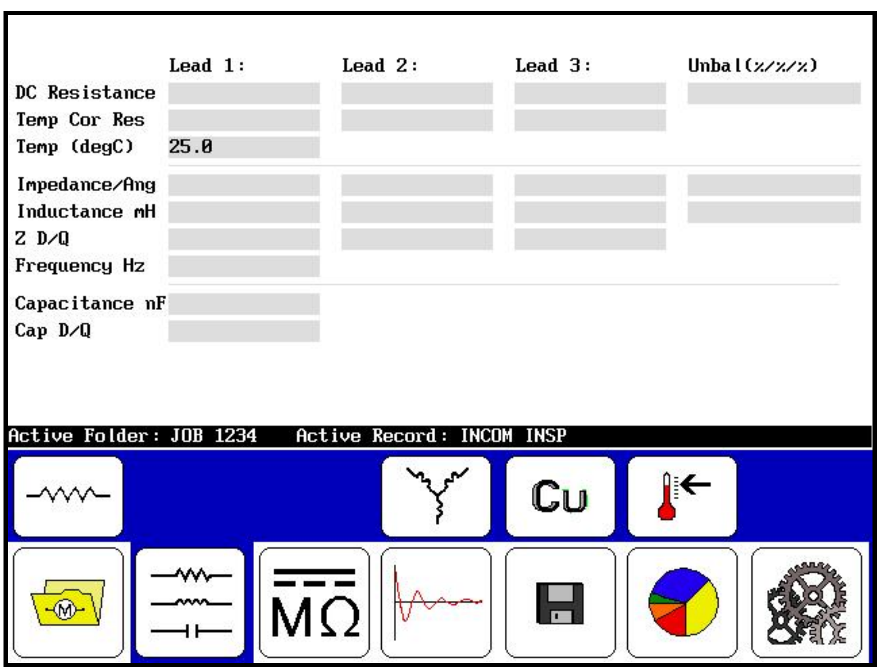


Figure 23. Capacitance Results.

9. Save data at this point, unless you will conduct subsequent capacitance tests (data will save to the active/selected folder). **The next test will overwrite unsaved test data.**

    a) Check to be sure that the active folder and/or active records are the intended location(s) for the test data.

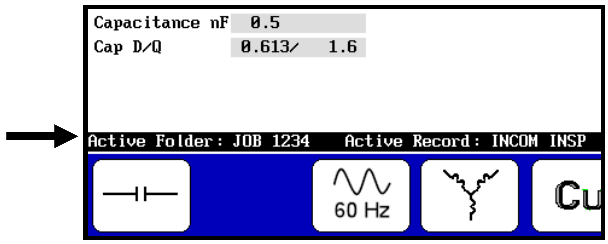


Figure 24. Active Folder and Active Record for Test Data.

    b) Select the save icon and select **Yes** to the Confirmation Window.

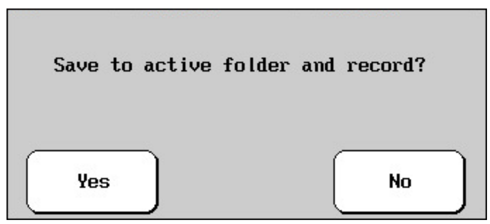


Figure 25. Save to Active Folder and Record Confirmation Window.

Performing DC Tests

Insulation Resistance (IR), Dielectric Absorption (DA), Polarization Index (PI), Step Voltage, DC High Potential (HiPot)

Background

DC tests of electric motors help determine the integrity of the ground wall insulation of a motor's coil. Ground wall insulation consists of wire insulation, slot liner insulation, wedges, varnish, and sometimes phase paper.

The DC tests performed by the Baker DX include insulation resistance (IR), DC-HiPot tests, DC step voltage, and Polarization Index (PI or DA) tests. The design of each type of test is to answer a specific question regarding the properties or integrity of the ground wall insulation system. The following example includes procedural details.

You should always begin DC testing with a megohm test, using a test voltage based on the motor's operating voltage and the appropriate standards/company testing guidelines. Look for an unusually low megohm value when compared to previous measurements or industry accepted limits for the type of insulation in the motor. If a low megohm value is measured, inspect the motor for ground wall insulation damage or if some part of the ground wall insulation has failed. Possible problems include the following:

- Either the slot liner insulation or enamel wire insulation may be burned or damaged.
- The motor might be full of dirt, carbon dust, water, or other contaminates.
- Connections to the actual coils may be bad.
- The wrong insulation may have been used to connect the coils to the motor's junction box.

No further testing is viable until you find the reason for low megohm readings and make any necessary corrections.

For more detail, refer to *Chapter 5*, which has supporting information and details about DC testing capabilities and methods.

WARNING! You can damage resistance test circuitry if resistance test leads connect to a line voltage, or connect to high voltage or anything exposed to a HiPot or surge test. **Disconnect and lay aside the resistance test leads.**

WARNING! DC tests of high-voltage motors (> 400 V DC) will be automatically discharged when releasing the start/**PTT** button (unless PTT lock is active). Wait for discharge to reach zero before removing any leads.

Before you begin to connect leads to a motor for a test, collect and save information about the motor you wish to test (e.g., motor plate information). We highly recommend you do this in order to efficiently set up the test and to ensure you compile accurate test records.

The following procedure uses all of the data collection capability of this test to produce a comprehensive set of condition analysis data. You can perform specific tests when desired.

1. Connect the test ground lead to motor ground. Attach motor leads to test leads No. 1, No. 2, and No. 3, respectively.

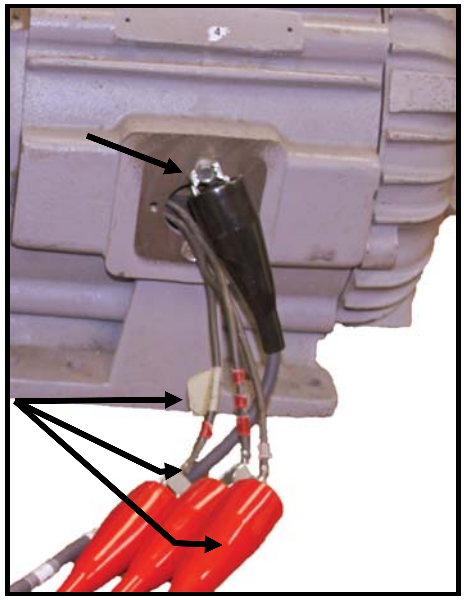


Figure 26. Attach Motor Leads to Test Leads.

2. Highlight/Click on the folder and record to use and check the status bar to ensure that it is the **Active Folder** and **Active Record** intended for the subsequent DC tests.

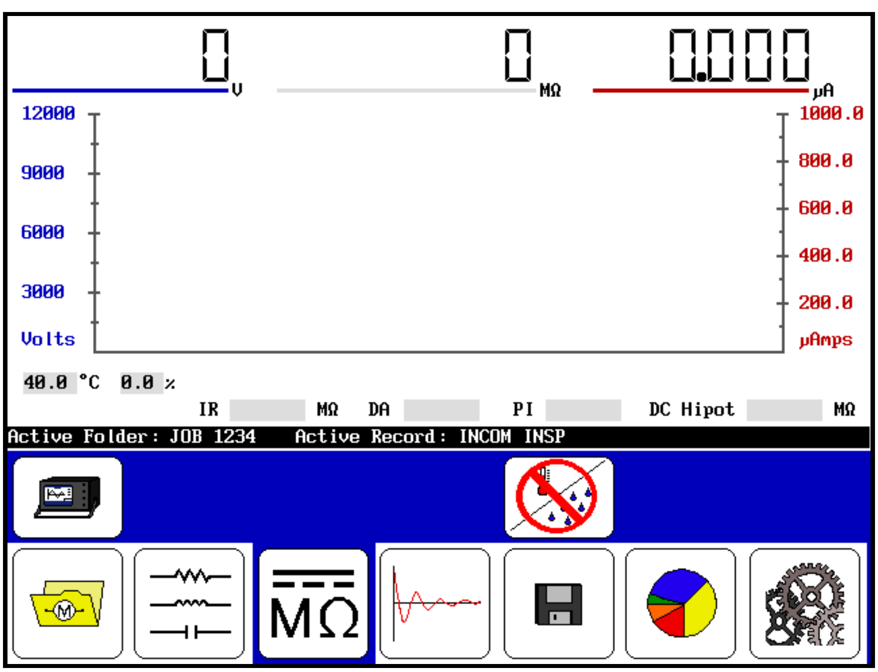


Figure 27. Active Folder and Active Record Displayed.

3. Select the DC/megohm icon. The configuration options icon will appear in the submenu; select it. Any icons that indicate installed options will appear, presenting a choice of operation as a standalone unit or with a power pack unit. If an optional interface board/option is **not** installed, the following message appears.

Figure 28. "No External Interface Options Installed" Message.

4. To use the following example, select the configuration options icon (optional configurations will be addressed in supplemental instructions later in this manual).

5. To temperature compensate and/or record humidity, click the icon or skip to Step 6.

   a) Select the temperature icon. The default temperature is 40 °C; key in the actual temperature to calculate compensation and click **Done**.

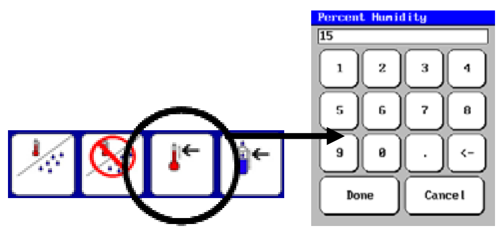


Figure 29. Temperature Icon and Pop-up Keypad.

   b) For reference purposes, enter the humidity by selecting the humidity icon. Key in the humidity percentage and click **Done**.

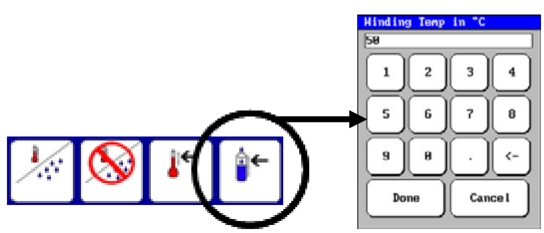


Figure 30. Humidity Icon and Pop-up Keypad.

6. Because this is a comprehensive test, you must predetermine the necessary values to input during the test before the test start (refer to *Appendix D, Recommended Test Voltages – DC Tests and Surge Tests*).

   - The value for the IR, DA, and PI tests would be operating or line voltage V_{LL}, and for this example that would be 960 volts (atypical).

   - The value for the DC-HiPot would be $2x(V_{LL}) + 1{,}000 = 2{,}920$ volts for this example.

   - The increments for the DC step voltage would be (2,920 – 960) = 1,960, so three increments is rather limited. Use five: 1,960/5 = 392 or ~400 v. The increments for the step DC-HiPot would then be 1,360 v, 1,760 v, 2,160 v, and 2,560 v, and to run a final DC-HiPot, set the voltage at 2,960 v.

7. Push and hold the start (**PTT**) button and the following controls appear.

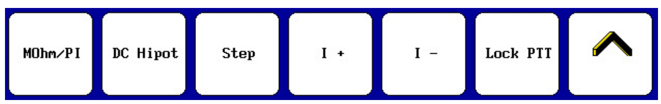


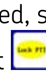
Figure 31. Test Submenu Items.

As a matter of best practice, perform the following steps in quick succession:

- Press the desired speed control icon  and select fast .

- Rotate the voltage control knob on the front of the panel to raise the voltage level to as close to 2,300 volts as it can get. Switch back to the slow control, if necessary, to quickly fine tune the level to 2,300 volts.

- Select the **MOhm/PI** icon to start the megohm insulation resistance (IR), dielectric analysis (DA), and polarization index (PI) tests.

- If hands-free testing is desired, select the **Lock PTT** icon. When the icon changes to a yellow highlight , release the start (**PTT**) button.

- The yellow highlights convey that the controls are locked in. The submenu will now look like the following while the tests are running:

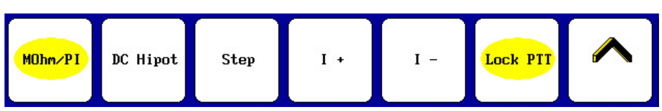


Figure 32. Test Submenu Items with Yellow Highlights.

Select the **I+/I-** icons as needed to adjust the current's scale.

➢ The status bar displays a countdown timer for each of the megohm, step-voltage, and standard DC-HiPot tests.

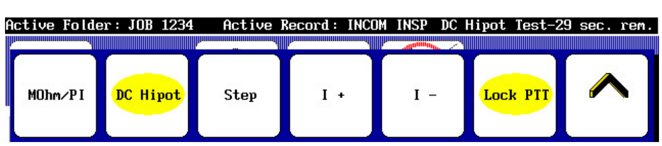


Figure 33. Status Bar with Countdown Timer.

Also, as each test progresses, the screen above the status bar displays the IR results after 60 seconds, the DA results after 180 seconds, and the PI test after 600 seconds. The test status ("Test Complete") performs a megohm test of the counter after the completion of a test.

8. Next, initiate a step voltage or DC-HiPot test following the PI test.

    - Select the speed control fast or slow icons as desired, then use the front panel voltage control knob to set the voltage to the next step. Select the **Step** icon to program/set a 30-second test. Repeat the steps until you achieve the desired voltage.

        - ➢ These incremental steps have the advantage of quantifying the voltage at which a specific HiPot test failed compared to the pass/fail results of the standard DC-HiPot test.

9. The final test can be a standard DC-HiPot test to supplement the results of the last step HiPot test.

    - Select the speed control fast or slow icons as desired, then using the front panel voltage control knob, set the voltage to the desired DC-HiPot voltage.

    - Select the **DC-HiPot** icon to program/set a 60-second test .

10. When the test is complete, **push the start (PTT) button, and allow the unit to discharge completely before disconnecting test leads.**

    - ➢ The HiPot over-current trip indicator detects any arc-over in the insulation and puts an immediate stop to testing in the event of such an arc. The over-current trip will remove the high voltage from the test leads, stop the test, and display a HIPOT TRIP message on the front panel display. If you press the **Test** button, it resets the trip circuitry, removes the HIPOT TRIP message, and readies the tester for a new test.

11. Select the save icon to save the test results to the active folder and active record.

12. View the test results through the report , display , and **DC Tests** icons, and by using the submenu icons to find and view the results.

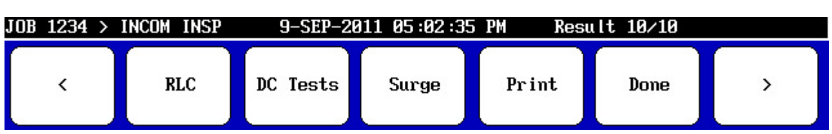


Figure 34. Submenu Icons.

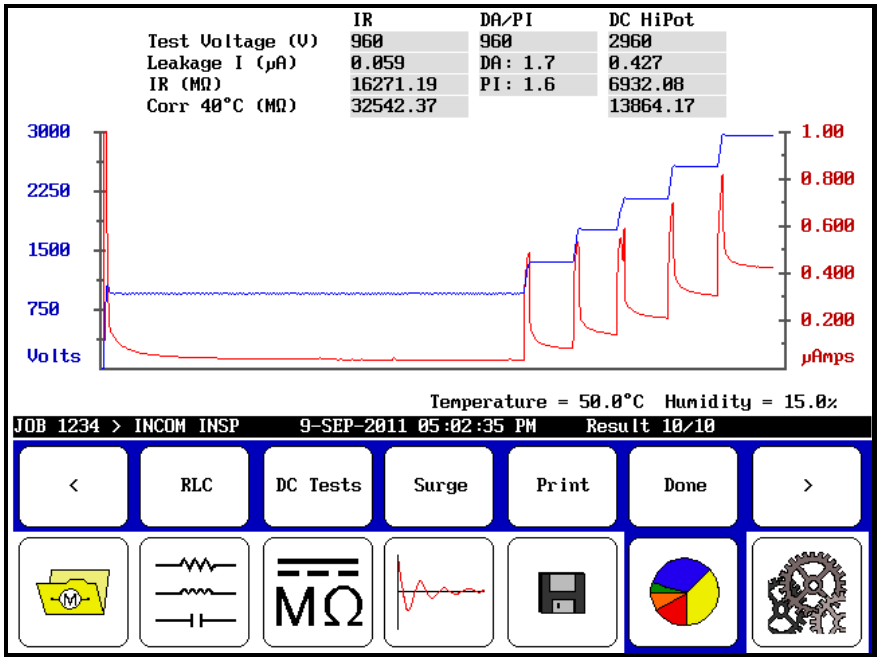


Figure 35. Test Results.

Each of these demonstrated DC tests were chained together in a recommended best-practice approach, but you may separate and perform them individually or in other combinations as required or desired.

Performing Surge Tests

Background

Surge testing detects insulation damage between the turns of a motor's winding. We cannot discern this type of insulation problem by any method other than a surge test. Surge tests involve the application of a short, high, and fast-rising current impulse to a winding. This impulse will induce (per Lenz's Law) a voltage difference or delta between adjacent loops of wire within the winding. If the insulation between the two loops of wire is damaged or somehow weakens, and if the voltage difference between the wires is high enough, there will be an arc between the wires. The Baker DX can detect arcs by observing a shift in the surge waveform produced by the test.

The surge test performs with an impulse generator and an oscilloscope type display on the Baker DX touch screen to observe a surge waveform in progress. The surge waveform is a representation of the voltage present across the test leads of the tester during a test. The indication of a turn-to-turn fault is a shift to the left and/or a decrease in amplitude of the surge test waveform as the test voltage increases.

The Baker DX can perform multiple surge tests. A common test is a test of multiple coils configured into windings. Another common test involves evaluation of an individual coil. Others include tests of field and armature coils. Refer to *Chapter 6* for more information and details on surge testing capabilities of the Baker DX.

WARNING! You can damage resistance test circuitry if resistance test leads connect to a line voltage, or connect to high voltage or anything exposed to a HiPot or surge test. Disconnect and lay aside the resistance test leads.

WARNING! You must discharge DC tests of high voltage motors (> 400 V DC) by pushing the **PTT** button and waiting for discharge to reach zero before removing any leads. In addition, you must ground one motor lead for at least four times the test time to allow any charge from depolarization to dissipate.

We recommend you collect information from or about the motor at this time in order to efficiently set up the test and for accurate records completion.

Motor Winding Tests

This test involves multiple winding configurations and multiple coils.

1. Connect the motor ground to the test ground lead. Connect motor leads to test leads No. 1, No. 2, and No. 3, respectively.

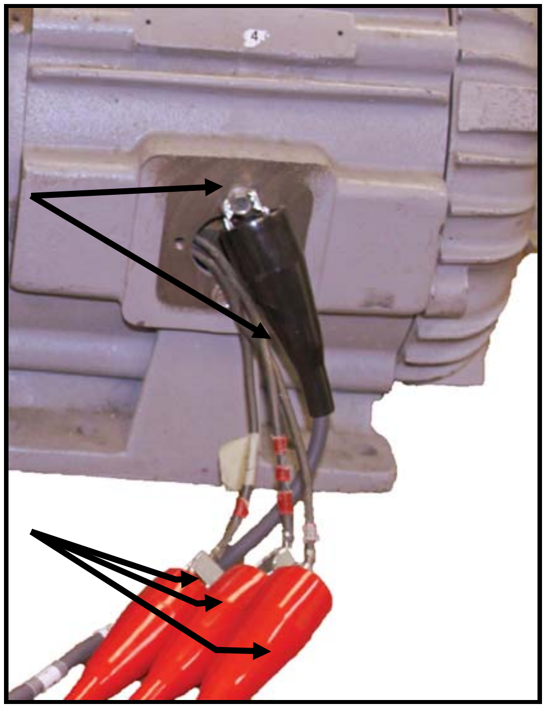


Figure 36. Attach Motor Leads to Test Leads.

2. Highlight/Click on the folder and record to use and check the status bar to ensure that it is the **Active Folder** and **Active Record** intended for the subsequent DC tests.

3. Select the Surge icon . This brings up the initial surge test screen, as seen below, where the first submenu item is the configuration options icon .

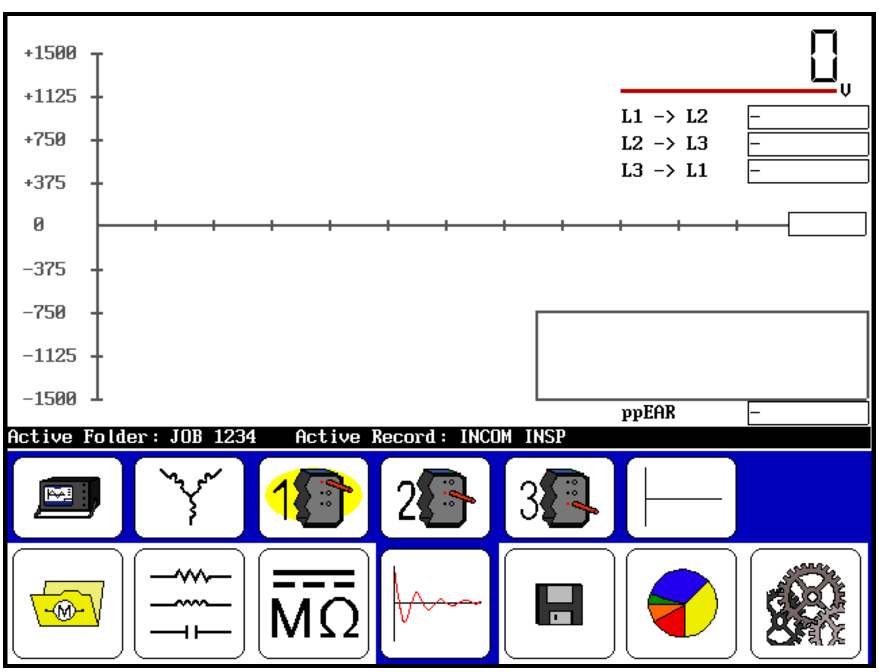


Figure 37. Initial Surge Test Screen.

Selection of the configuration options icon indicates any options that may be installed, such as operation as a standalone unit, with a power pack, with a ZTX, or with a power pack containing a built-in ZTX. If optional interface boards are **not** installed, the following message appears:

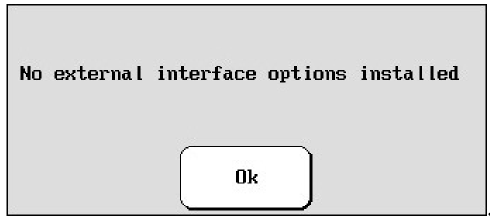


Figure 38. "No External Interface Options Installed" Message.

For the following example, select the icon (optional configurations will be addressed in supplemental instructions later in this manual).

4. Select the winding configuration icon to bring up the different configurations submenu. You will then select from a choice of tests: wye three-phase, single coils, field coils, and armature coils.

   In this example, select the wye icon (other optional configurations are addressed in supplemental instructions later in this manual).

5. The configurations of coils icons default to coil No. 1 to start the test. If the motor is a single-phase motor, only the first coil will be tested.

6. You must predetermine the input values for the test before the test start. Refer to *Appendix D* for recommended test voltages for DC-HiPot and surge tests. The operating voltage is the basis for the test voltage V_{LL} = 960 volts:

   - The value for the surge test would be 2x(V_{LL}) + 1,000 = 2,920 volts for this example.

7. Press and hold the start (**PTT**) button, and the following scale control icons will appear.

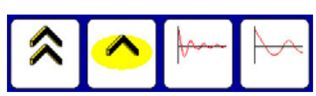


Figure 39. Scale Control Icons.

Alternately use the speed control (fast/slow icons) to control the rate of scaling while rotating the voltage knob to set the test voltage. Use the time base icons to scale the horizontal axis.

8. If the winding is a wye or delta configuration, select coil No. 2 and repeat Step 6 and repeat for coil No. 3.

   ➢ The maximum *ppEAR* box will highlight in red if it exceeds this criteria. This criterion is set to a default in the user setting, but you can change it to different criteria.

9. The completion of winding tests of a wye or delta configuration will appear, as shown below. You can save results at this time or perform other tests before saving. You can clear all test results by using the clear icon .
   - ➢ Selecting the clear icon immediately and permanently deletes all data and the reference test.

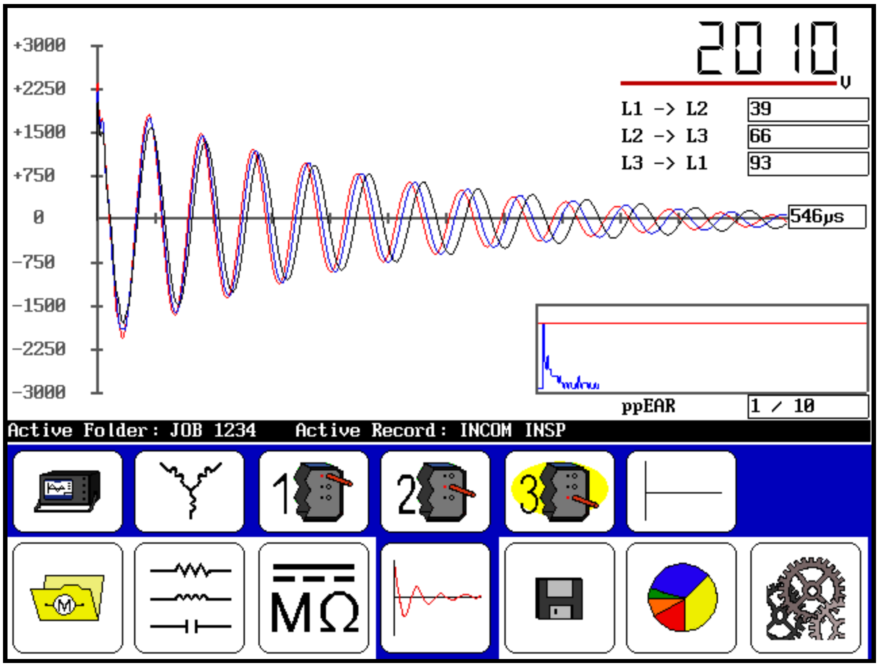


Figure 40. Completion of Winding Test.

Single Coil Testing

The focus is on a succession of coils that are to be the same and starts with a known "good" coil or reference from which to make comparisons.

1. Connect test lead No. 1 to coil lead 1 and test lead No. 2 to coil lead 2. Test lead No. 3, No. 2, and ground are all at ground.

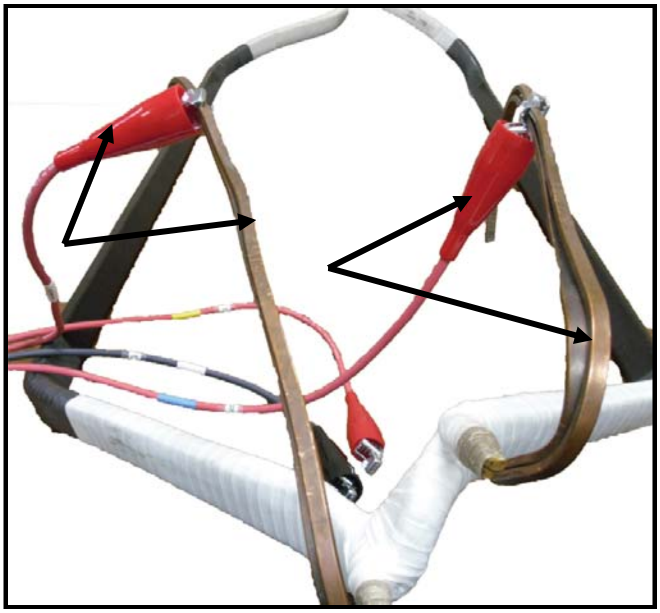


Figure 41. Connect Test Leads to Coil Leads.

2. Highlight/Click on the folder and record to use and check the status bar to ensure that it is the **Active Folder** and **Active Record** intended for the subsequent DC tests.

3. Select the winding configuration icon  to bring up the different configurations that test wye three-phase, single coils, field coils, and armature coils.

   Select the coil icon  for purposes of instruction (optional configurations are addressed in supplemental instructions later in this manual).

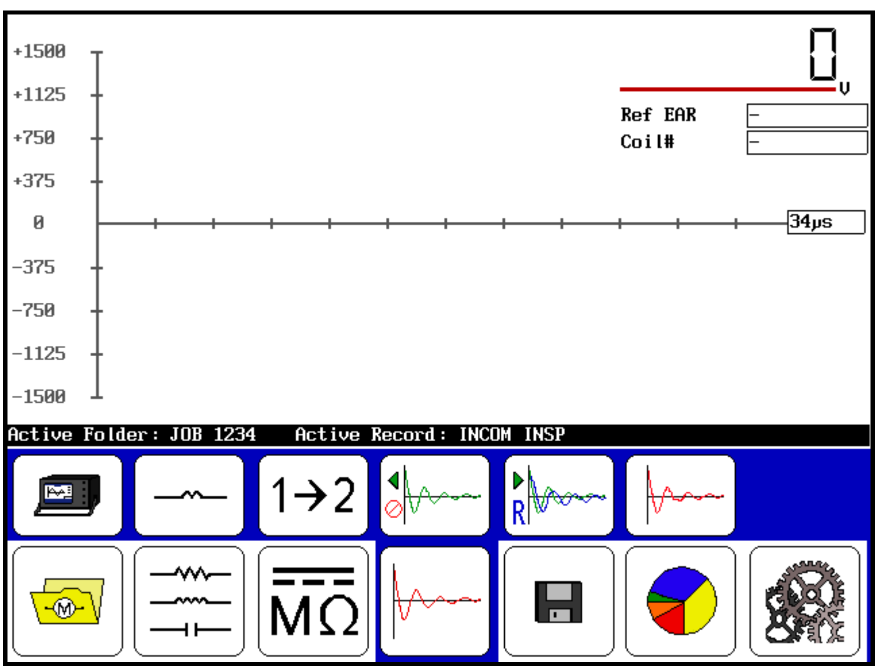


Figure 42. Single Coil Testing.

4. Be sure that the first coil connected in the series of coils is the coil you will use as the reference for comparison.

5. Press and hold the start (**PTT**) button and the following scale control icons will appear.

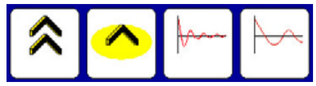


Figure 43. Scale Control Icons.

Alternately use the speed control fast/slow icons to control the rate of scaling while rotating the voltage knob to set the test voltage for the series.

Use the time base icons to scale the horizontal axis. Release the start (**PTT**) button.

6. Select the reference icon, then the **ZS Override** icon, and then click **Yes** when the following message appears:

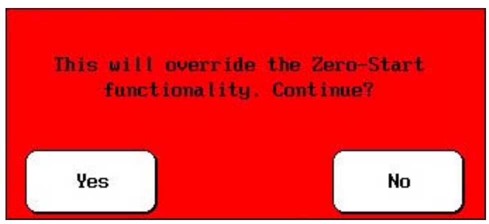


Figure 44. Override Zero-Start Functionality Message.

These selections establish the reference test for comparisons and locks in the reference voltage when performing all subsequent tests.

7. Next, perform a series of checks about this "known good" reference coil.

   a) If the coil selected is the only reference, test it several times to see if the connections, the system, and the coil produce consistent, closely repeatable results. If not, recheck connections and the known coil for damage, and then test settings.

   If three tests were made and the preferred reference was the first or second test, use the backspace icon, select **Yes** to delete back to that coil, and then repeat Step 7.

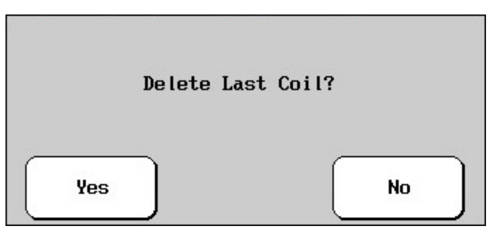


Figure 45. "Delete Last Coil" Message.

   ➢ Since a reference had already been set, a notice box will ask you if you want to clear all and use the new reference; select **Yes**.

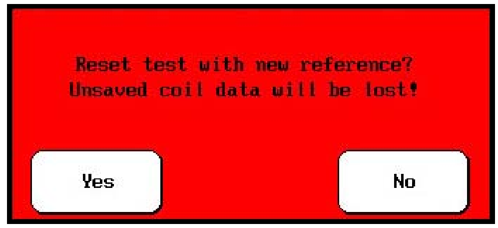


Figure 46. "Reset Test with New Reference" Message.

b) If you are to recheck several references, use the same Step 7 procedure and set up the chosen coil as the new reference.

8. You can now accomplish testing a group of "identical" coils by sequentially connecting the test leads to each coil, pressing the **Start** button and holding it (for more than two seconds). It is best to view this series of different coils by selecting the display icon .

   ➢ Selecting the clear data icon  immediately deletes all data and the reference test. From the display icon, choose all from the last/all charts icon . If something happens that requires a retest of the last coil or coils, simply use the backspace icon as described in Step 7 to delete it/them.

9. You may view the results as follows.

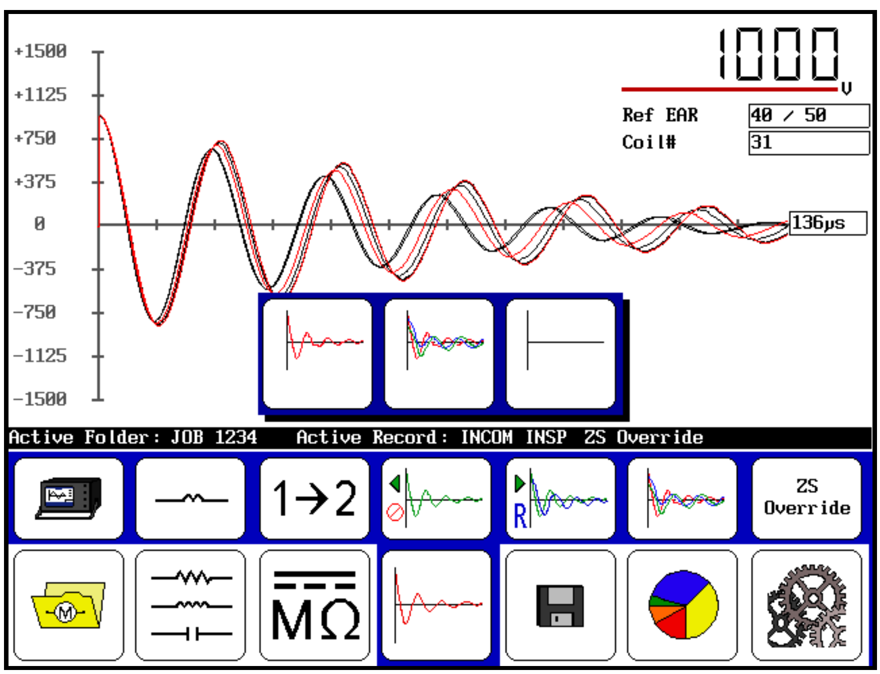


Figure 47. Test Results.

10. Note the *Ref EAR* box reveals when and what criteria is exceeded with highlighting in red. This criterion is set to a default in the user setting, but you can change it to different criterion.

11. Select the save icon and press **Yes** to save the data.

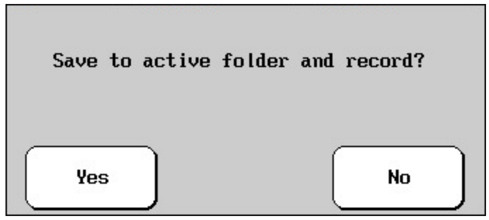


Figure 48. Save to Active Folder and Record Confirmation Window.

- ➢ Use of a footswitch, which is available for use with the tester, enables hands-free operation. The footswitch plugs in the front panel and you may use it in place of the start (**PTT**) test button.
- ➢ For more help with specific applications of surge testing, refer to *Chapter 7*.

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 (5 hp to less than 10,000 hp)
- 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
- IEEE 1415-2006 Guide for Induction Machinery Maintenance Testing and Failure Analysis
- NEMA MG1-1993 Motors & Generators

Reprints or EASA standards are available from:

1331 Baur Boulevard
St. Louis, MO 63132
Phone: 314-993-2220
FAX: 314-993-1269
www.easa.com

Reprints of IEC standards are available from:

International Electrotechnical Commission (IEC)
www.IEC.ch

Reprints of IEEE standards are available from:

IEEE Customer Service
445 Hoes Lane
Piscataway, NJ 08855-1331
Phone: 1-800-678-IEEE
Fax: 908-981-9667
www.ieee.org

Reprints of NEMA standards are available from:

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

4
Principles and Theory of Coil Resistance Testing

The coil resistance test is a very simple test to perform and is an immediate indication of the health of the conductor(s) in a winding. The coil resistance test involves an injection of a known constant current through the winding, and then measurement of any voltage drop or delta across the winding. The Baker DX then calculates the coil resistance using Ohm's law. If a coil is shorted somewhere in the winding's interior, the resistance will be lower than normal. You can compare the coil resistance test result to previous measurements of the same coil, measurements of identical coils, or to the motor nameplate value to identify a "bad" coil.

Variations of copper conductivity associated with the copper's temperature can affect measured resistance. Measured resistance values should be "corrected" to reflect conductivity at a common temperature, usually 25 °C *(77 °F)*, before comparisons are made between two measurements. The Baker DX is capable of correcting resistance readings to 25 °C *(77 °F)*. See IEEE 118 for more information on correcting resistance measurements to 25 °C *(77 °F)*.

Since windings found in many motors have very low resistances, an injected current might have to be as high as several amps to accurately measure any voltage drop across the coil. One of the difficulties encountered with measurements of the voltage drop across the coil itself is the effect of the contact resistance of clip leads used to connect to the motor's winding. Contact resistances can be comparable or even greater than the resistance of some coils. The use of a four-wire or Kelvin measurement reduces the effects of contact resistance; Baker testers use this technique.

Resistance Test Display

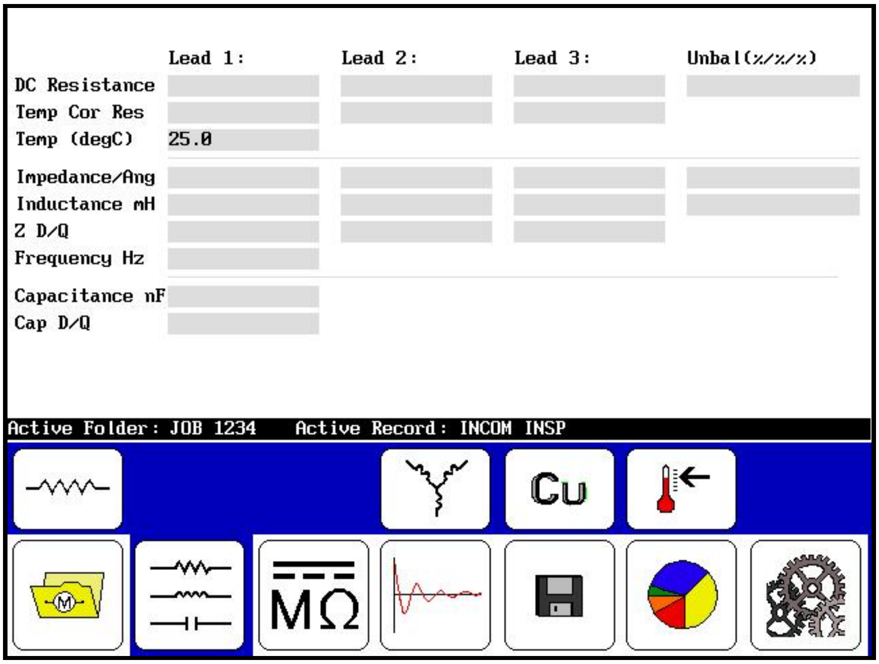


Figure 49. Resistance/Inductance/Capacitance Main Display.

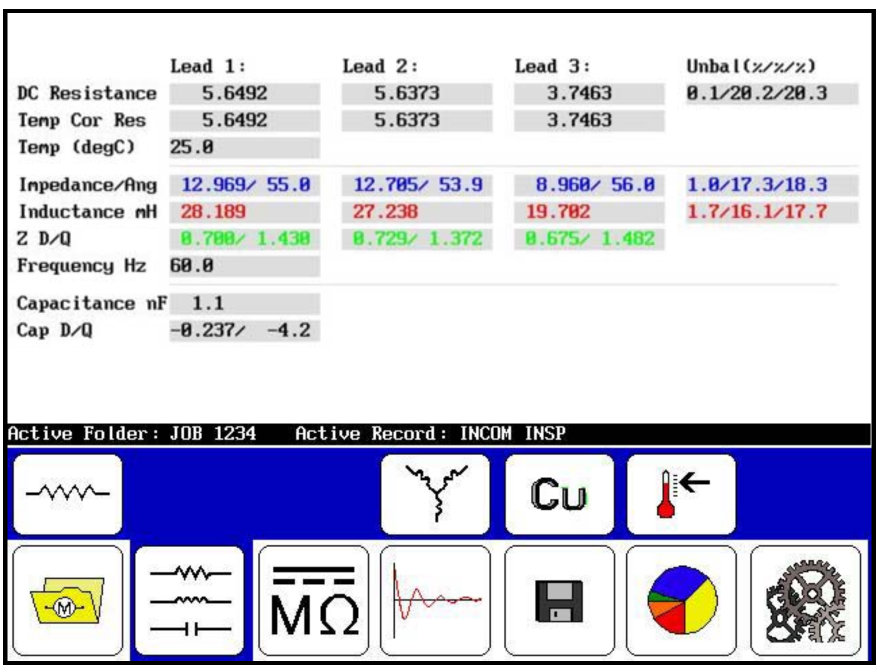


Figure 50. Completed RLC Test Screen.

To perform step-by-step test procedures, refer to *Chapter 3, Performance of Tests, Sequences and Applicable Standards*.

Auto-Ranging Resistance

The Baker DX performs auto-ranging resistance measurements with injections of a low current (20 to 50 mA) into a coil, then measurement of any voltage drop across the coil. If the analyzer does not detect a voltage drop, the current will increase to approximately 0.2 amps and the voltage drop is measured again. If a sufficient voltage still does not develop across the coil, the current will rise to 2 amps. Once it detects the voltage, it uses the measured voltage to calculate the coil's resistance using Ohm's law. If the tester is still unable to detect a voltage drop after injecting the maximum current, the unit will increase the gain in the voltage measurement circuit until it detects a voltage. If it still cannot detect voltage drop, the analyzer will indicate 0.000 ohms on the display.

Indications of Problems in a Motor

If the resistance readings are significantly different from the motor nameplate data, or if a single lead is more than a few percent different from the others, there is probably a short in one or more of the motor's windings. If one of the values is substantially higher, there can be problems, such as one or more of the following:

- A loose or corroded wire nut connection
- An incorrect amount of turns or incorrect wire gauge used during a rewind job
- An incorrect gauge of cable/feeder used from motor control to motor terminals
- Poor or incorrect solder technique used to connect phases
- Phases/Coil groups are misconnected

5
Principles and Theory of DC Testing

Principles of DC Testing

Perform high voltage DC testing of electric motors in order to determine the integrity of the ground wall insulation system of a motor's coil. The ground wall insulation system consists of the wire's insulation, slot liner insulation, wedges, varnish, and sometimes phase paper.

There are three types of DC tests performed by the Baker DX: **megohm** tests, **high potential** (HiPot) tests, and **polarization index** (PI) tests. Each type of test answers a specific question regarding the properties or integrity of the ground wall insulation system. There is also a **stepped HiPot** test that the testers can perform. A brief discussion on each of these tests follows below.

Before going further, we need to discuss the meaning of "HiPot test." The phrase "HiPot test" describes the general idea of high voltage testing and describes a specific type of high voltage insulation stress test. One must differentiate between the concept of HiPot testing and the specific HiPot test based on the discussion's context.

To perform any of the DC tests, the motor's windings are isolated from ground, the red test leads from the tester connect to the motor's three-phase coils, and the black test lead connects to the motor's steel core/frame. The output voltage on the red test leads raises to a predetermined test voltage and the leakage current flowing from the motor's coils through the ground wall insulation to the motor frame is measured. The digital tester then calculates the resulting insulation resistance (IR) using Ohm's law.

The **megohm test** consists of applying a DC voltage to the windings of a machine after first isolating the winding from ground. The test lead selector switch makes all test lead connections. Usually choose the test voltage to be at or near the machine's operating voltage (see IEEE 43). You can find recommended test voltages in *Appendix D*.

The intended purpose of the megohm 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. We calculate the IR value by using Ohm's law – divide the applied voltage by the measured leakage current:

- $IR = \dfrac{Applied\ voltage}{Measured\ leakage\ current}$

This leakage current is the current that is actually able to pass 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 insulation's surface. To accurately determine the insulation resistance, you must reduce the surface leakage to an inconsequential level.

The insulation resistance is a function of many variables: the physical properties of the insulating material, temperature, humidity, contaminants on the surface of the winding's insulation, etc. We can compensate for the effects of temperature by converting the IR value to a standard temperature of 40 °C *(104 °F)*, as shown later in this chapter. The effects of humidity and contaminants cannot be readily taken into account. You must use good judgment when analyzing IR values from motors that may be wet, dirty, loaded with carbon dust, etc.

A suggested test voltage for the megohm test is 1.7 times the applied/operating line voltage for the motor. For example, a 480 V motor would be tested at 480 V × 1.7 = 816 V DC. You can also find recommended test voltages in IEEE 43-2000, NEMA MG-1-1993, and EASA technical manuals (see *Appendix D*).

When first applying the voltage to a motor or when increasing the voltage, you will observe an unusually high current. This high current is not a leakage current, but the charging current of the capacitor formed by the motor's copper coils, the ground wall insulation, and the motor's steel core. We usually call this capacitor the "machine capacitance."

Perform the **polarization index (PI) test** to quantitatively measure the ability of the ground wall insulation to polarize. The PI test is the most confusing DC test in use due to the subtleties in the interpretation of the results. When an insulator polarizes, the electric dipoles distributed in the insulator align themselves with an applied electric field. As the molecules polarize, a "polarization current," also called absorption current, develops that adds to the insulation leakage current. The test results become confusing when attempting to attribute variations in the PI value to the polarization ability of the insulator or other affects such as humidity, moisture, and instrument error.

We typically perform the PI test at the same voltage as the megohm test and it takes 10 minutes to complete. Calculate the PI value by dividing the IR at 10 minutes by the resistance at one minute, as shown below:

- $PI = \dfrac{IR\ (10\ \text{min})}{IR\ (1\ \text{min})}$

In general, insulators that are in good condition will show a "high" polarization index, while insulators that are damaged will not. IEEE 43 recommends minimum acceptable values for the various thermal classes of motor insulation:

NEMA Class	Minimum Acceptable Values
NEMA Class A	1.5
NEMA Class B	2.0
NEMA Class F	2.0
NEMA Class H	2.0

Table 1. IEEE 43 Minimum Acceptable Values for Thermal Classes.

The tester will automatically calculate the PI value at the end of a 10-minute test. At the test's conclusion, you may store the PI value in the memory locations in the tester for later recall.

- **Effects of temperature:** Temperature has a strong effect on megohm readings because insulation resistance varies inversely with temperature on an exponential basis (IEEE 43 has a very good description of this effect).

Insulation resistance drops in half for every 10 °C *(18 °F)* rise in temperature. Therefore, before making any judgments regarding the health of a motor's insulation based on a trend of past megohm measurements, all measurements used in the trend should be compensated or corrected for temperature. The temperature compensation of the insulation resistance means the user must convert all the IR measurements used in the analysis to the same temperature. The recommended temperature to use is 40 °C *(104 °F)*. Use the following formula to make the calculation:

- $R_c = \left[(1/2) \wedge \left\{\frac{40 - T}{10}\right\}\right] \times Rr$

For example, an insulation resistance/megohm value is 5,000 megohms at 30 °C *(85 °F)*; the compensated IR value at 40 °C *(104 °F)* is 2,500 megohms.

- Some insulating materials developed in recent years for wire insulation do not readily polarize. For example, the newer inverter grade wire insulation does not significantly polarize. As recommended in IEEE 43, if the one minute insulation resistance is greater than 5,000 megohms, the PI measurement may not be meaningful. In these situations, the leakage current is often very low – almost zero. Such low leakage currents are difficult to accurately measure and, as a result, instrument errors become very evident. However, the operator must use judgment before declaring the PI test to be meaningless. The indication of damaged insulation based on the PI test can be a very low leakage current and a low PI value.

We often substitute the **dielectric absorption (DA) test** for the PI test for the following reasons:

- Some insulation systems do not polarize, or polarize so fast the process is not observed
- Some motors are so small that a PI test will offer no useful information
- Some motors have such a small total current leakage that it is not possible to resolve the polarization current
- Sometimes users do not have or do not want to take the time to perform the full requisite 10-minute PI test

The DA test is basically a shortened version of the PI test. Instead of forming the ratio of insulation resistances at 10 minutes and one minute, the DA test (as SKF has it implemented) is the IR ratio at three minutes and 30 seconds:

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

There are no accepted minimum or maximum values of the DA test. However, we consider the DA value to be a trend value. Any change in the DA value indicates that something is changing in the ground wall insulation system. The stator may be contaminated or wet, and the stator may also be running hot and burning insulation. Usually, changes in the DA accompany a change in one of the other “recognized” tests, such as the megohm test, PI test, or the DC over-voltage test.

The **high potential (HiPot) test** demonstrates that the ground wall insulation system can withstand a “high” applied voltage without exhibiting an extraordinarily high leakage current or actually breaking down. The test consists of applying a DC voltage to the machine’s windings, the same as a megohm test, but at a higher voltage – usually more than twice the voltage of the machine’s operating voltage. Therefore, we often call the HiPot test a “proof” test. The insulation resistance value at the high applied voltage is not of interest with the HiPot test. What is of interest is the value of the leakage current and, more specifically, whether or not the observed leakage current is within acceptable limits.

The choice of test voltage depends on whether we are testing a new motor (or coil) for acceptance, or whether we are testing an existing motor for continued service. Consult your organization’s policies regarding the HiPot test voltage to use. The simple formula of “2V + 1,000” generally results in a good test voltage for the HiPot test for motors already in service. You can find other recommended HiPot test voltages in IEEE 95, ANSI C50.10-1977, IEC 34.1, and NEMA MG-1 (see *Appendix D*).

The HiPot test usually lasts one minute and we record the leakage current at the end of the minute. Record the leakage current at the end of this minute for future comparisons. Between the time when the voltage is applied to the motor and the time when the leakage current measurement is taken, the operator should carefully observe the leakage current and watch for any variances in leakage current that may indicate weak insulation. You should consider such variations an insulation failure.

DC Tests Display

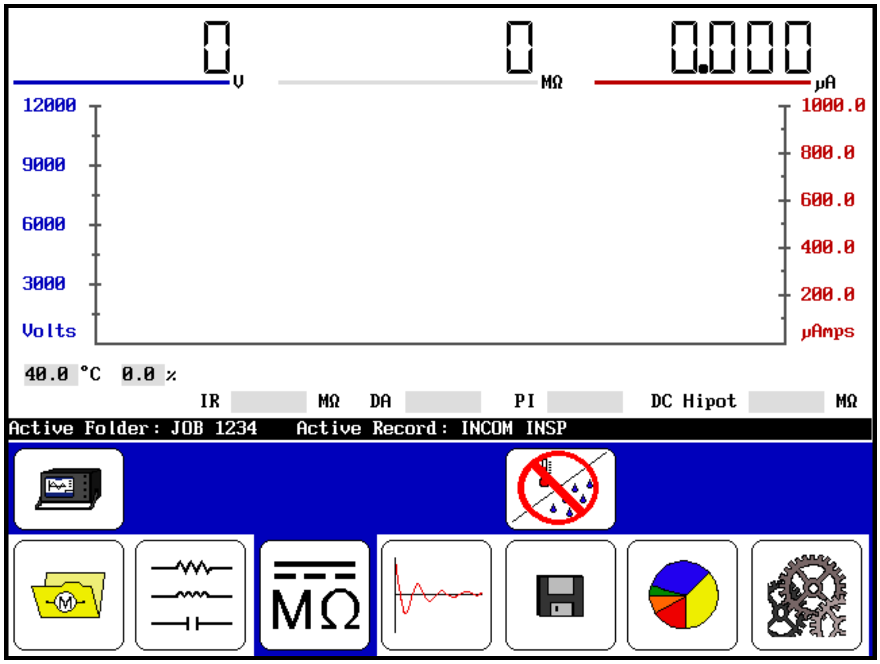


Figure 51. DC IR, DA, PI Step Voltage and DC-HiPot Tests Main Screen.

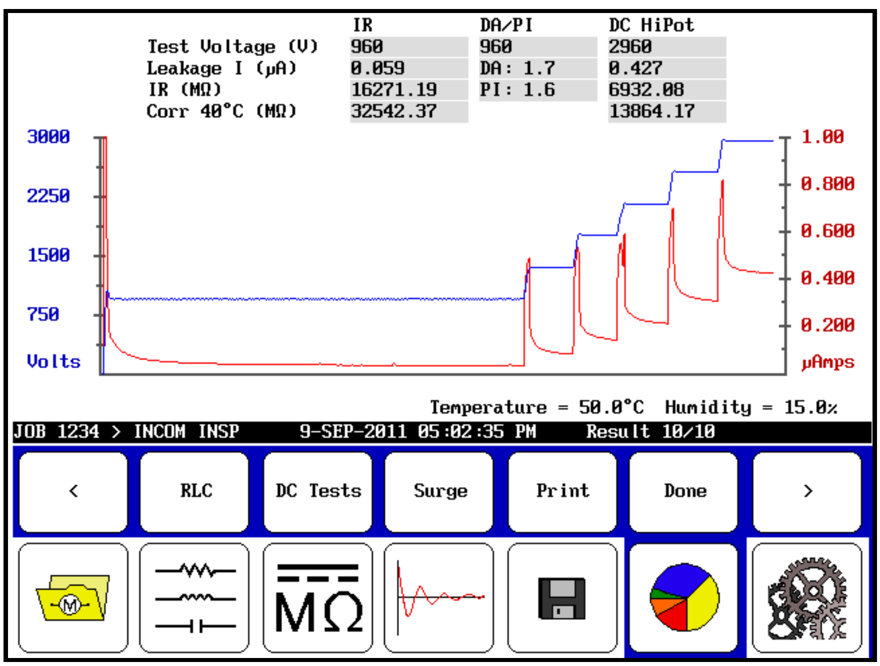


Figure 52. Completed DC Test Results Screen.

To perform step-by-step test procedures, refer to *Chapter 3, Performance of Tests, Sequences and Applicable Standards* and *Supplements 1* and *2*.

6
Principles and Theory of Surge Testing

Surge tests detect insulation damage between turns within a motor's winding; there is no other test or way to determine if this type of insulation problem exists. A surge test consists of applying a high current impulse to a winding using a short, fast rise time. Such a high rise time impulse will induce, via Lenz's Law, 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 between the wires is high enough, it will produce an arc between the wires. You can detect the arc by observing a shift in the surge waveform.

The surge test is performed with an impulse generator and an oscilloscope type display in order to observe the "surge waveform" in progress. The surge waveform is a representation of the voltage present across the test leads of the tester during a test. The indication of a turn-to-turn fault is a shift to the left and/or a decrease in amplitude of the surge test waveform as the test voltage increases.

Surge Testing Theory

As mentioned above, very short, high-current pulses are applied to a coil during a surge test to create a voltage gradient (or potential) across the length of the wire in the winding. This gradient produces a momentary voltage stress between turns.

The coil will respond to the surge pulse with a ringing or damped sinusoidal waveform pattern. Each coil has its own unique signature ringing or wave pattern, which can display on a test display screen, as shown below.

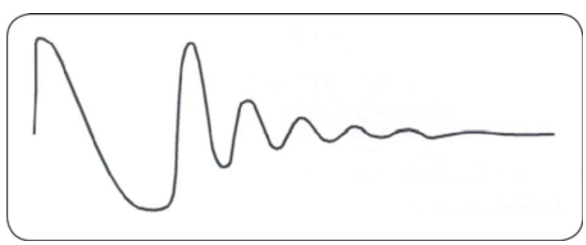


Figure 53. Example of a Ringing Wave Pattern Resulting from Surge Testing.

The wave pattern observed during a surge test directly relates to the coil's inductance. (There are other factors influencing the wave pattern, but inductance is the primary one.) The coil becomes one of two elements in what is known as a tank circuit – a LC-type circuit made up of the coil's inductance (**L**) and the surge tester's internal capacitance (**C**).

Inductance of a coil is basically set by the number of turns in a winding and the type of iron core in which it rests. The wave pattern's frequency is determined by the formula:

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

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

A surge test can detect a fault between turns that is due to weak insulation. If the voltage potential is greater than the dielectric strength of a turn's insulation, one or more turns may short 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 also reduces due to the decrease in inductance of a coil with a fault between turns. The following formula determines the voltage (where the current, *i*, varies according to time, *t*):

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

When the insulation between turns is weak, the result is a low energy arc-over 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.

A reduction in inductance occurs due to turn-to-turn faults, phase-to-phase faults, misconnections, or open connections. A surge test also performs partial ground wall testing when there is a ground line to the machine frame.

The surge test is most often used to test turn-to-turn insulation of coils or single windings. Form coils, start and run windings, and multi-tapped windings are a few examples. Surge tests are also used to compare new windings to a standard winding to assure they conform.

Determination of a Fault

If a fault exists in a motor, 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). When inductance decreases, the frequency of the wave pattern will increase according to the formula above.

The figure below illustrates this. This type of fault is generally one that indicates a failure of the turn-to-turn short.

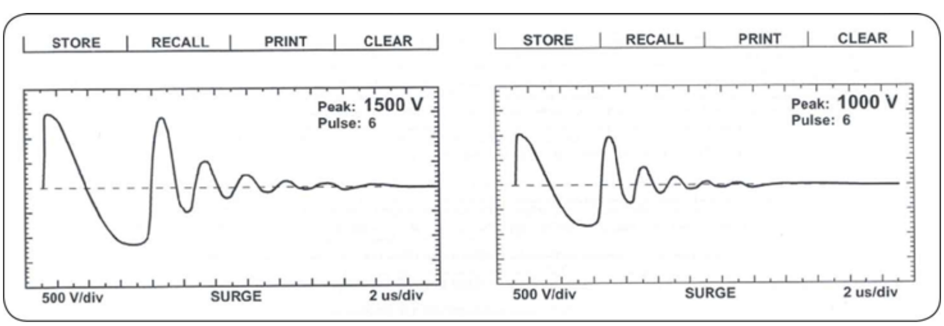


Figure 54. Good Coil (left) Versus Bad Coil (right) Waveforms.

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. Audible sounds often accompany arcing. It may be desirable to store the wave pattern by this arcing for reference if the operator can release the test or freeze the wave pattern at the moment when the wave pattern appears most affected by the fault (e.g., reduced amplitude and increased frequency or shift to the left).

Motivation for Surge Testing

Motors are subjected to high-energy, high-voltage transients in everyday operating environments. These transient pulses can damage the insulation in the motor and, given enough time, cause a catastrophic failure with the motor. High-energy, high-voltage transients are typically caused by:

- Motor start-up current coupled with contact bounce in the MCC
- Lightning strikes in the power system
- Inverter drive transients
- Line surges caused by tripped motors or transformers elsewhere in the power system

One of the primary functions of a tester is to simulate real-world transient voltages likely to be encountered by the motor without the high energy typical of real-world transients. Such spikes are a significant aging factor for the end turn insulation of an electric motor.

Contact Bounce

Oddly enough, one of the major sources for the high-energy transients is the MCC, a device that is supposed to protect the motor. When the breaker contacts close in the MCC during startup, they will often “bounce” or chatter; this means that the high inrush current is being made and breaking several times. As a result of interrupting the current, an inductive “kick back” voltage spike develops. Large inrush currents along with the high inductance of electric motors are what give these “kick back” voltage spikes their high energy.

Lightning Strikes

Lightning strikes often hit power systems or grids. Although a great amount of effort is made to protect grids from lightning damage, high-voltage transients caused by strikes can still reach motors.

Inverter Transients

Variable speed drives or pulse width modulated drives are based on switching currents very quickly in such a manner that the motor runs at a preset speed. The switching of the current, combined with the obvious fact that the motor is an inductor, results in the motor drive electronics generating high-speed transients. These transients impress on the motor where they can slowly degrade the insulation in the motor windings.

Line Surges

The stored energy in a motor or transformer must dissipate when that motor or transformer trips offline from its power system. Either the device absorbs the energy or the energy pushes out onto the power system where other transformers or motors absorb the energy. Often, large transient voltage spikes are generated when this energy is released on a power system. Such spikes can easily damage motors, especially if the motor has weakened insulation.

IGBT Switching Technology

Baker DX surge testers use Insulated Gate Bipolar Transistors (IGBTs) to make a very fast high voltage switch, which is the heart of the surge impulse generator. These IGBT devices are very fast switching transistors. These are often found in variable speed motor drives and are used in the Baker DX in much the same manner as in the drives. However, SKF has uniquely configured many IGBT devices in series to form the high voltage switch. With the fast-switching characteristics of the IGBT transistors, the rise time of each surge pulse is between 0.1 and 0.2 microseconds.

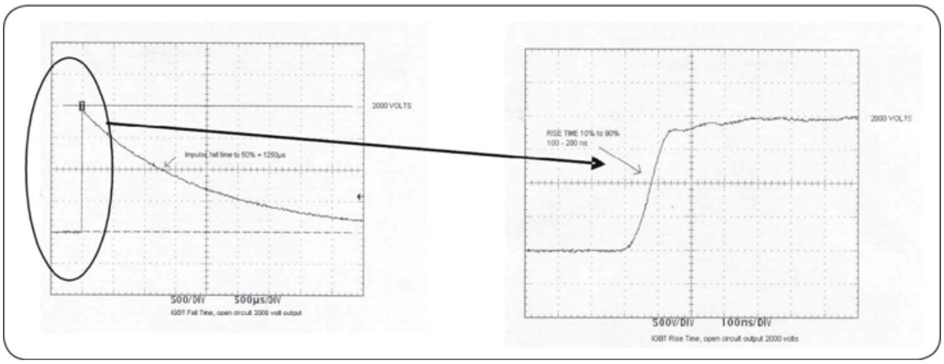


Figure 55. IGBT Fall and Rise Time.

Surge Test Display

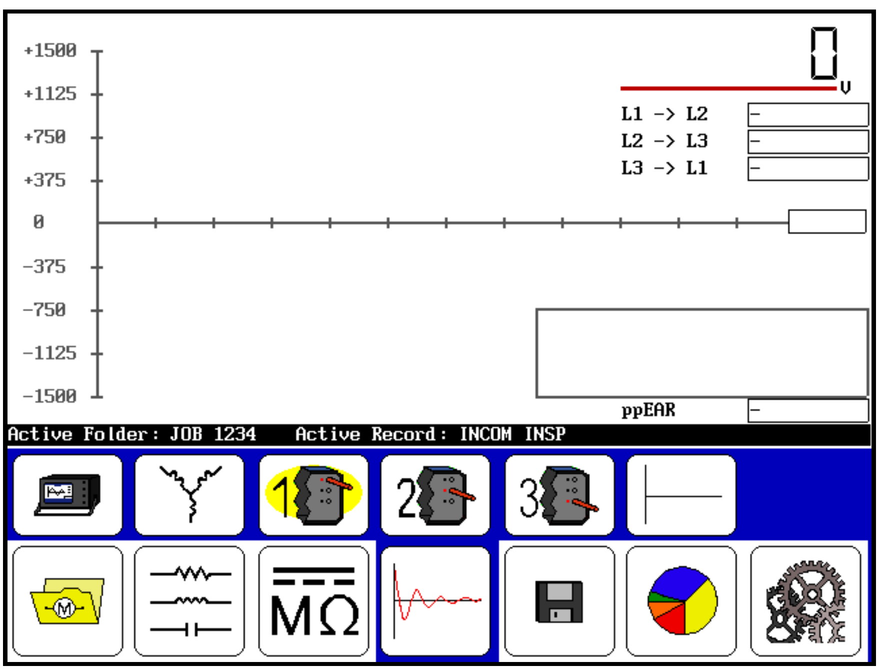


Figure 56. Surge Test Display Main Screen.

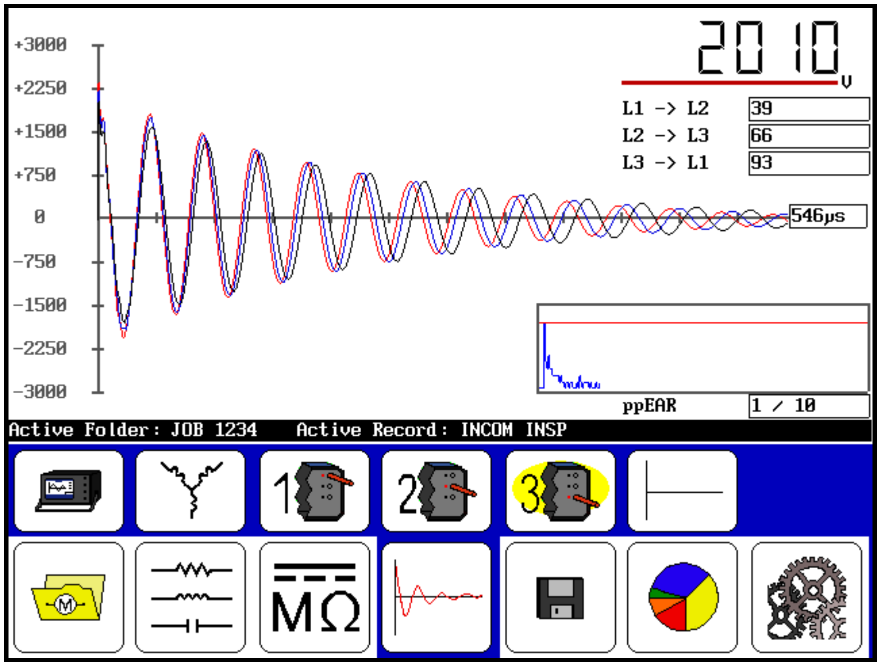


Figure 57. Completed Surge Test Screen.

- The flicker in wave patterns displayed when arcing occurs between the windings or phases cannot be stored in the Baker DX. As soon as you release the **PTT** button, the wave pattern freezes. This is the only wave pattern that can be stored.

For each direction a coil is tested, check the display for the wave pattern produced in each test. If there are two good stable patterns, the winding is good. If you see anything other than good patterns, there is a possible fault. Refer to the *Determination of a Fault* section earlier in this chapter for explanations of wave patterns indicating good or faulty windings. For determination of wave patterns for a variety of devices, refer to *Chapter 7, Surge Test Applications*. Keep in mind that fault determination is often a result of experience.

Example: Comparison to a Master Coil

Occasionally a manufacturer may want to test against a standard. In such a situation, a selected standard coil is surge tested, results are stored in memory, and then they are recalled to the screen. All unknown coils would be tested and compared to the standard coil's wave pattern. Standard testing demonstrates the coil's ability to withstand minimum test voltages and you can compare the signature waveform to the standard's single waveform.

To perform step-by-step test procedures, refer to *Chapter 3, Performance of Tests, Sequences and Applicable Standards*.

7
Surge Test Applications

- For additional reference for fault determination, refer to *Appendix A, Winding Faults*.
- If all three wave pattern comparisons in surge testing show considerable separation when testing three-phase windings, the motor has a phase-to-phase short.

Maintenance Testing

SKF testers have become extremely popular for industrial maintenance programs. They are used extensively for motor analysis and troubleshooting, and are the industry-standard means to make sure all motors (spares, reconditioned motors, or rewinds) are thoroughly tested. The following are guidelines for performing surge tests on assembled motors in the field as part of maintenance testing.

You will rarely find hard-shorted winding faults 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 weld together. It is rare in maintenance testing because of a transformer action, which occurs within the windings, that 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 to expect to see 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 (refer to the *Rotor Loading (Coupling) When Testing Assembled Motors* section later in this chapter). In this case, a consistent double wave pattern displays at all voltage levels.

- You should not interpret separation due to rotor coupling as a fault.

The key to the surge test 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 460 V motor that shows a good trace at 500 V, but shows an unstable, flickering pattern (regardless of rotor coupling) at 1,500 V definitely contains a fault. When detecting the fault above operating voltage, time is available to schedule service for the motor before a hard short and rapid failure occurs.

Consider a 460 V AC motor. The operating voltage is the root mean square, a kind of average, of the AC power supply. For this motor, multiply 460 V by 1.4 to determine the maximum voltage level that the coil undergoes during normal operation; it is approximately 650 V. Now suppose the motor has an insulation fault at 500 V. 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.

Therefore, the surge test's goal is to detect weakness well above the motor's operating voltage, as much as twice the operating voltage plus 1,000 volts. Refer to the recommended voltages for a thorough description of how to determine test voltages along with IEEE references that explain the reasons for these recommendations.

As you can see in the figures below, a good winding will produce stable wave patterns from zero volts up to the recommended test voltage. Faults detected during surge tests are unstable, flickering wave patterns that appear as the voltage increases.

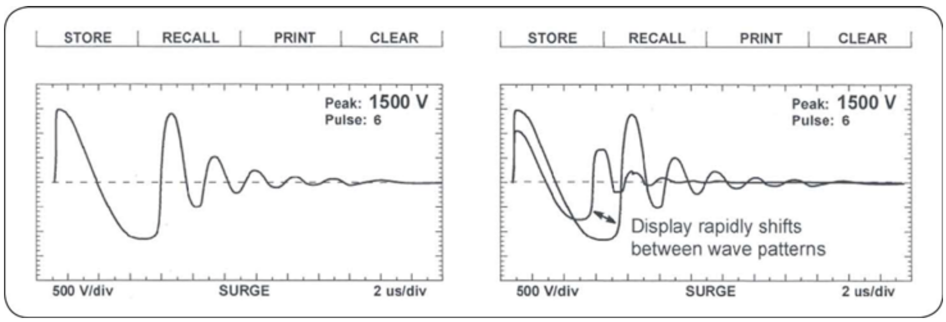


Figure 58. Good Wave Pattern (left) and a Representation of how a Live Wave Pattern May Appear to Move on the Display for a Winding or Coil That Contains an Intermittent Short or is Arcing (right).

Application Notes

- If there is indication of an open circuit, check the connections between all three test leads and the device under test.
- Check for open test leads at the clip end. With heavy use, check test leads weekly to make sure there is no breakage. You can check test leads easily by firmly grasping the boot and clip in one hand while pulling on the lead with the other. A broken lead will stretch; a good lead will not stretch.

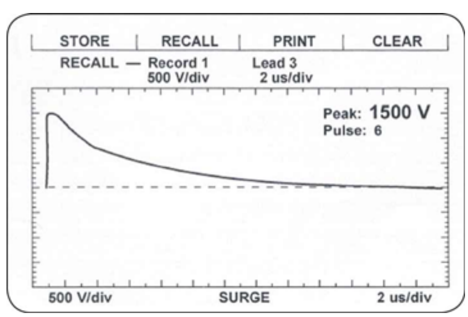


Figure 59. Open Phase in Lead in a Wye-Connected Motor.

Single-Phase Motors and Two-Terminal Devices

Connect test lead No. 1 to one side of the device. Connect test lead G to the opposite side of the two-terminal device. Connect the ground lead and test lead G of the tester to the frame or metal core material.

Determination of a Fault

If a fault exists in a single-phase motor or two-terminal device, 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). When inductance decreases, the frequency of the wave pattern will increase according to the formula:

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

The figure below illustrates this. This type of fault is generally one that indicates a failure of turn-to-turn insulation.

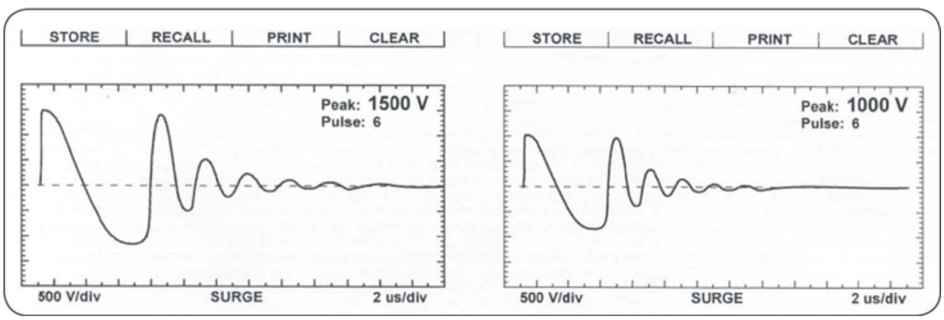


Figure 60. Good Coil (left) and Bad Coil (right).

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. Audible sounds often accompany arcing. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected by the fault (reduced amplitude and increased frequency or shift to the left).

Form Coils

Form coils should be tested similarly to a two-terminal device (refer to the previous section *Single-Phase Motors and Two-Terminal Devices*). A surge test is recommended for form coil testing because only surge tests 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 Motors and Two-Terminal Devices* to determine if a fault is present.

Notes and Tips for Form Coils

- IEEE-522-1992 recommends a test voltage for vacuum-pressure impregnation coils, before they are cured, of 60 to 80% 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.
- **Exercise caution**, since the laminations or stator core have induced voltage on them and can provide a path or ground.
- Calculating a test voltage for AC form-wound coils uses many formulas. 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 × 500 V
  - Maximum = Winding operating voltage × 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 digital tester's storage capabilities allow the comparison of all three phases after reconnecting the test leads. The operator simply recalls any one of the previously tested leads. SKF recommends the following procedure:

1. Connect test lead No. 1 to terminal lead No. 1. Connect leads No. G to terminals No. 2 and No. 3.
2. Connect the BLK G lead to the frame or core of the winding.
3. Begin with terminal No. 1. This indicates lead No. 1 will be hot while No. G leads connected to terminals No. 2 and No. 3 provide a ground path for the surge impulse.
4. Perform the test as described in the *Chapter 3, Performance of Tests, Sequences and Applicable Standards*.

For each test, check the display for a wave pattern. Recall a summary from the digital tester's memory (the wave patterns for the motor) for comparison. If you see three good wave comparisons, there is every indication to believe the motor is good. If you see anything other than good patterns, there is a possible fault.

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. Audible sounds often accompany arcing. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected (reduced amplitude and increased frequency or shift to the left).

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 that 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 (refer to the *Rotor Loading (Coupling) When Testing Assembled Motors* section later in this chapter).

Two or More Single Coils

Use a surge test to test two or more identical single coils separately and then compare their wave patterns against each other.

1. Connect test lead No. 1 to one side of coil No. 1 and connect the ground test lead G to the other side.
2. Surge test the first coil and store the results in memory.
    - Use **Quick Store** for a fast determination of the results of the test.
3. Surge test the second coil or any number of identical coils. Compare the display to the pattern obtained in Step 2 (store the results, if desired).

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. Audible sounds often accompany arcing. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected (reduced amplitude and increased frequency or shift to the left).

Separation of the wave patterns when compared indicates incorrect turns count. The fault will be in the coil connected to the test lead that produces the wave form most 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 testing DC fields coils, 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 magnetic properties 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 than 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 V 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 V. Because of the sometimes non-linear distribution of the surge pulse, it is recommended to use a minimum surge potential of 500 V 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 are generally 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.
- You may notice a slight imbalance (separation) if the windings are not correctly phased, e.g., the winding configuration of one compared to another is clockwise versus counterclockwise. Try reversing one set of test leads 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 coil's impedance 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

Test wound rotor motors 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. Perform a surge test on the stator as would be done on a three-phase induction motor. Refer to the *Three-phase motors* section earlier in this chapter or follow the directions in *Chapter 3, Performance of Tests, Sequences and Applicable Standards.*
    - ➢ Since the rotor is shorted out, there is no chance for a high-induced voltage transformed from the stator to damage the rotor.

4. To surge test the rotor, disconnect the jumpers from the slip rings. Connect the tester test leads to the rotor slip rings.
5. Short together the stator leads with jumpers, as done for the rotor.
6. Repeat Step 3 for the rotor.
   - Check the motor nameplate for rotor voltage to calculate the rotor test voltage level. Rotor voltage is **not the same** as 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 becomes erratic and/or flickers during testing, intermittent shorting or arcing is probably occurring in the windings under the voltage stress. Audible sounds often accompany arcing. It may be desirable to store the wave pattern produced by this arcing for reference if the operator can release the test (this freezes the wave pattern) at the moment when the wave pattern appears the most affected (reduced amplitude and increased frequency or shift to the left).

During comparison, separation of the wave patterns indicates incorrect turns count. Interpret the separations as for three-phase motors.

Synchronous Motor/Generator

Test the synchronous stator as a three-phase induction motor. You should test the rotating fields individually.

1. Before surge testing the stator:
   a) Remove the DC leads to the brush boxes or lift all of the brushes off of the slip rings.
   b) Short the slip rings for the rotating fields together.
2. Perform a surge test the stator, following the procedure 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 V per pole. It is not necessary to disconnect the pole piece leads before testing.
4. Reverse the hot and ground leads and repeat the test 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.

- You can test one field and store its surge wave pattern for reference. You can then compare the other fields 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 faults or stator winding faults.

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 (refer to the previous *Three-phase Motors* section).

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 specified 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 V.

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. The bar-to-bar low-impedance test accessory from SKF will be necessary to perform this test. This item is present inside the D65R test set.

DC Motor/Generators

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

Armatures

There are two methods of performing surge tests on armatures: the bar-to-bar surge test and the span surge test. The use of a footswitch is highly recommended to ease the operation of each of these tests.

Bar-to-Bar Surge Test

Bar-to-bar armature surge tests are the most effective method to test DC armatures and detect winding insulation weaknesses and faults. In many cases, where the impedance of the coils in the armature is very low, it may be the only method possible to test the armature.

Span Testing

This method uses the brushes of the assembled DC motor to make the connections with the commutator for armature testing. You can use any number of bars in this test. You can either surge test adjacent bars or you can test a specific number or “span” of bars. 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 Tests of Armatures*).

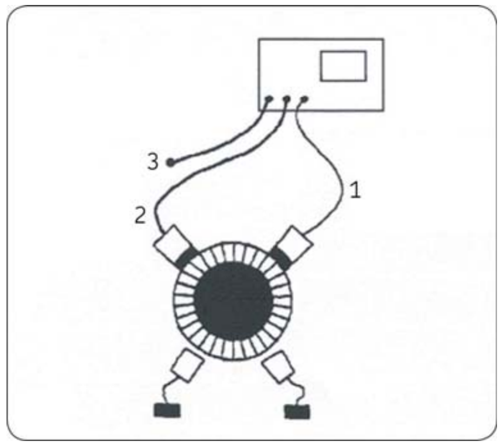


Figure 61. Span Test Setup.

Description

① Test lead No. 1 – HOT
② Test lead No. 2 – GROUNDED
③ Test lead No. 3 – OPEN

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 rotates, all the commutator segments, and therefore their respective coils, pass into the “test area” between the hot surge test lead and the GRD lead.

- It is important that the same number of bars (and therefore coils) is always 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. Connect test lead No. 1 to one of the brush assembly pigtails. Connect the ground test lead to the shaft or other good ground on the frame.
   - When testing armatures that have bars wired in series, it is very important to ground at least two bars of the armature a few bars away from those that are being surged. If not, very high potential voltages to ground can develop in the armature due to a transformer effect in the coil.

3. Select the adjacent set of brushes or the brushes of the bar corresponding to the desired span. Connect test leads No. 2 and No. 3 to the pigtail of that brush assembly.
4. Put the unit into arm span mode.
5. Begin the test by pressing the **Test** button or footswitch and slowly raising the output control to the desired test voltage level. Carefully observe the wave pattern for its reference shape.
6. Store this wave pattern as the "reference" wave pattern for this span on this particular armature. Recall the reference wave pattern to the display (use **Quick Store** if desired). Note the peak voltage displayed on the screen.
7. Begin testing again using the same output voltage until the test wave pattern matches the reference wave pattern.
8. Rotate the armature slowly through 360 degrees so that all commutator segments are tested while observing the reference wave pattern.
   - We recommend releasing the **Test** button (or footswitch) each time the armature is turned, but it is not necessary. Doing so minimizes the chance of marking the commutator.

If you do not release the **Test** button or footswitch 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. Ignore these wave pattern movements 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. The illustration below shows an example of a fault discovered after performing a surge test using the motor's brushes.

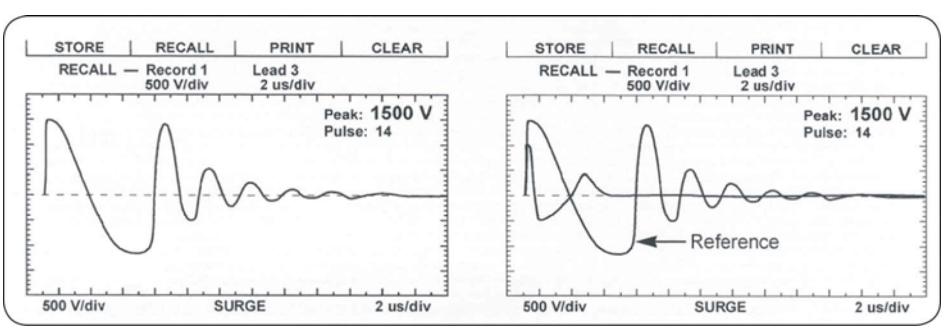


Figure 62. Fault Located Under the Ground Brush (left) and
Fault Grounded Under the Brush or Outside of Surge Test Span (right).

Notes and Tips for Span Tests of Armatures

- A test fixture may be used instead of using the motor's brushes to make contact with the armature.
- Set the span between the fixture's brushes to the desired number of commutator bars. Either move the fixture around the commutator during testing or rotate the armature. Procedures for testing and fault determination are the same.
- Always HiPot the armature to ground first. 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 V according to Paschen's Law). Voltage stress is measured by the differential or drop between each bar. For example, a ten-bar span with 1,000 V applied to it will result in a 100 V stress between bars. If the span is lowered to f bars, 1,000 V applied to the span will result in 200 V between bars.
- Consider, however, that a ten-bar span at 335 V between bars would require a span test voltage of 3350 V. 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 2,200 V.
- 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 wave pattern's response 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 a seven-bar span may sometimes match that for an 11-bar span. 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 or the footswitch before moving to the next bar during the test minimizes the chance of marking the commutator.

Testing Large AC Stators/Motors

Due to the input area's physical non-symmetry, high capacitance, and inductance on some large AC high voltage machines, exercise care when evaluating the waveforms.

The screens below show wave pattern comparisons for a typical 4,160 V stator. The first wave pattern is produced when the Seconds/Div control (sweep rate) has been turned clockwise too far, expanding the wave pattern display; the sweep rate is set too fast. This wave pattern is actually the first half cycle of the full wave. Distortion is caused by the non-symmetrical, distributed capacitance in the input portion of the winding.

To correct for this display condition, turn the Seconds/Div control counterclockwise, slowing the sweep rate. The correct surge wave pattern will always extend below the zero line. Observe the natural ringing to the right of the point where the wave pattern crosses the zero line in a positive (upward) direction.

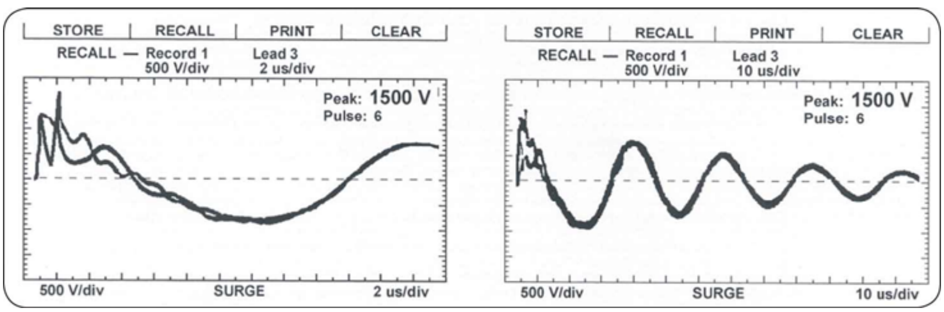


Figure 63. Seconds/Div Set Too Far Clockwise (left) and Adjusted Counterclockwise (right).

Good practice is to start with the Seconds/Div control turned to its counterclockwise limit to begin when testing high voltage AC machines.

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 the SKF milli-ohmmeter or a third-party micro-ohmmeter whenever evaluating the condition of a motor winding.
- You must perform the surge test 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:

- **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.
- **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.

We can understand rotor loading when we consider the rotor as a secondary of a transformer. When one phase being surged 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. When we compare them, the wave patterns on the display indicate this difference by displaying separated wave patterns.

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).

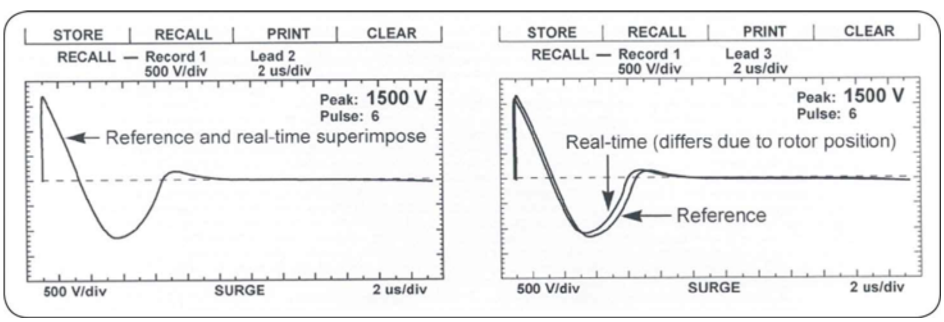


Figure 64. Wave Pattern Comparison for Motor with Rotor in Place.

The recommended procedure for testing assembled motors where rotor coupling may occur is as follows. Refer to *Chapter 3, Performance of Tests, Sequences and Applicable Standards* and this chapter for detailed instructions for surge testing and storage and print capabilities of the storage and recall functions.

1. Surge test phase No. 1 of the motor. Store and recall the wave pattern by using the **Quick Store** function.
2. Surge test phase No. 2 of the motor. During the test, carefully turn the rotor until the wave pattern superimposes that of phase No. 1 on the display. Store the results in Lead 2 in memory.
3. Repeat the steps for phase No. 3.

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

- The 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.

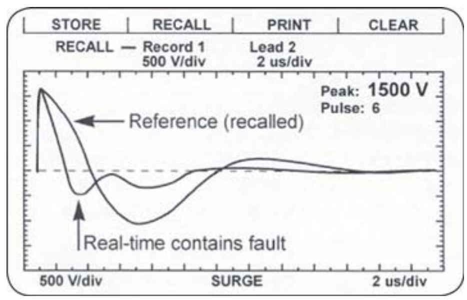


Figure 65. Motor with Rotor in Place and Fault Windings, Showing One Trace Shift Significantly to the Left.

Testing Assembled Motors from the Switchgear

The surge and HiPot tests are valid tests when performing tests from the switchgear at the motor control center. Not only are the motor's windings 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 the wave patterns for good or bad windings, stability and symmetry are the most important factors.

> **WARNING!** You must de-energize the motor before testing. Connect the test leads to only the load side of the open disconnect.

Notes and Tips for Testing from the Switchgear

- Properly tag the test motor during the test as a safety precaution.
- All limitations and guidelines covered for testing assembled motors apply here (refer to the previous *Rotor Loading (Coupling) When Testing Assembled Motors* section).
- You must disconnect any power factor capacitors in the circuit. If power factor capacitors are present, you will not observe a waveform when the voltage rises. This will also happen if the motor was not connected to the cable. You will only note a rise in the trace on the far left.
- The feeder cable's capacitance, as well as the motor's, will load the surge test circuit. It will need significantly higher output settings to reach the required test voltage. If the surge tester is too small to handle both the cable and the motor load, you will observe a trace, but will not reach the proper test voltage. A higher output surge tester model will be required or you may have to test the motor 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 you should perform 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 SKF at 1 (800) 752-8272 for further assistance or if you encounter difficulties when testing transformers.

Single-Phase Transformers

1. Jumper (or short out) the secondary side (low side) of the transformer.
2. Select test lead No. 1. Follow the diagram below to connect test lead No. 1 to H1 and lead No. 2 to H2 of the transformer. The black GRD lead and test lead No. 3 attach to the frame.
3. Perform a surge test on the winding following the procedures outlined for single-phase motors and two-terminal devices. The discussion of determining a fault applies.
    - ➢ Secondary winding insulation problems reflect into the primary winding and will show on the display.

4. After completing the test, reverse the test leads (connect test lead No. 2 to H1 and test lead No. 1 to H2) and repeat the surge test. This is commonly known as "shooting in the other direction."
5. Repeat this test process for each TAP position.

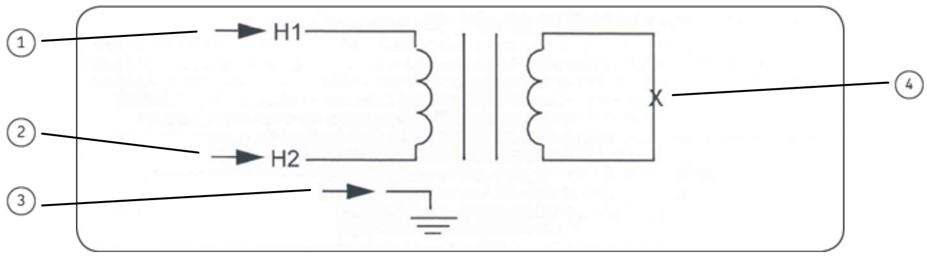


Figure 66. Single-Phase Transformer Connections.

Description
① Test lead No. 1
② Test lead No. 2
③ Test lead No. 3 and black ground lead
④ Jumper together

Three-Phase Transformers

It is beyond the scope of this manual to cover all possible transformer connections. It is important to remember that you must surge test each line high side connection point to the other end of its own coil, and that the secondary side of the coil being surged must be shorted out (with jumpers connected together and to ground).

- A wye-wye transformer with the star point internally tied can be surge tested without opening the tie point.

1. Use test lead No. 1.
2. Connect the black ground test (GND) lead to the frame (ground) of the transformer.
3. Follow one of the charts below for connections for wye-wye or delta-wye transformers. You should surge test the transformer windings 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

The determination of a fault when surge testing a transformer winding follows that of the two-terminal device (refer to single-phase motors and two-terminal devices).

Wye-Wye Transformers

Test Lead No. 1	Test Lead No. 2	Jumper
H1	H0	X0 to X1
H2	H0	X0 to X2
H3	H0	X0 to X3

Delta-Wye Transformers

Test Lead No. 1	Test Lead No. 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

8
Supplement 1:
DC Tests, Surge Tests Using Power Packs

General Information

The Baker DX series digital analyzer works with the SKF PP30, PP40, and PP85 (30, 40, 30 kV) power packs, which enables testing of larger, higher-voltage machines that are beyond the capacity of the Baker DX alone. Experience has shown that the DX standalone unit is able to test up to a 1,000 hp, 4,160 V, 1,800 RPM machine. When used with a power pack, the Baker DX is able to test much larger motors as well as higher-voltage motors. The power packs are not able to operate alone – many of the control functions of the Baker DX are required. The Baker DX also works with the ZTX high-current surge adapter designed to test DC motors (refer to ZTX operation in *Supplement 2*).

Review the instructions for stand-alone operation of the Baker DX before attempting to operate with a power pack. This chapter provides instruction on how to correctly set up, connect, and operate the power pack.

A power pack is purchased with and calibrated to the DX host it is shipped with. The back panel of the power pack lists the DX serial number and, therefore, certified to work only with that power pack.

Important Safety Information

NOTICE: The ground-fault system on the Baker DX will render it inoperative without a proper ground. When the host Baker DX tester is connected to a power pack, an inoperable condition will also affect the power pack due to loss of the surge enable signal.

NOTICE: Never attempt to test a load with both 12 kV and power pack leads attached to the load at the same time. Damage to the tester may occur.

Danger

High Voltage

To prevent serious injury or death:

- **Do not use in explosive atmospheres.**
- **Do not contact test leads or the device being testing while a test is in progress or during discharge period.**
- **Do not connect test leads to live circuits.**

Read and follow safety precautions and safe operating practices in the operator manual. Do not exceed maximum operating capabilities of this instrument.

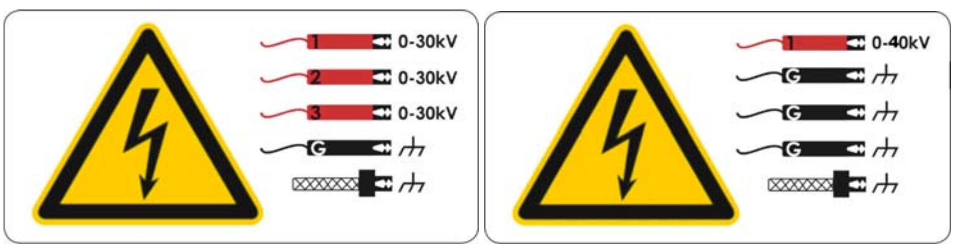


Figure 67. Lead Safety Labels – PP30 and PP85 (left) and PP40 (right).

Emergency Shutoff Button

Power packs are equipped with a red **Emergency Stop** (E-Stop) button on the front panel of the unit. Use it to quickly discontinue a test and to shut off power to both the power pack and the Baker DX.

- When using this button, the computer will shut down and unsaved data will be lost.

The button will remain locked in position until manually retracted by rotating the **Emergency Stop** button clockwise.

Figure 68. Emergency Stop Button.

Other Important Safety Warnings

Failure to follow these precautions can result in severe electrical shock or death.

1. **Never** attempt a two-party operation. Always know what test is being performed and when. For example, **do not** adjust test leads when operating a footswitch. Leads will have live voltage and severe electrical shock may result.
2. For capacitor-started motors or systems with surge arrestors/power factor capacitors, be sure to **disconnect** all capacitors from the test circuit **before** testing.
3. Upon completion of any DC-HiPot, megohm, polarization index (PI), step voltage, or dielectric absorption (DA) tests, be sure to short the winding, motor, etc., to ground and allow time for discharge before disconnecting the test leads. If you do not do this, voltage may still be active on leads and tested components.
4. Make sure to disconnect the tester leads before energizing or powering up the motor.
5. **Do not** remove the product covers or panels or operate the tester without the covers and panels properly installed. Components on the inside of the tester carry voltage for operation and can render a shock if touched.
6. Use appropriate safety equipment required by your organization, including high voltage gloves and eye protection.
7. **Repair parts notice:** You must replace defective, damaged, or broken test leads with factory-authorized parts to ensure safe operation and maintain performance specifications.
8. **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/grounded 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 cause an electric shock!

9. This instrument is **not** waterproof or sealed against water entry.
10. The unit is for indoor use. If using outdoors, you must protect the unit from rain, snow, and other contaminants.

Power Pack Setup

- When shipped, the package containing the power pack must be properly labeled with "this side up" to ensure there is no damage to the instrument. Inspect for damage and notify the carrier immediately.
- Check to confirm that the back panel of the power pack lists the Baker DX serial number before connecting to power pack.

Figure 69. Power Pack Setup.

1. Connect the power pack to the tester. Use the short AC line cord on the power pack rear side panel to connect to the Baker DX's power entry receptacle.
2. Connect the 25-pin interconnect cable to the two units. The cable is marked on each end. Be sure to plug in the end marked **Host** or **BAKER DX /D** into the auxiliary port (**AUX**) on the front of the Baker DX and the end marked **30 kV** or **power pack** into the auxiliary port (**AUX**) on the front of the power pack.
3. Connect the long AC power cord to the power pack front panel receptacle and then to an appropriate AC power source. Refer to the *Power Requirements* section in the *Preface* of this manual for appropriate power requirements.
    - With 220/240 V AC units, the user may be required to supply an appropriate AC connector for mating to the power source. These units are designed for use on a single (1) phase 220/240 V AC power source. Split phase AC power sources will not work.

4. Note the storage of Baker DX high voltage leads out of the way.
5. If you will use the remote E-Stop, connect it to the indicated location on the back of the power pack.
6. Power up the Baker DX and the power pack. Follow the Baker DX setup procedures in this manual.
7. After a one or two minute warm up period, both units will be ready for operation.
    - The Baker DX is equipped with a ground-fault monitor and indicator. This circuitry should not hinder operation of GFI protected AC power circuits.

Instrument Notices

Before use:

- Do not allow the Baker DX's test leads to lie anywhere near the power pack test leads. The unit's leads should coil on top of the unit or loop on the power pack handle. Otherwise, testing can result in interference with its computer.
- Make sure the Baker DX's (host) leads do not connect together.
- Make sure the Baker DX's (host) ground test lead does not connect for grounding during the power pack test.
- Make sure no printer or CD ROM is hooked up to the USB port.
- The power pack, when equipped with the three-phase selector switch option, is not rated for operation in any position other than standing vertically, with all four wheels down on a level surface.
- If the Baker DX is getting AC power from the power pack and if the power pack is off, the Baker DX is also off.

During use:

- Do not switch the test leads or change the three-phase selector switch.
- If the power pack connection to the Baker DX is maintained and the power pack is turned off, I/O lines are influenced. This may cause problems with Baker DX operation.

Three-Phase Test Lead Selector Switch

The PP30 and PP85 power packs are supplied with three-phase test leads. Use the one additional knob, located on the lower front panel of the power pack, to switch between the different leads. The options on this knob are **Test Select 1** (test lead 1), **2**, **3**, and **HiPot**. Some units are equipped with a **Ground** position. With the three-phase test lead option, the operator is only required to connect the three leads once to the motor. Whereas the power pack that only has the single-phase test lead requires the operator to manually move a red test lead between the motor's different leads.

Figure 70. Three-Phase Lead Selector Switch with Ground Position Only on PP30 and PP85.

Output Lead Configuration

PP30 and PP85

- Three red output cables, with insulated jacket rated at 60 kV DC, appropriately marked
- One black ground cable, with insulated/braided jacket at 60 kV DC, appropriately marked

PP40

- One red output cable, with insulated jacket rated at 60 kV DC, appropriately marked
- Three black ground cables and one insulated/braided jacket at 60 kV DC, appropriately marked

HiPot connections PP30 and PP85

60 kV Red	60 kV Red	60 kV Red	60 kV Black	Black Braid
Energized	Open	Open	Ground	Safety Ground

HiPot connections PP40

60 kV Red	60 kV Black	60 kV Black	60 kV Black	Black Braid
Energized	Ground	Ground	Ground	Safety Ground

Surge connections PP30 and PP85

	60 kV Red	60 kV Red	60 kV Red	60 kV Black	Black Braid
Surge Lead 1	Energized	Ground	Ground	Ground	Safety Ground
Surge Lead 2	Ground	Energized	Ground	Ground	Safety Ground
Surge Lead 3	Ground	Ground	Energized	Ground	Safety Ground

Surge connections PP40

	60 kV Red	60 kV Red	60 kV Red	60 kV Black	Black Braid
Surge Lead 1	Energized	Ground	Ground	Ground	Safety Ground

- You must place the power pack control panel function switch into the **HiPot** position to perform a HiPot test. Be sure to switch the power pack test lead selector switch (PP30 and P85 only) into the **HiPot** position. Both switches must be in their correct positions simultaneously when performing the test. If the tester does not operate in this fashion, the tests will not perform correctly and the data recorded will be in error.

Do not switch the test lead select switch while a test is in progress; this may substantially reduce the switching element's useful life.

Operating and Shipping Position

The power pack, when equipped with the three-phase selector switch option, is **not** rated for operation in any position other than vertically, with all four wheels down on a level service.

When shipped, the package containing the power pack must be properly labeled with "this side up" labels to ensure the instrument is shipped in the upright position.

Figure 71. PP30 – 30 kV Power Pack with Three-Phase Selector Switch (Lower Right Front Panel).

Figure 72. PP85 – 30 kV Power Pack with Three-Phase Selector Switch (Lower Right Front Panel).

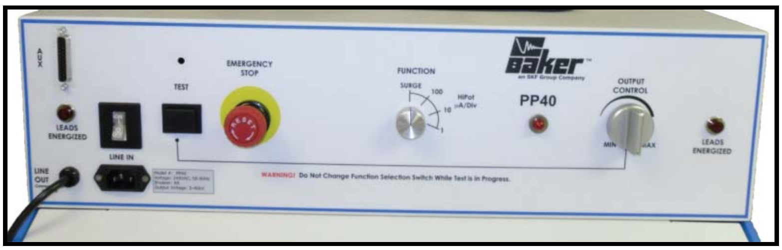


Figure 73. PP40 – 40 kV Power Pack.

Combining DX Host and PP30, PP85 and PP40 Power Pack Tests

To completely test a large motor, functions from both the Baker DX and a power pack are used together. Use the Baker DX to perform the winding resistance test and the megohm and PI tests. Use the power pack to perform the HiPot test and the surge test. The test data collected by both instruments combines into a single test record in data storage.

Power Pack and Resistance Testing

The resistance tests are run from the standalone unit. Refer to the procedures for the host resistance, inductance and capacitance testing earlier in the manual in *Chapter 3*.

- During resistance testing, you must disconnect the power pack's leads from the device you are testing. Store the power pack leads on the power pack handle, on the Baker DX or away from the unit's high-voltage leads or resistance test leads during resistance testing. At the conclusion of resistance testing, you must connect the power pack leads. ***Do not connect both sets of leads together at any time; damage to the tester may result.***

Power Pack DC-HiPot Testing – PP30, PP85, PP40 (Three-Phase Test Lead Option PP30 and PP85 Only)

> **WARNING!**
> – **High voltage testing**. Make sure all personnel are away from the device under test and not in contact with either the load or the test leads.
> – Some test leads will be open during the test and can be at the same voltage potential as the winding. Take all precautions to avoid touching these leads.

1. Check that the power pack setup procedure has been followed.
2. Turn the power pack "Output Control" voltage knob on the power pack to **MIN** (full counter-clockwise). Select one of the HiPot settings on the power pack function knob.

Figure 74. Power Pack DC-HiPot Testing Settings.

For the PP30 and PP85, ensure that the three-phase selector switch (lower right front panel) is also set to **Ground** (not available on the PP40).

3. Connect the power pack leads to the test motor.

Motor Leads	**Lead 1**	**Lead 2**	**Lead 3**	**Frame**	**Black Braid**
Test Leads	Energized: 60 kV Red	Open 60 kV Red	Open 60 kV Red	Ground 60 kV Black	Safety Ground

When connecting to a three-phase motor, connect test lead No. 1 to motor phase A, test lead No. 2 to motor phase B, and test lead No. 3 to motor phase C.

- If not using the PP40 power pack, skip to the next step. When using the PP40 power pack (single-phase testing), connect test lead No. 4 to ground and test lead No. 1 to any of the winding phase connections and leave test leads No. 2 and No. 3 disconnected/open, but connect the safety ground to the motor frame.

Motor Leads	**Lead 1**	**Lead 2**	**Lead 3**	**Frame**	**Black Braid**
Test Leads	60 kV Red	60 kV Black	60 kV Black	60 kV Black	Safety Ground

- When using the PP40 power pack for single-phase testing of three-phase windings, move connections as follows:

Motor Leads	**Lead 1**	**Lead 2**	**Lead 3**	**Frame**	**Braid**
Test Phase A	Energized 60 kV Red	60 kV Black	60 kV Black	60 kV Black	Safety Ground
Test Phase B	60 kV Black	Energized 60 kV Red	60 kV Black	60 kV Black	Safety Ground
Test Phase C	60 kV Black	60 kV Black	Energized 60 kV Red	60 kV Black	Safety Ground

4. Power up both the Baker DX and the power pack. If the function knob has been set on, for instance, the HiPot 100 µA/division setting, you will normally hear a loud relay noise.

5. Ensure that you plug the Baker DX and power pack into a good grounded source.

6. If a folder and record have not been created for the motor selected to test, do that now (following data management instructions in *Chapter 2*) from the folders icon and set up the intended folder/record as the "Active Folder" and "Active Record" in the status bar.

7. Select the DC/megohm icon from the DX screen, which brings up the configuration options icon . When you press the configuration icon, new icons appear that indicate installed options that allow operation either as a standalone unit or with a power pack. If an interface board is **not** installed, the following message appears.

Figure 75. "No External Interface Options Installed" Message.

For purposes of this instruction, select the power pack icon .

8. If you need temperature or relative humidity compensation, select the icon and follow the pop-up display menus (see *Chapter 3* for detailed procedures on the standalone Baker DX's DC tests section). Otherwise, skip to the next step.

9. For the PP30 and PP85, ensure that the three-phase selector switch (lower right front panel) is also set to **HiPot** (not available on the PP40). The DC-HiPot test is now ready for test start from the following screen.

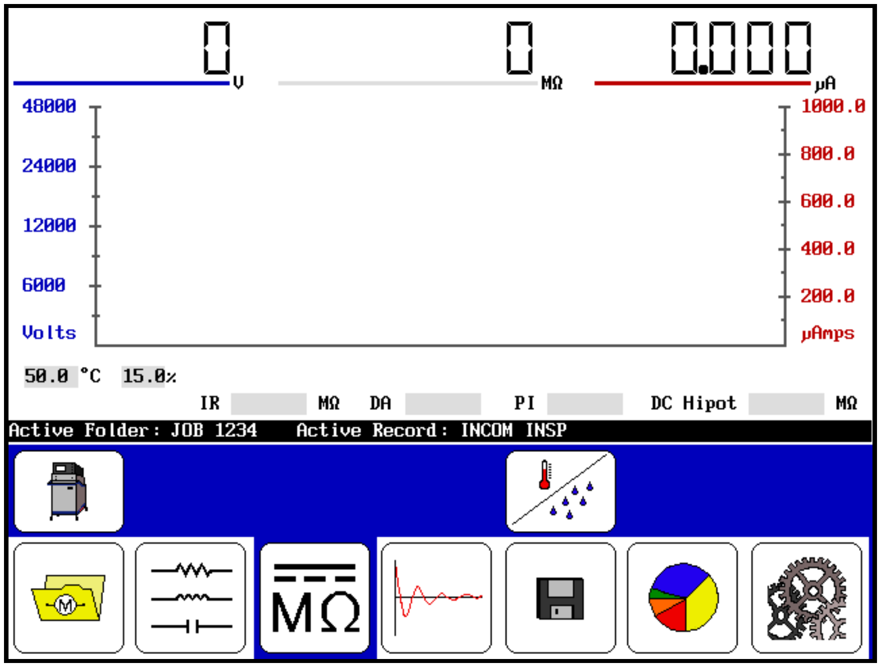


Figure 76. DC-HiPot Test Start Screen.

10. Start the test by pushing and holding the start button (or footswitch). Adjust the "Output Control" voltage knob so that HiPot voltage is at least 2,000 V. Use the DX speed control icons  to reach the target voltage faster.
    - You should interrupt this test any time you observe a fast, sharp rise in current – by releasing the start (**PTT**) button.
    - The over-current trip levels that activate the HiPot trip are 8.5 times the µA/division setting on the tester. For example, on the 10 µA/division setting, HiPot trip will occur at 100 µA. If a HiPot trip occurs, release the **Test** button and press the **HiPot** and **Lead 3** on the Baker DX to reset the over-current trip and begin testing again. If a HiPot trip occurs, release the **Test** button and press the **HiPot** and **Lead 3** on the Baker DX to reset the over-current trip and begin testing again.
    - An error message may appear on the Baker DX screen if you select the power pack option but the start button on the DX host unit is pressed versus the start button on the power pack/or footswitch.

Figure 77. "Press 'Test' on Power Pack" Message.

- Do not change either the function knob out of **HiPot** or the three-phase test lead selector switch during the performance of a HiPot test.

11. Adjust the function knob to select a different µA/division scale on the right side of the display to better monitor the leakage current (for example, if the signal is < 50 µA, switch to 10 µA/division; < 5 µA switch to 1 µA/division). Typically, the leakage current should rise initially and then fall and remain at a constant level. This constant level is the measure of the leakage current.

12. Upon completion of the test, return the voltage "Output Control" to **Min** (full counter-clockwise rotation) and release the start button (or footswitch). If desired, save the test results in the Active Folder / Active Record. Rerunning the test overwrites the last test results.

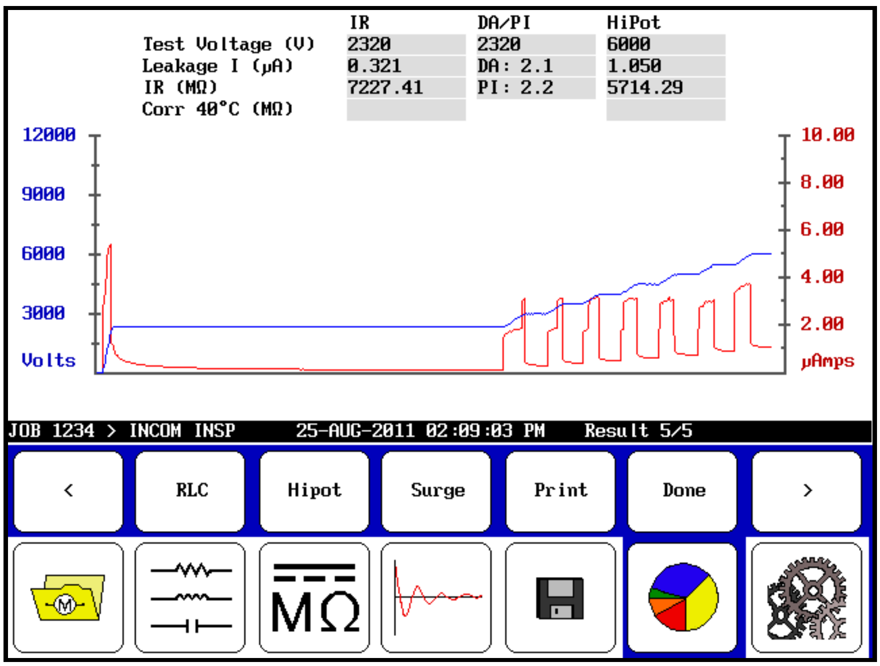


Figure 78. Test Results Screen.

- Shutting down the power pack prior to saving will cause the loss of all data.
- On the PP30, set the three-phase selector switch to the **leads ground** position before disconnecting test leads.
- On the PP40, wait at least 10 seconds before disconnecting test leads.

> **WARNING**! Always allow sufficient time for the test winding to completely discharge before disconnecting the test leads. The recommended practice is to discharge the winding for a duration of at least four times the duration of the DC-HiPot test for high voltage windings.

- To perform HiPot tests with the DX 12 kV host as a standalone unit, **you must disconnect the power pack from the host**.

For surge operation of the 12 kV host tester alone, the operator need not disconnect the two units. Simply place the 12 kV host unit function switch back to the **Surge** position.

Connect the safety ground (the smaller braided black ground) to the test winding's frame and not the coil ground lead. Surge test results will be erroneous if you use the coil ground lead instead of the frame for grounding.

Manual connection of the winding to test is required once for the PP30 and PP85. At this point, apply the different tests to all of the phases of the test object remotely, negating the need for manually-switched test operations that will still be required for the PP40.

Power Pack Surge Testing – PP30, PP85, PP40 (Three-Phase Lead Test Option PP30 and PP85 Only)

> ⚠ WARNING!
> – **High voltage testing**. Make sure all personnel are away from the device under test and not in contact with either the load or the test leads.
> – Some test leads will be open during the test and can be at the same voltage potential as the winding. Take all precautions to avoid touching these leads.

1. Check and confirm that the power pack setup procedure has been followed.
2. Turn the power pack "Output Control" voltage knob on the power pack to **MIN** (full counterclockwise). Select the **Surge** setting on the power pack function knob.

Figure 79. Power Pack Surge Testing Settings.

For the PP30 and PP85, ensure that the three-phase selector switch (lower right front panel) is also set to **Ground** (not available on the PP40).

3. Connect the power pack (PP30, PP85 only) leads to the test motor.

Motor Leads	**Lead 1**	**Lead 2**	**Lead 3**	**Frame**	**Black Braid**
Test Leads	60 kV Red	60 kV Black	60 kV Black	60 kV Black	Safety Ground

When hooking up to a three-phase motor, hook lead No. 1 or A to lead No. 1 or A of the motor, lead No. 2 or B to lead No. 2 or B of the motor, and lead No. 3 or C to lead No. 3 or C of the motor.

- If not using the PP40 power pack, skip to the next step. When using the PP40 power pack (single-phase testing), connect test lead No. 4 to ground and test lead No. 1 to any of the winding phase connections and leave test leads 2 and 3 disconnected/open, but connect the safety ground only to the motor frame.

Motor Leads	**Lead 1**	**Lead 2**	**Lead 3**	**Frame**	**Black Braid**
Test Leads	60 kV Red	60 kV Black	60 kV Black	60 kV Black	Safety Ground

- When using the PP40 power pack for single-phase surge testing of three-phase windings, move connections as follows:

Motor Leads	**Lead 1**	**Lead 2**	**Lead 3**	**Frame**	**Braid**
Test Phase A	Energized 60 kV Red	60 kV Black	60 kV Black	60 kV Black	Safety Ground
Test Phase B	60 kV Black	Energized 60 kV Red	60 kV Black	60 kV Black	Safety Ground
Test Phase C	60 kV Black	60 kV Black	Energized 60 kV Red	60 kV Black	Safety Ground

4. Turn on both the Baker DX and the power pack. If the function knob has been set on a surge setting, you will normally hear a loud relay noise.

5. Ensure that you plug the Baker DX and power pack into a good grounded source. Check that the open ground detect light is off or testing will be inhibited.

6. If a folder and record have not been created for the motor selected to test, do that now (following data management instructions in *Chapter 2*) from the folders icon  and set up the intended folder/record as the "Active Folder" and "Active Record" in the status bar.

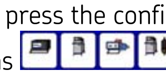
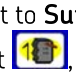
7. Select the surge Icon  from the DX start up screen to bring up the configuration options icon . When you press the configuration icon new icons appear that represent installed options , enabling operation as a standalone unit or with a power pack. If an interface board is **not** installed, the following message appears:

Figure 80. "No External Interface Options Installed" Message.

For this example, select the power pack icon .

8. Select the winding configuration icon wye/delta . The other options are . For this example, select the  icon.
9. For the PP30 and PP85, ensure that the three-phase selector switch (lower right front panel) is also set to **Surge** (not available on the PP40). With the first winding selected by default , the surge test is now ready for test start from the following screen.

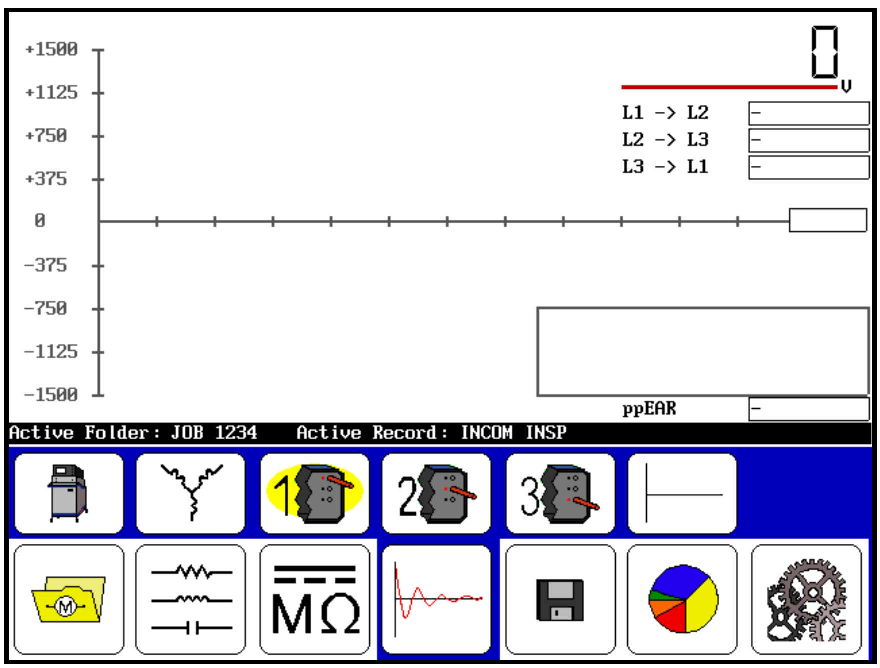
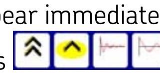


Figure 81. Surge Test Start Screen.

10. Start the test by pushing and holding the power pack start button (or footswitch). Using the power pack's "Output Control" voltage knob, slowly increase the voltage. Test results should appear immediately. Use the Baker DX unit's speed control and scale time base icons  to reach the target voltage faster and to display the appropriate scale time base.
11. Upon completion of the test, return the voltage "Output Control" to **Min** (full counter-clockwise rotation) and release the start button (or footswitch). If desired, save the test results in the Active Folder/Active Record. If you rerun the test without saving, the new test will overwrite the last test results.

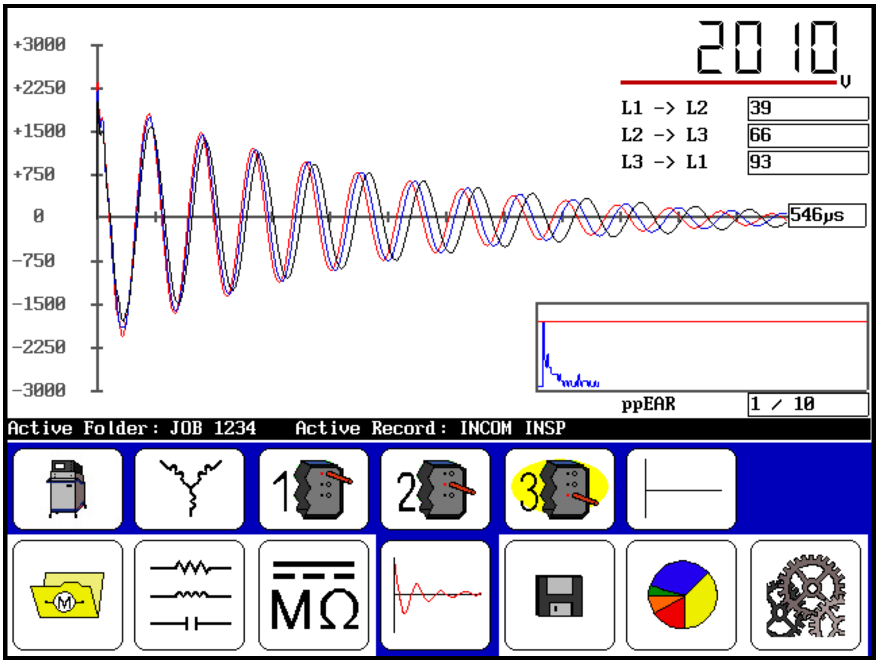


Figure 82. Test Results Screen.

- Shutting down the power pack prior to saving will cause the loss of all data.
- On the PP30, set the three-phase selector switch to the **leads ground** position before disconnecting test leads.
- On the PP40, wait at least 10 seconds before disconnecting test leads.

> **WARNING!** Always allow sufficient time for the test winding to completely discharge before disconnecting the test leads. The recommended practice is to discharge the winding for a duration of at least four times the duration of the DC-HiPot test for high voltage windings.

- For HiPot operation of the DX 12 kV host as a standalone unit, you must disconnect the power pack from the host.

For surge operation of the 12 kV host tester alone, the operator need not disconnect the two units. Simply place the 12 kV host unit function switch back to the surge position.

Connect the safety ground (the smaller braided black ground) to the test winding's frame and not the coil ground lead. Surge test results will be erroneous if you use the coil ground lead instead of the frame for grounding.

Manual connection of the winding to test is required once for the PP30 and PP85. At this point, apply the different tests to all of the phases of the test object remotely, negating the need for manually-switched test operations that will still be required for the PP40.

9
Supplement 2: Armature, Bar-to-Bar, Span, DC IP, and DC FC Testing

General Information

The Baker DX series digital tester works with the PP85 (30 kV) power pack and the ZTX high current surge test adapter, both of which have an armature testing capability for low impedance series wound DC motor armature windings, as well as other low-impedance coils.

Review the instructions for stand-alone operation of the Baker DX before attempting to operate with a power pack. This chapter provides instruction on how to correctly set up, connect, and operate the power pack.

A power pack and ZTX are purchased with and calibrated to the Baker DX host it is shipped with. The back panel of the power pack lists the DX serial number and, therefore, certified to work only with that power pack.

Important Safety Information

NOTICE: The ground fault system on the Baker DX will render it inoperative without a proper ground. When the host Baker DX tester is connected to a power pack, an inoperable condition will also affect the power pack due to loss of the surge enable signal.

NOTICE: Never attempt testing a load with both 12 kV and power pack leads attached to the load at the same time. Damage to the tester may occur.

Danger

High Voltage

To prevent serious injury or death:
- **Do not use in explosive atmospheres.**
- **Do not contact test leads or the device being testing while a test is in progress or during discharge period.**
- **Do not connect test leads to live circuits.**

Read and follow safety precautions and safe operating practices in the operator manual. Do not exceed maximum operating capabilities of this instrument.

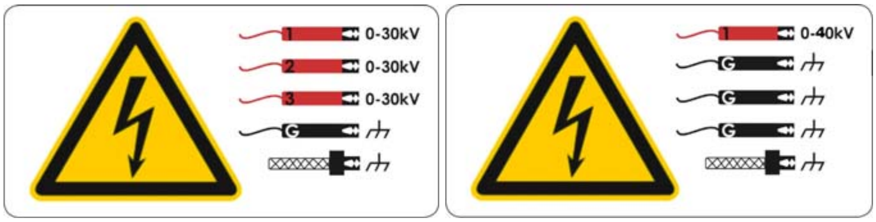


Figure 83. PP85 Lead Safety Label.

Emergency Shutoff Button

Use the E-Stop to quickly discontinue a test and to shut off power to both the power pack and the Baker DX.

PP85 Power Pack E-Stop

Power packs are equipped with a red **Emergency Stop** (E-Stop) button on the front panel of the unit.

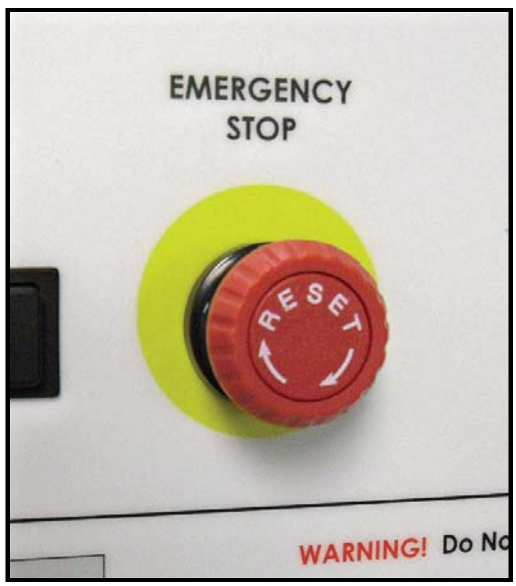


Figure 84. Emergency Stop (E-Stop) Button.

ZTX E-Stop and Remote E-Stop

The ZTX unit and the remote E-Stop both are each equipped with a red **Emergency Stop** (E-Stop) button. The E-Stop is on top of the ZTX unit and it is in the line with the status lights on the remote E-Stop accessory.

Figure 85. ZTX E-Stop.

Figure 86. Remote E-Stop.

- When using this button, the computer will shut down and you will lose unsaved data.

The button will remain locked in position until manually retracted by rotating the **Emergency Stop** button clockwise.

Other Important Safety Warnings

Failure to follow these precautions can result in severe electrical shock or death.

1. **Never** attempt a two-party operation. Always know what test is being performed and when. For example, **do not** adjust test leads when operating a footswitch. Leads will have live voltage and severe electrical shock may result.
2. For capacitor-started motors or systems with surge arrestors/power factor capacitors, be sure to **disconnect** all capacitors from the test circuit **before** testing.
3. Upon completion of a DC HiPot, megohm, polarization index (PI), step voltage, dielectric absorption (DA), or continuous ramp test, before disconnecting the test leads, short the winding, motor, etc., to ground and allow time for discharge. If this is not complete, voltage may still be active on leads and tested components.
4. Make sure to disconnect the tester leads before energizing or powering up the motor.
5. **Do not** remove the product covers or panels or operate the tester without the covers and panels properly installed. Components on the inside of the tester carry voltage for operation and can render a shock if touched.
6. Use appropriate safety equipment required by your organization, including high voltage gloves and eye protection.
7. **Repair parts notice:** You must replace defective, damaged, or broken test leads with factory-authorized parts to ensure safe operation and maintain performance specifications.
8. **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/grounded 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 cause an electric shock!
9. This instrument is **not** waterproof or sealed against water entry.
10. The unit is for indoor use. If using outdoors, you must protect the unit from rain, snow, and other contaminants.

Power Pack Set up for Armature Tests

(If you are using the ZTX unit, skip to the next section)

- When shipped, the package containing the power pack must be properly labeled with "this side up" to ensure there is no damage to the instrument. Inspect for damage and notify the carrier immediately.
- Check to confirm that the back panel of the power pack lists the Baker DX serial number before connecting to power pack.

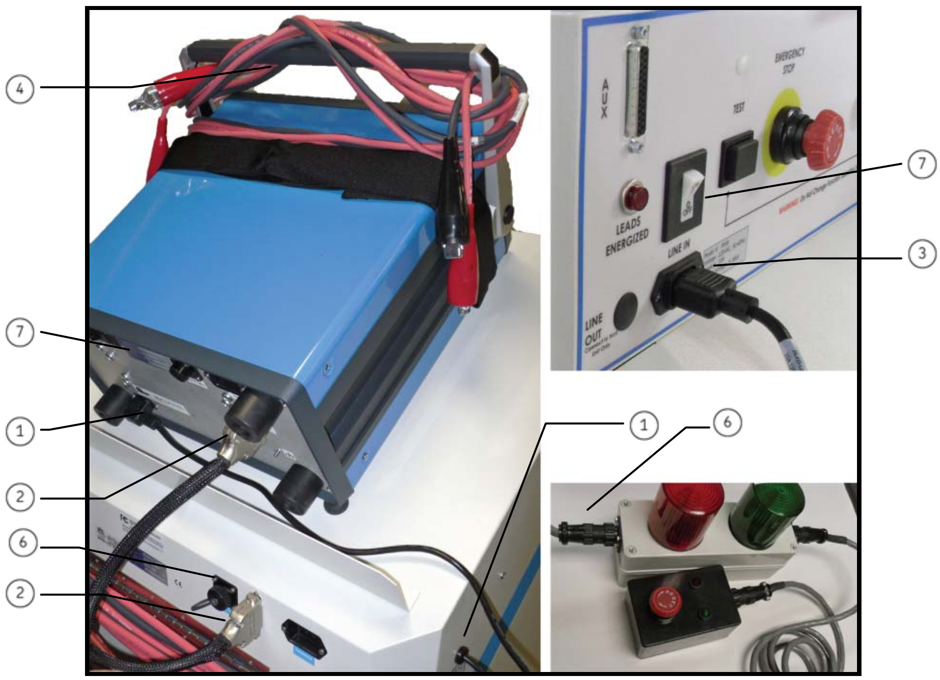


Figure 87. Power Pack Setup for Armature Tests.

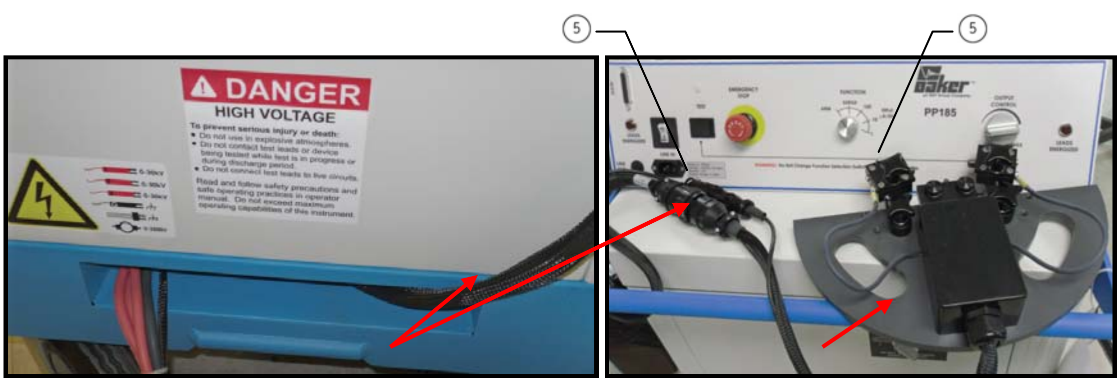


Figure 88. Test Head Cable and Connectors and Armature Fixture.

Figure 89. Accessory Clips – Inter-Pole Testing.

Figure 90. Accessory Probes – Armature Span Testing.

1. Connect the power pack to the tester. Use the short AC line cord on the power pack rear side panel to connect to the Baker DX's power entry receptacle.
2. Connect the 25-pin interconnect cable to the two units. The cable is marked on each end. Be sure to plug in the end marked **Host** or **BAKER DX /D** into the auxiliary port (**AUX**) on the front of the Baker DX and the end marked **30 kV** or **power pack** into the auxiliary port (**AUX**) on the front of the power pack.
3. Connect the long AC power cord to the power pack front panel receptacle and then to an appropriate AC power source. Refer to the *Power requirements* section in the *Preface* of this manual for appropriate power requirements.
    - Regarding 220/240 V AC units, the user may be required to supply an appropriate AC connector for mating to the power source. These units are designed for use on a single (1) phase 220/240 V AC power source. Split phase AC power sources will not work.
4. Note the storage of Baker DX high voltage leads out of the way.
5. Connect the test head cable from the PP85 to the test head fixture.

6. If you will use the remote E-Stop, connect it to the indicated location on the back of the power pack.
7. Power up the Baker DX and the power pack. Follow the Baker DX setup procedures in this manual.
8. After a one or two minute warm up period, both units will be ready for operation.
   - The Baker DX is equipped with a ground fault monitor and indicator. This circuitry should not hinder operation of GFI protected AC power circuits.

ZTX AT101 Set up

(If you are using the PP85 power pack, see the previous section)

- When shipped, the package containing the ZTX must be properly labeled with “this side up” to ensure there is no damage to the instrument. Inspect for damage and notify the carrier immediately.
- Check to confirm that the back panel of the ZTX lists the Baker DX serial number before connecting to the ZTX.

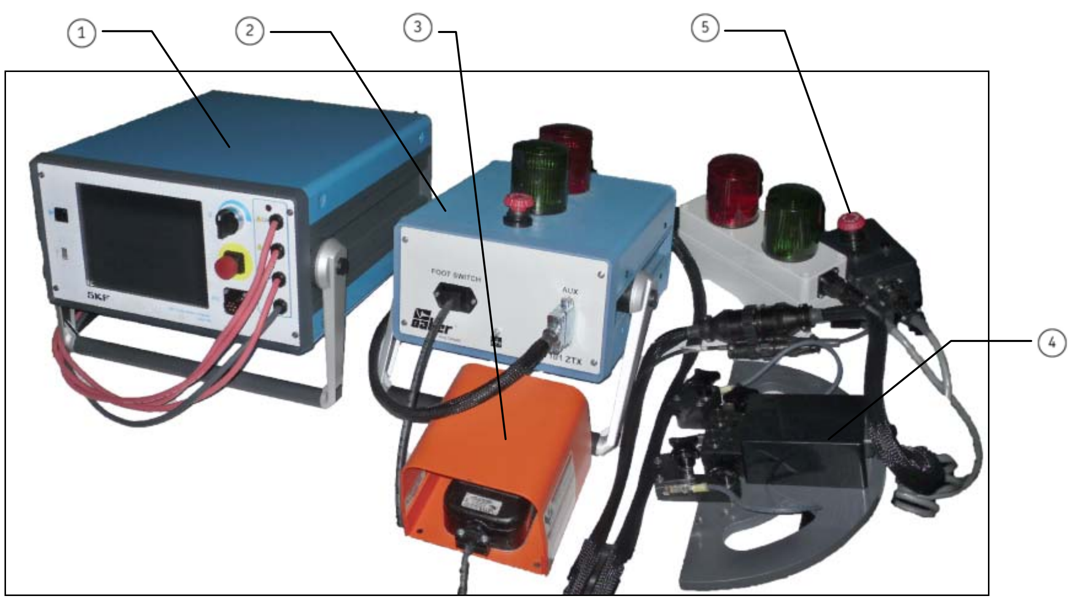


Figure 91. ZTX AT101 Setup.

	Description
1	Baker DX
2	ZTX unit
3	Footswitch
4	Armature fixture
5	Remote E-stop/lights accessory

1. Connect the 25-pin interconnect cable to the two units. The cable is marked on each end. Be sure to plug in the end marked **Host** or **BAKER DX** into the auxiliary port (**AUX**) on the rear of the Baker DX and the end marked **ZTX** into the auxiliary port (**AUX**) on the rear of the ZTX unit.
2. Connect the high voltage test leads of the Baker DX to the ZTX unit's recessed bars located on the rear of the ZTX as follows:
   - Connect test lead No. 1 to the bar labeled "Test Lead 1."
   - In a similar manner, connect the ground and test leads No. 2 and No. 3 to the recessed bar labeled as such.
3. Connect the "Test Head" cable to the back of the ZTX unit as labeled and the other end to the test head using the two connectors, the smaller of which is the frame ground.
4. Connect the footswitch to the front panel connector labeled as such.
5. If using the remote E-stop, connect it to the indicated location on the back of the Baker DX.
6. Connect the long AC power cord to the power pack front panel receptacle and then to an appropriate AC power source. Refer to the *Power requirements* section in the *Preface* of this manual for appropriate power requirements.
   - ➢ Regarding 220/240 V AC units, the user may be required to supply an appropriate AC connector for mating to the power source. These units are designed for use on a single (1) phase 220/240 V AC power source. Split phase AC power sources will not work. Color codes for the AC line cords supplied are as follows.

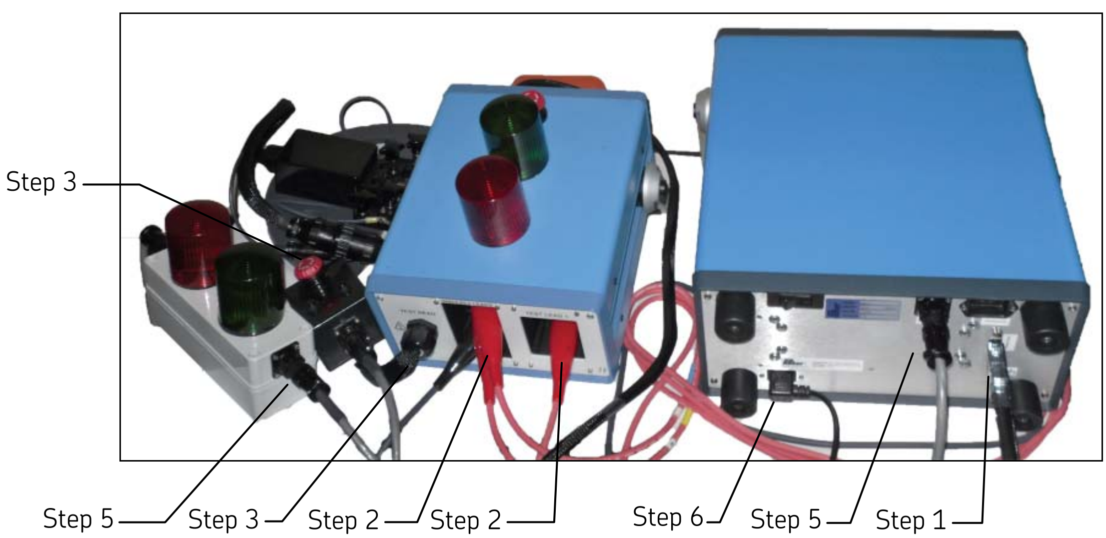


Figure 92. ZTX AT101 Setup.

7. Power up the Baker DX (ZTX is powered from the DX host). Follow the Baker DX setup procedures presented earlier in this manual.
8. After a one or two minute warm up period, both units will be ready for operation.

- The Baker DX is equipped with a ground-fault monitor and indicator. This circuitry should not hinder operation of GFI protected AC power circuits.

Instrument Notices

Before use:

- Use the footswitch to facilitate armature bar-to-bar or span testing.
- Do not allow the Baker DX's test leads to lie anywhere near the power pack test leads. The unit's leads should coil on top of the unit or loop on the power pack handle. Otherwise, testing can result in interference with its computer.
- Make sure the Baker DX's (host) leads do not connect together.
- Make sure the Baker DX's (host) ground test lead does not connect for grounding during the power pack test.
- Make sure no printer or CD ROM devices are hooked up to the USB port.
- The power pack, when equipped with the three-phase selector switch option, is not rated for operation in any position other than standing vertically, with all four wheels down on a level surface.
- If the Baker DX is getting AC power from the power pack and if the power pack is off, the Baker DX is also off.

During use:

- Do not switch the test leads or change the three-phase selector switch.
- If the power pack connection to the Baker DX is maintained and the power pack is turned off, I/O lines are influenced. This may cause problems with Baker DX operation.

For armature, bar-to-bar, span test, and DC IP, set the three-phase lead selector switch to the ground position on PP85.

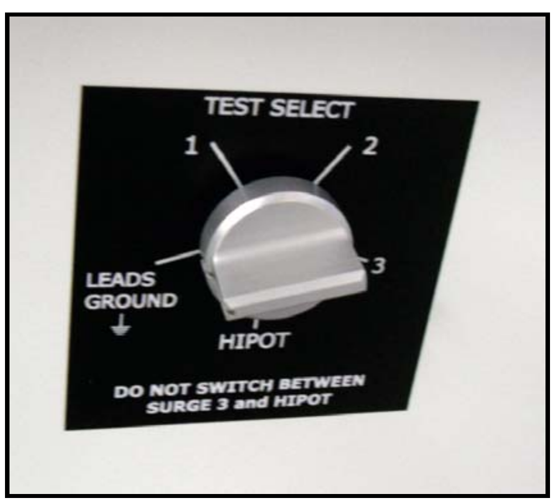


Figure 93. Three-Phase Lead Selector Switch – Ground Position.

Output Lead Configuration

The protocol of the test leads in the braided test head cable are predetermined for the testing in this section.

- You must place the “Function” switch of the power pack control panel into the Armature position (**ARM**) to perform armature tests.

Do not switch the test lead select switch or the function switch while a test is in progress. You may substantially reduce the switching element’s useful life if you perform such switches in the middle of a test.

Operating Procedure – PP85 Power Pack Armature Testing

(If you are using the ZTX unit, skip to the ZTX section)

The power pack, when equipped with the three-phase selector switch option, is **not** rated for operation in any position other than vertically, with all four wheels down on a level service.

When shipped, the package containing the power pack must be properly labeled with “this side up” labels to ensure the instrument is shipped in the upright position.

Figure 94. PP85 – 30 kV Power Pack with Three-Phase Selector Switch (Lower Right Front Panel).

The armature test feature is built and can be selected with the “Function” switch.

> **WARNING!**
> – **High voltage testing**. Make sure all personnel are away from the device under test and not in contact with either the load or the test leads.
> – Some test leads will be open during the test and can be at the same voltage potential as the winding. Take all precautions to avoid touching these leads.

1. Check that the power pack setup procedure has been followed.
2. Turn the power pack "Output Control" voltage knob on the power pack to **MIN** (full counter-clockwise). Set the "Function" switch to Armature (**ARM**).

Figure 95. PP85 Power Pack with Three-Phase Selector Switch (Lower Right Front Panel) Set to Ground.

For the PP85, ensure that the three-phase selector switch (lower right front panel) is also set to **Ground**.

3. Ensure the test lead cable is properly connected to the Armature test fixture.
4. Power up both the Baker DX and the power pack. When powering up the power pack, it is normal to hear a loud noise.
5. Ensure that the Baker DX and power pack plug into a good grounded source. An open ground detect will keep the tester from operating. Check using the settings icon  and the "Open Ground" icon to see if it is set correctly.
6. If a folder and record have not been created for the motor selected to test, do that now (following data management instructions in *Chapter 2*) from the folders icon  and set up the intended folder/record as the "Active Folder" and "Active Record" in the status bar.

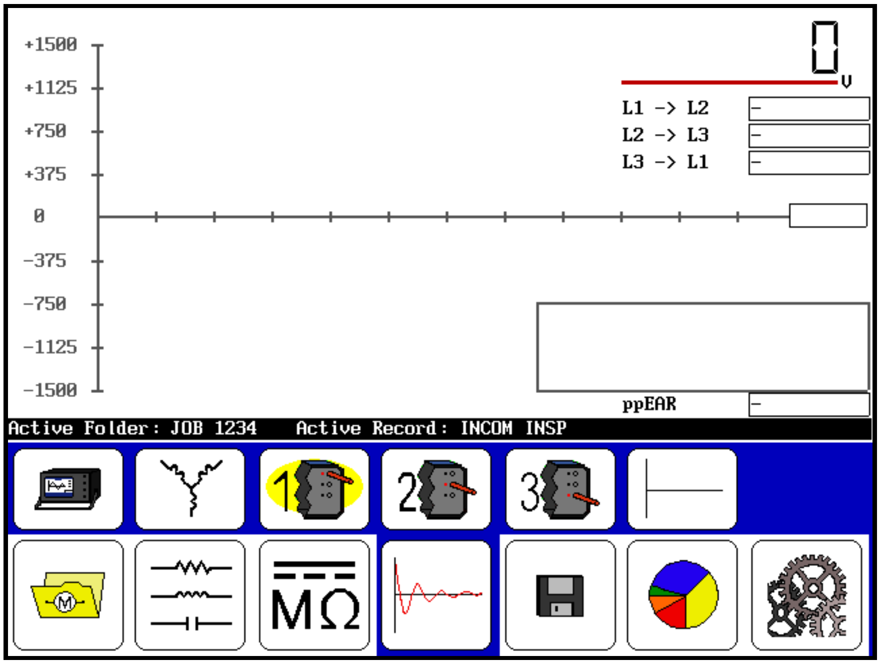


Figure 96. Start Screen.

7. Using the touch screen, select the surge icon to bring up the configuration options icon, which then indicates if there are any installed options. Icons that appear will allow operation as a standalone unit or with power packs (PP30, PP40), ZTX, and PP85 power pack with ZTX built in. If an interface board is **not** installed, the following message appears:

Figure 97. "No External Interface Options Installed" Message.

Select the PP85 power pack icon to continue with this example.

8. Select the coil icon and then the **Arm Bar** icon from the menu.

9. Select the test lead icon.

10. For the PP30 and PP85, ensure that the three-phase selector switch (lower right front panel) is set to **Ground**.

11. Position the armature fixture on the armature at a selected starting point.

    Use knobs to adjust contacts (centered on commutators). Set up the hot contact centered on selected No. 1 commutator (60 total). Position the two ground contacts such that they center on the selected commutator.

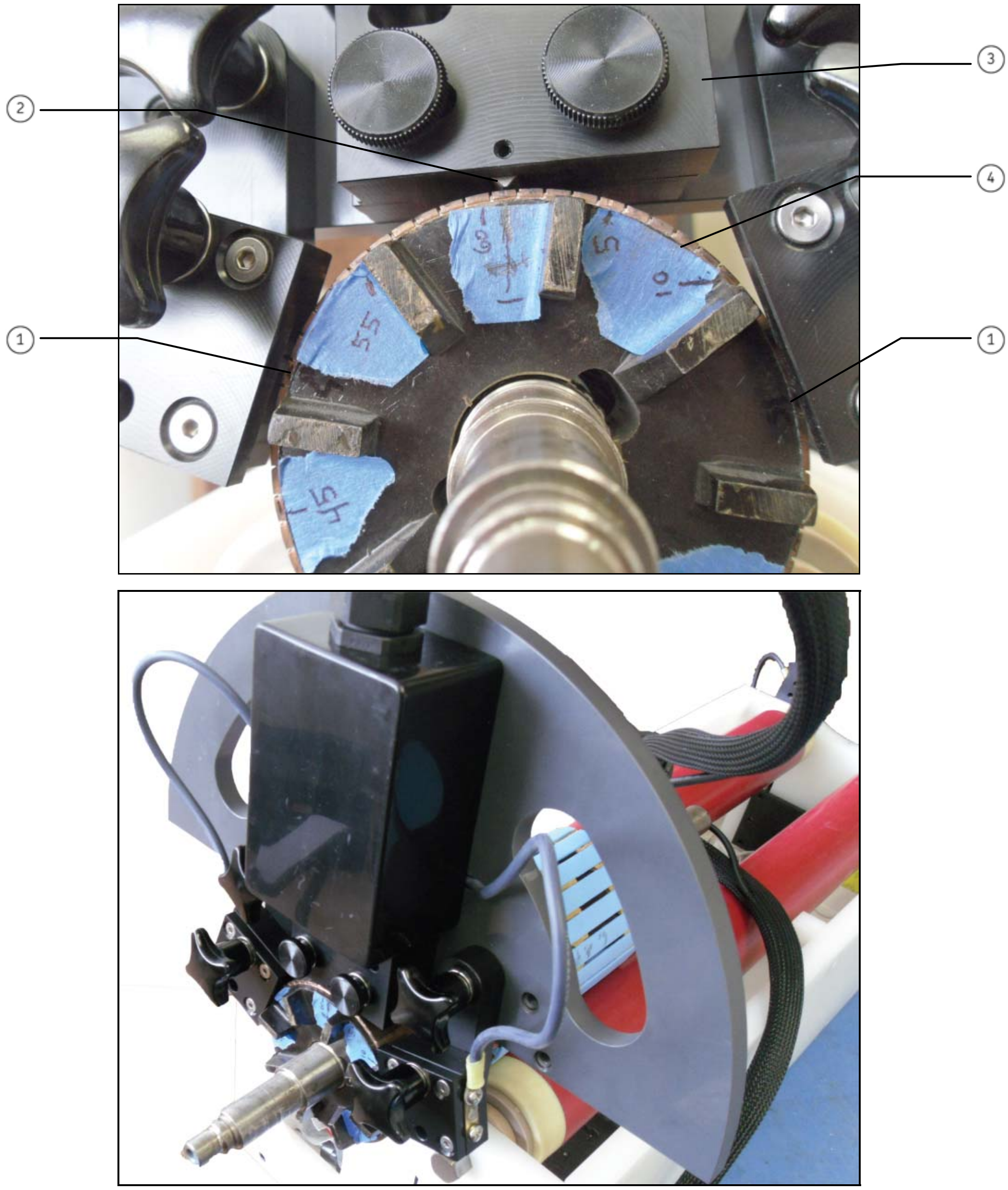


Figure 98. Position the Armature Fixture on the Armature.

	Description
1	Ground contacts
2	Hot contact centered
3	Text fixture
4	Armature commutator

The "Arm Bar" test is now ready for test start from the following screen.

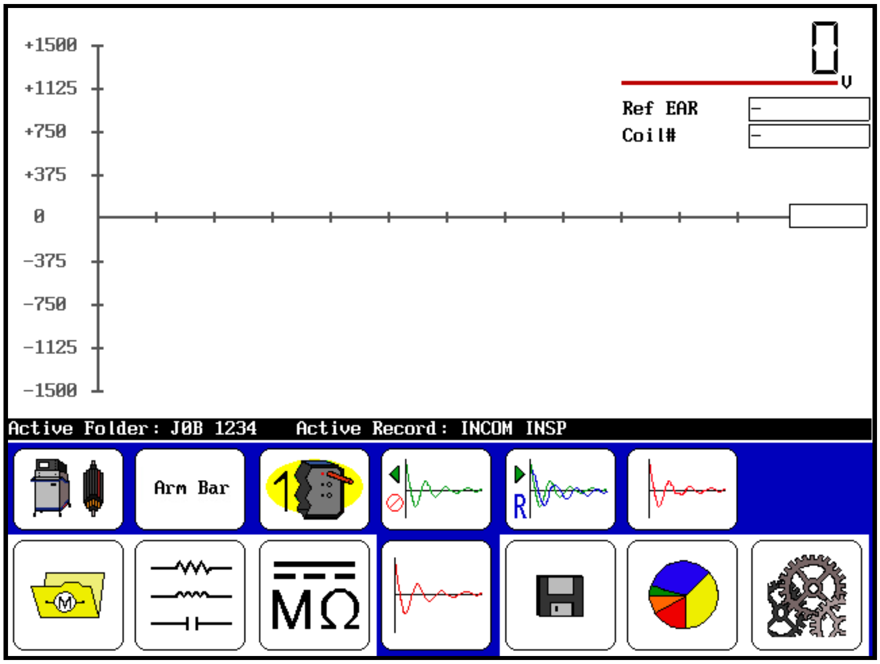
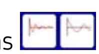


Figure 99. Arm Bar Test Start Screen.

12. Go to the power pack and press and hold the start (**PTT**) button and the scale control icons appear .

    Alternately use the speed control fast/slow icons  to control the rate of scaling while rotating the "Output Control" voltage knob to set the test voltage. For this example, set the voltage to 870 volts (typically add 300 volts for each turn).

    Use the time base icons  for scaling the horizontal axis to an appropriate time base.

    - An error message may appear on the Baker DX screen if you select the power pack option and the power pack has not been properly connected to power or connected to the Baker DX.

Figure 100. "Press 'Test' on Power Pack" Message.

- Do not change either the function knob out of **Arm** or use the three-phase test lead selector switch during the performance of any armature test.

13. Preferably using the footswitch, test several commutator samples and select one for a starting point and as a reference.

    From a sample, select one to be the reference by selecting the reference icon  and then press the **ZS Override** icon and select **Yes** to the override message. (**Note:** Do not move the "Output Control" knob after selecting **Yes**.)

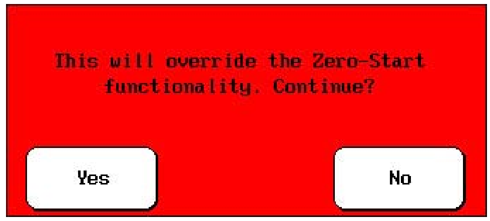


Figure 101. Override Message.

14. Starting at position one, press and hold the footswitch momentarily.
15. On the power pack, press and briefly hold the start button (or preferably the footswitch) to test an armature winding. Rotate the armature to the next commutator and repeat for each. Prior to Step 16, some deviant armature scan results appear as follows:

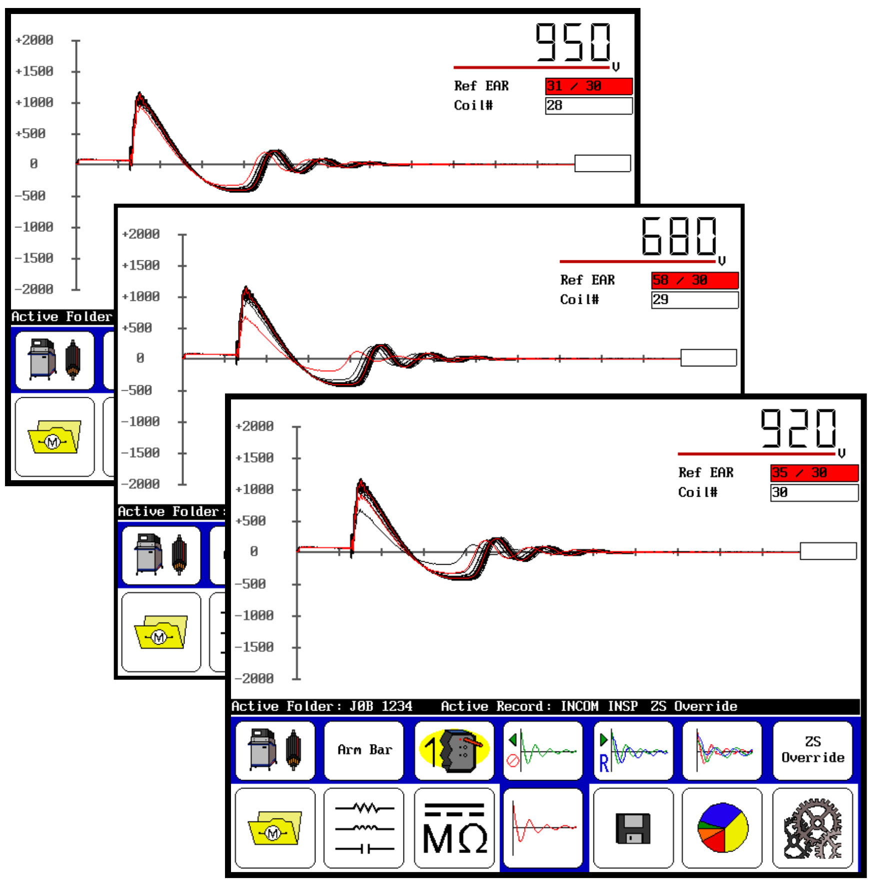


Figure 102. Deviant Armature Scan Results.

16. Upon completion of the test, return the voltage "Output Control" to **Min** (full counter-clockwise rotation) and release the start button (or footswitch).
    - ➢ Shutting down the power pack prior to saving test data will result in the loss of all data.
    - ➢ On the PP30, set the three-phase selector switch to the **leads ground** position before disconnecting test leads.
    - ➢ On the PP40, wait at least 10 seconds before disconnecting test leads.

If desired, save the test results  in the Active Folder/Active Record. It will save as **Arm Bar** data and it will appear on the results as such. Running the test continues adding armature coils up to 200, after which you must create a new record for armature with more commutators. View the 30 commutator coil results (below) by selecting the report icon  and display icon to view results.

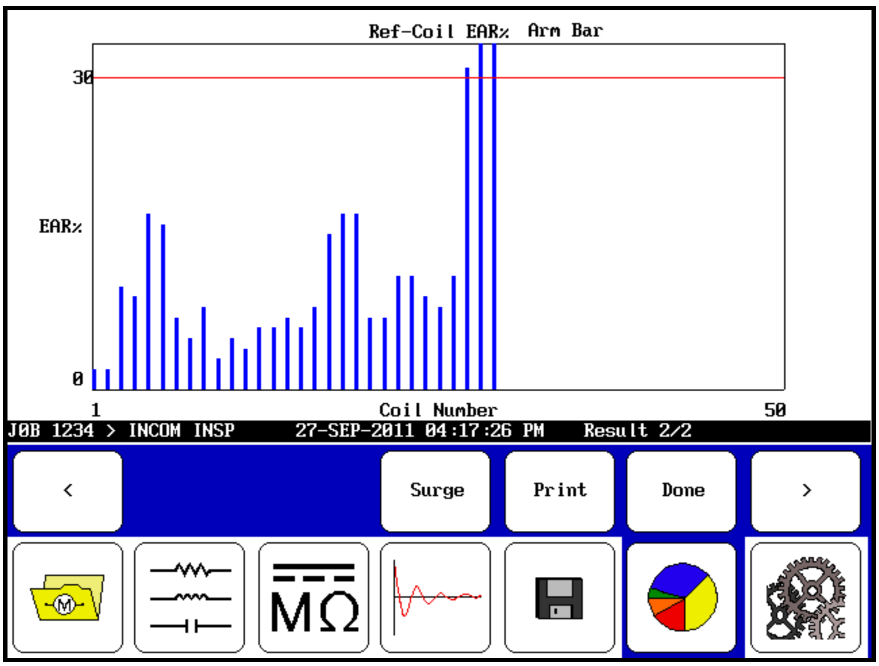


Figure 103. Commutator Coil Results Screen.

- ➢ As indicated by scans, armature coils 28, 29, and 30 are out of criteria.

For surge operation of the DX 12 kV host tester as a standalone, the operator need not disconnect the two units. Simply place the 12 kV host unit function switch back to the **Surge** position.

Operating Procedure – PP85 Power Pack Generic Coil and DC IP Testing

(If you are using the ZTX unit, skip to the ZTX section)

The Baker DX, in combination with the PP85 power pack, also accommodates testing of DC IP (inter-poles) and generic coils.

1. Go to Step 1 of the prior *Operating Procedure – PP85 Power Pack Armature Testing* procedures and follow it to Step 3, where an exception is noted.
2. In Step 3, connect the clip accessory to the test lead cable (versus the armature fixture). Follow the prior procedures to Step 8.

Figure 104. Connect the Clip Accessory to the Test Lead Cable .

3. In Step 8, select the coil icon or **DC IP** icon (versus the **Arm Bar** icon). From Step 8, follow the prior procedures to Step 11.
4. In Step 11, connect the clips accessory to a DC inter-pole coil (versus the armature fixture) and proceed, with the exception that you must connect each coil before each test. Follow the prior procedures to Step 16.

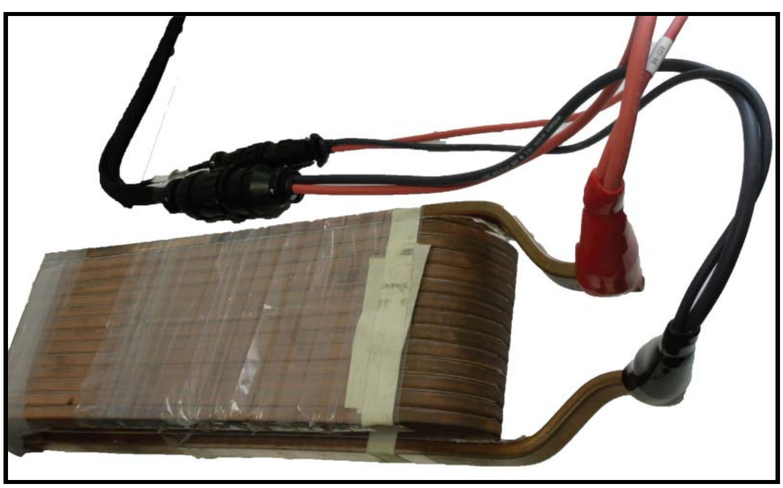
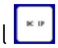


Figure 105. Connecting the Clip Accessory to a DC Inter-Pole Coil.

This leads to the following screen for testing of a coil or a DC inter-pole coil  (chosen for this example).

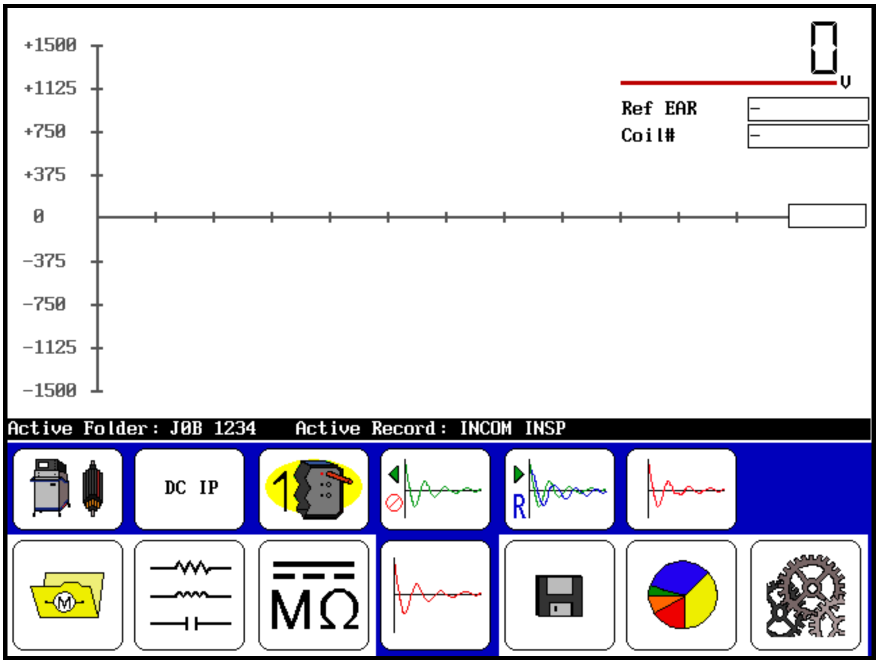


Figure 106. Coil Testing Screen.

5. Before Step 16 in the prior procedure, the scan results appear as follows.

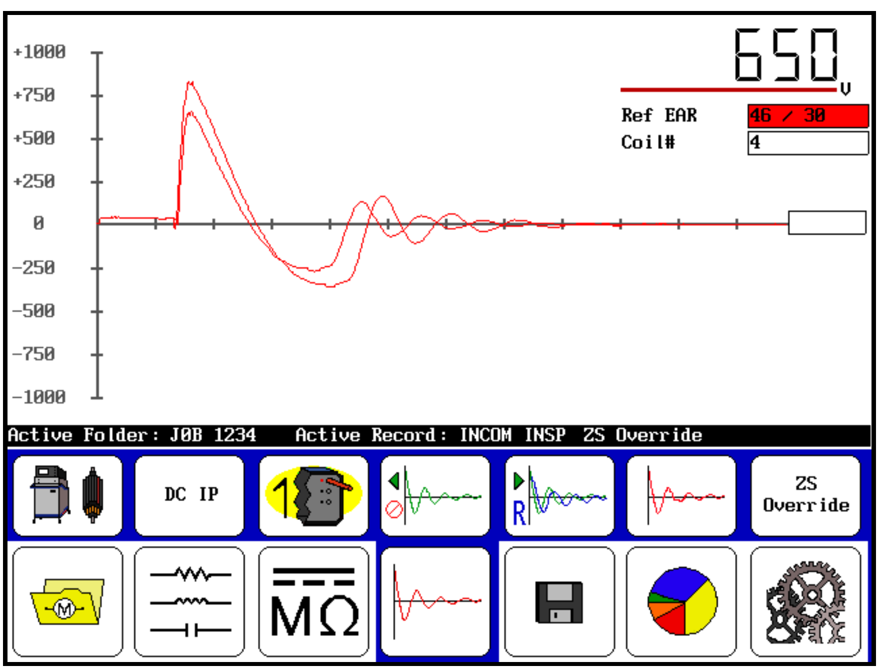


Figure 107. Scan Results.

Instead of performing Step 16, do the following. For completion of the tests, return the voltage "Output Control" to **Min** (full counter-clockwise rotation) and release the start button (or footswitch). If desired, save the test results in the Active Folder / Active Record. It will save as the name of the original test selected, such as generic coil or the DC IP mode, and it will appear on the results as such. A retest of a coil overwrites the last test unless you save the data for the last test.

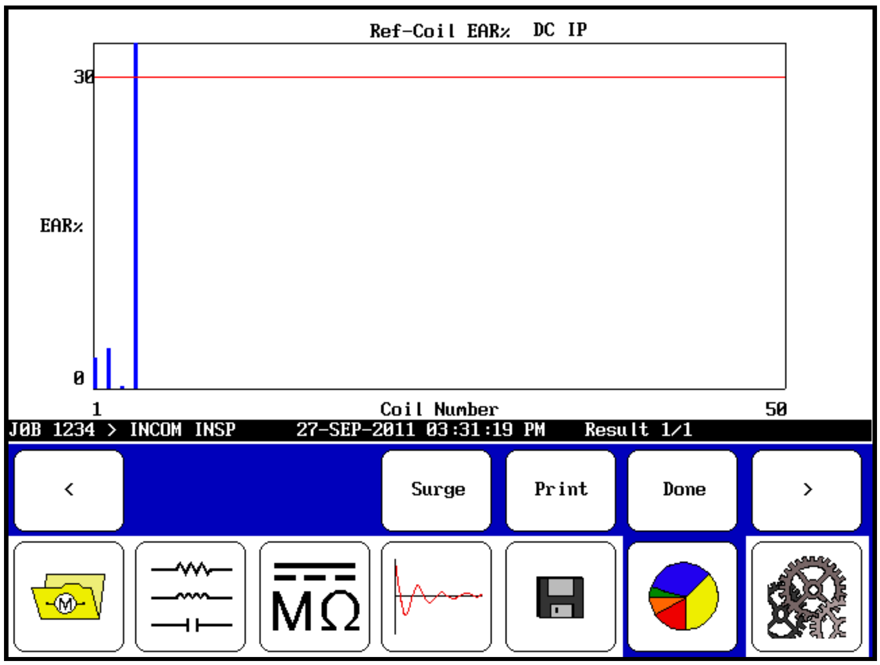


Figure 108. Results Screen.

Operating Procedure – ZTX A101 Armature Testing

(If you are using the PP85 power pack, refer to the PP85 section above)

The ZTX A101 unit extends the capabilities of the DX host unit to be able to test low-impedance coils, such as found in DC armature and other coils.

Figure 109. DX and ZTX Armature Testing System.

	Description
1	Footswitch
2	Armature fixture
3	Remote E-stop and warning lights

WARNING!

– **High voltage testing**. Make sure all personnel are away from the device under test and not in contact with either the load or the test leads.
– Some test leads will be open during the test and can be at the same voltage potential as the winding. Take all precautions to avoid touching these leads.

1. Check and confirm that the ZTX A101 unit setup procedure has been followed.
2. Ensure to properly connect the test lead cable to the armature test fixture.
3. Power up the Baker DX; the DX host powers the ZTX.

4. Ensure that the Baker DX and power pack plug into a good grounded source. An open ground detect will keep the tester from operating. Check the settings icon and the "Open Ground" icon to see if it is set correctly.

5. If a folder and record have not been created for the motor selected to test, do that now (following data management instructions in *Chapter 2*) from the folders icon and set up the intended folder/record as the "Active Folder" and "Active Record" in the status bar.

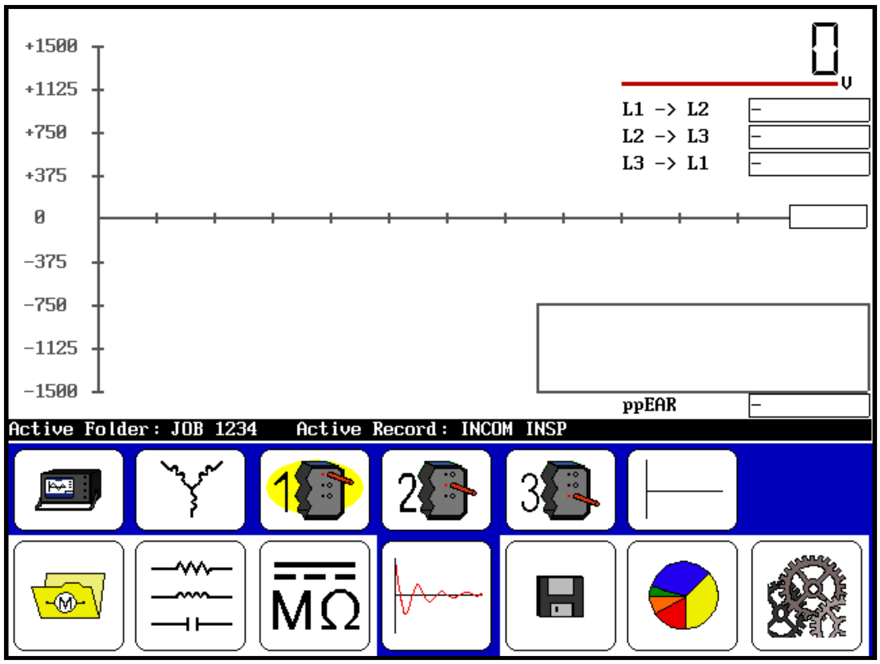


Figure 110. Start Screen.

6. From the DX screen, select the surge icon to bring up the configuration options icon. When selected, any icons that appear indicate installed options that enable operation as a standalone unit, or with power packs (PP30, PP40), ZTX, and PP85 power pack with ZTX built in. If an interface board is **not** installed, the following message appears:

Figure 111. "No External Interface Options Installed" Message.

Select the ZTX icon for purposes of this instruction.

7. Select the coil icon and then the **Arm Bar** icon from the menu.

8. Select the test lead icon.

9. Position the armature fixture on the armature at a selected starting point:

   Use knobs to adjust contacts (centered on commutators). Set up the hot contact centered on selected No. 1 commutator (60 total). Position the two ground contacts such that they center on the selected commutator.

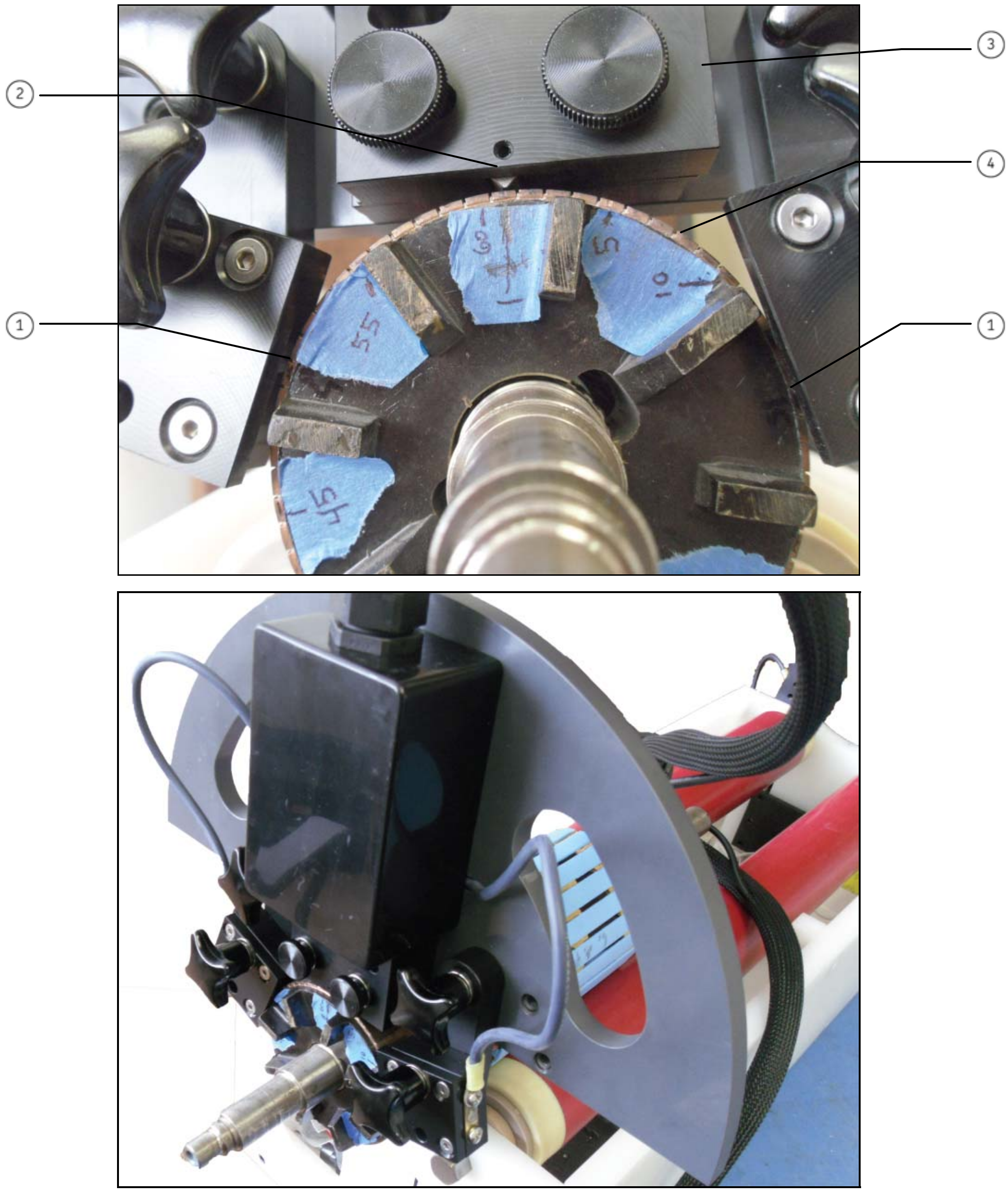


Figure 112. Position the Armature Fixture on the Armature.

	Description
①	Ground contacts
②	Hot contact centered
③	Text fixture
④	Armature commutator

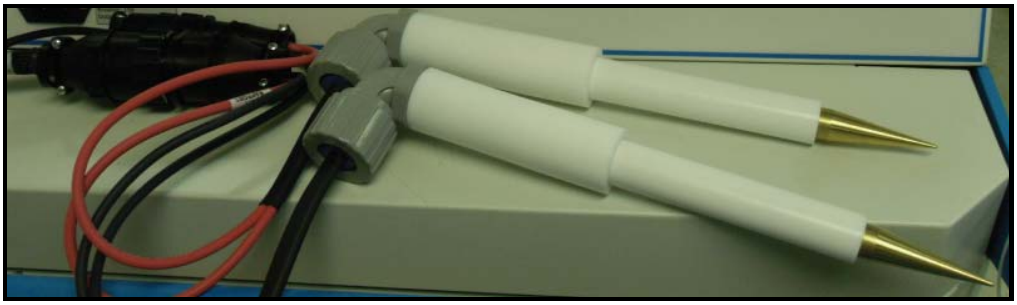


Figure 113. Span Probes.

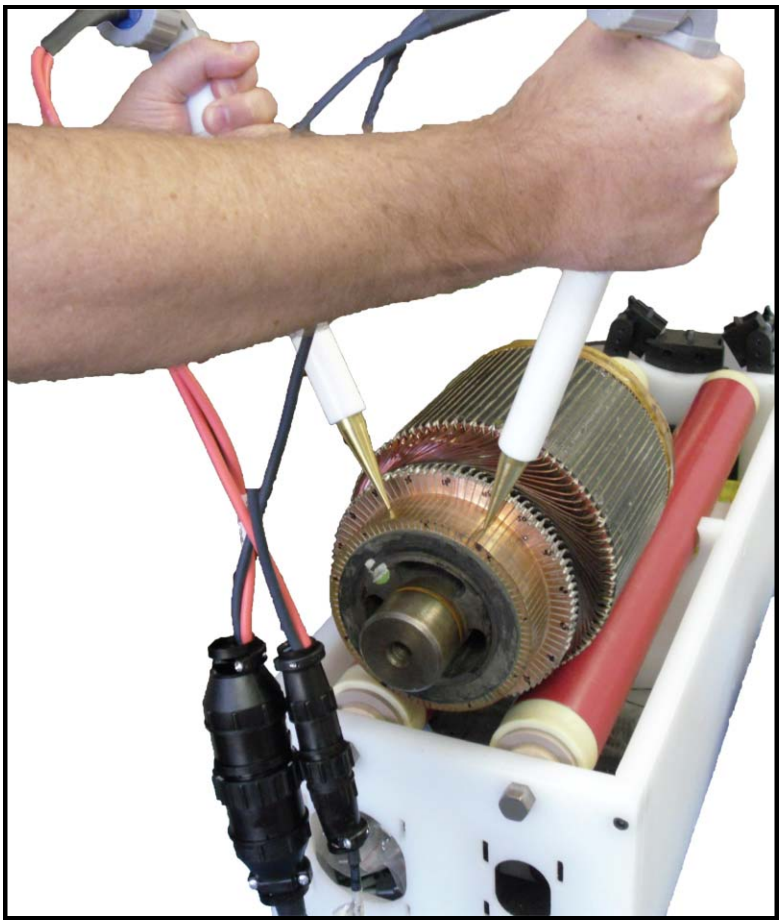


Figure 114. Span Probes.

- The span probes are a substitute accessory that you can attach to the test cable leads instead of the armature fixture. The probes can further expand the low impedance capability of armature testing by testing over several coils and incrementing through the armature in this manner.

The "Arm Bar" test is now ready for test start from the following screen.

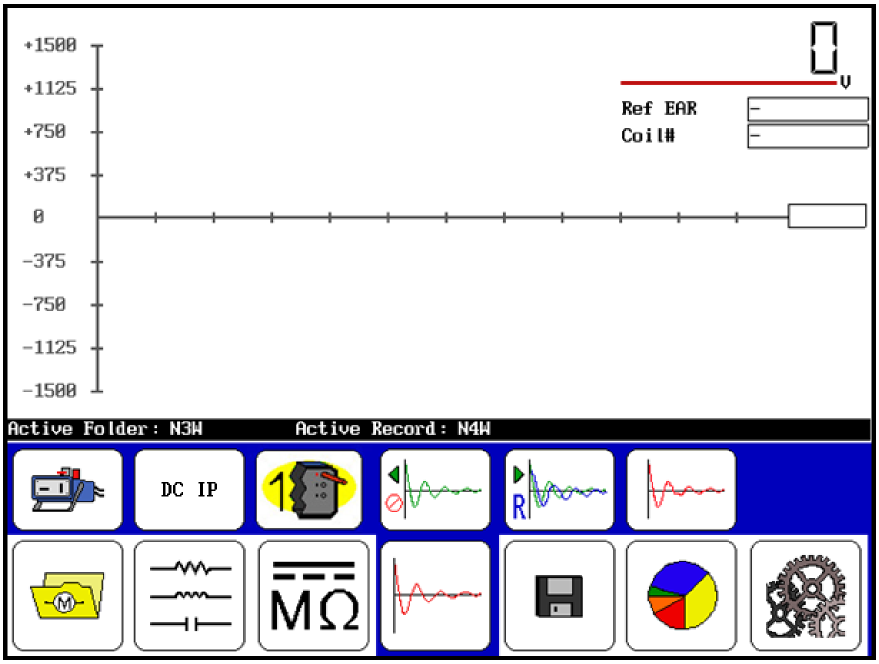


Figure 115. Arm Bar Test Start Screen.

10. Go to the DX host and press and hold the start (**PTT**) button and the scale control icons appear .

    Alternately use the speed control fast/slow icons  to control the rate of scaling while rotating the "Output Control" voltage knob to set the test voltage. For this example, set the voltage to 870 volts (typically add 300 volt for each turn).

    Use the time base icons  for scaling the horizontal axis to an appropriate time base.

11. Preferably using the footswitch, test several commutator samples and select one for a starting point and as a reference.

    From a sample, select one to be the reference by selecting the reference icon  and then press the **ZS Override** icon and select **Yes** to the override message.

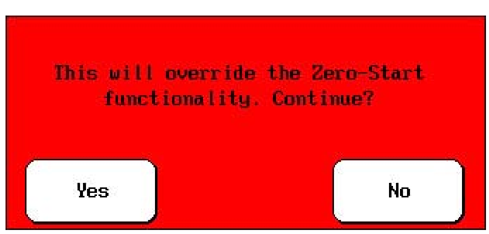


Figure 116. Override Message.

12. Starting at position one, press and hold the footswitch momentarily.

13. On the power pack, press and briefly hold the start button (or preferably the footswitch) to test an armature winding. Rotate the armature to the next commutator and repeat for each. Prior to Step 14, some deviant armature scan results appear as follows:

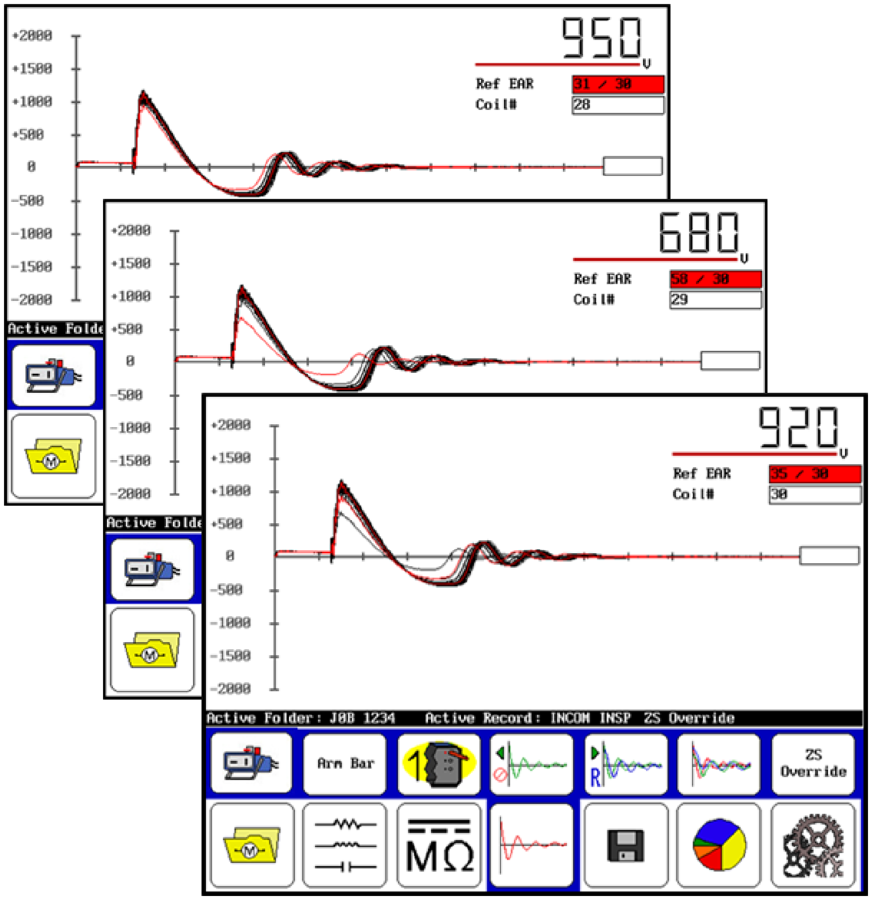


Figure 117. Deviant Armature Scan Results.

14. Upon completion of the last test, release the start button (or footswitch).
    - ➢ Shutting down the DX host prior to saving will result in the loss of all data from the previous unsaved test.

If desired, save the test results  in the Active Folder / Active Record. It will save as **Arm Bar** data and it will appear on the results as such. Running the test continues adding armature coils up to 200, after which you must create a new record for armature with more commutators. View the 30 commutator coil results (below) by selecting the report icon  and display icon to view results:

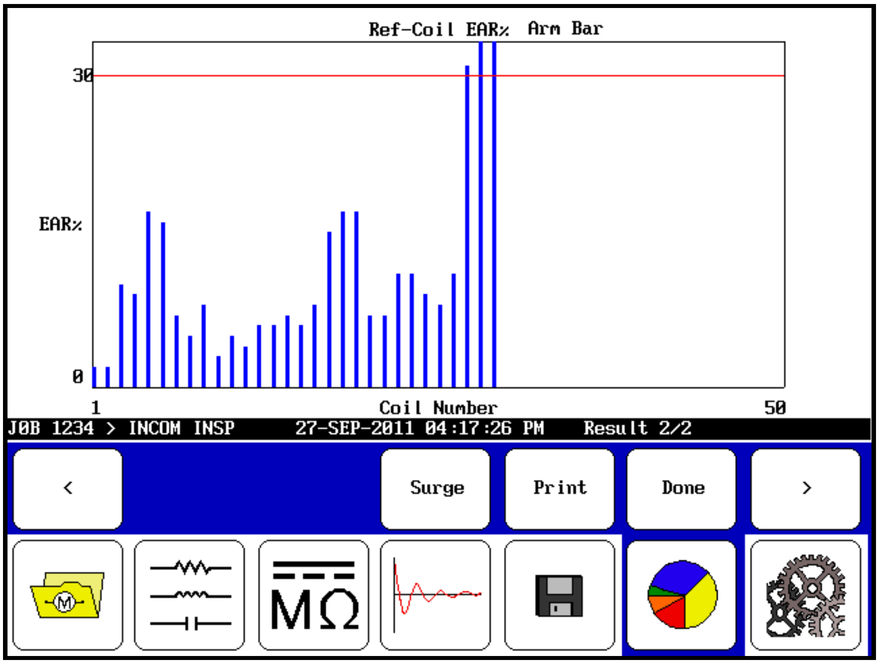


Figure 118. Commutator Coil Results Screen.

➢ As indicated by scans, armature coils 28, 29, and 30 are out of criteria.

For surge operation of the DX 12 kV host tester as a standalone, the operator need not disconnect the two units. Simply place the 12 kV host unit function switch back to the **Surge** position.

Operating Procedure – ZTX A101 Generic Coil, DC FC, Span Armature Coil and DC IP Coil Testing

(If you are using the PP85 power pack, see the PP85 section above)

The ZTX A101 unit extends the capabilities of the Baker DX to be able to test low impedance coils such as found in DC armature and other coils. The Baker DX as a standalone provides the capability of **DC FC** (field coil) testing and span (armature coil) testing (**Arm Span**). The Arm Span test is typically used as a substitute for not having the low impedance ZTX Arm Bar capability. The DX, in combination with the ZTX A101 unit, has expanded capabilities to test **low impedance** generic coils , DC armature coils (**ARM Bar**), and DC inter-pole coils (**DC IP**). The following procedure will focus on low impedance DC IP/generic coil testing (Arm Bar covered above), but the DC FC/Arm Span test capabilities follow the same methodology using the DX as a standalone without the ZTX attached, and exceptions will be noted.

1. Check that the ZTX A101 unit setup procedure has been followed.
   - If performing the DC FC/Arm Span test as a DX standalone, skip to Step 2.
2. Connect the test lead cable to the clip accessory.

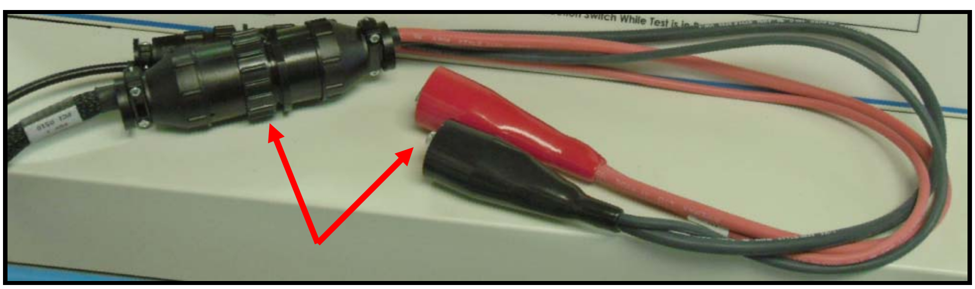


Figure 119. Connect Test Lead Cable to Clip Accessory.

   - For the DX standalone DC FC/Arm Span test, connect the high voltage leads directly to the coils.
3. Power up the DX host unit. If connected to a ZTX unit, it powers up from the DX host.
4. Ensure that the Baker DX plugs into a good ground source. An open ground detect will keep the unit from operating. Check the settings icon and the "Open Ground" icon to see the ground status.
5. If a folder and record have not been created for the motor selected to test, do that now (following data management instructions in *Chapter 2*) from the folders icon and set up the intended folder/record as the "Active Folder" and "Active Record" in the status bar.

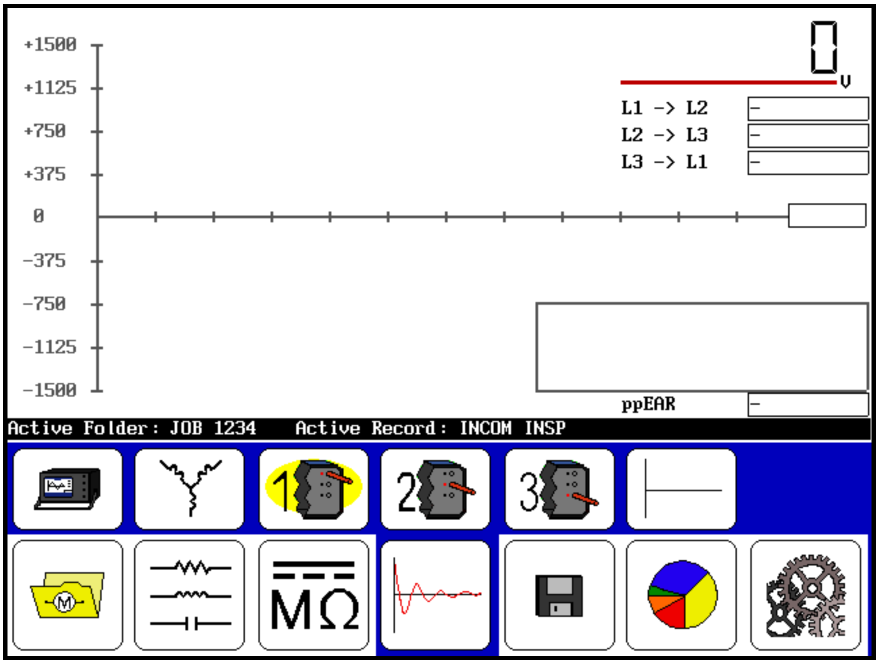


Figure 120. Start Screen.

6. From the DX screen, select the surge icon to bring up the configuration options icon. When selected, it indicates installed options that enable choice of operation as a standalone unit, or with power packs (PP30, PP40), ZTX, and PP85 power pack with ZTX built in. If an interface board is **not** installed, the following message appears:

Figure 121. "No External Interface Options Installed" Message.

Select the ZTX icon for purposes of this instruction.

- For the DX standalone DC FC/Arm Span test, the selection is .

7. Select the coil icon and then the **DC IP** icon (or reselect the coil icon).
   - For the DX standalone DC FC/Arm Span test, select the windings icon , then from this menu , select the generic, **DC FC**, or **Arm Span** coil tests.

8. Select the test lead icon .

9. Connect the clips accessory to a DC inter-pole coil.

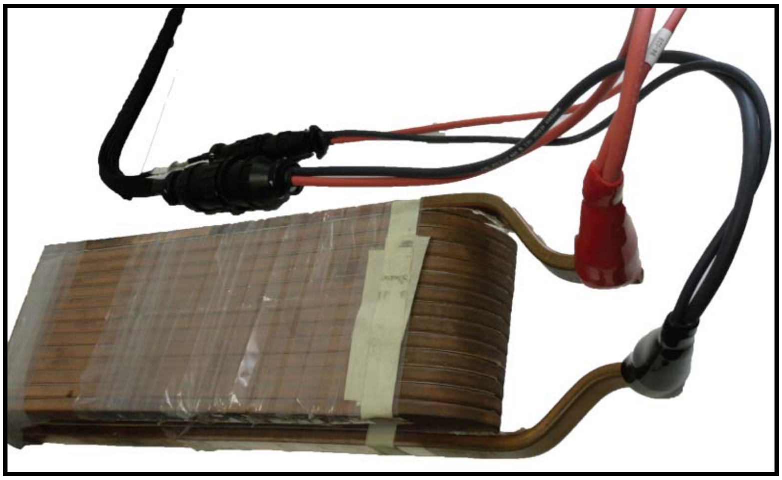


Figure 122. Connect Clips Accessory to DC Inter-Pole Coil.

- For the DX standalone DC FC/Arm Span test, use the DX high-voltage leads to connect to the DC FC (field coils) or generic coils. This is also the case with the Arm Span test where probes can be connected to the Baker DX's high-voltage leads and then manually advance through the armature coils.

A span probe accessory facilitates armature span testing.

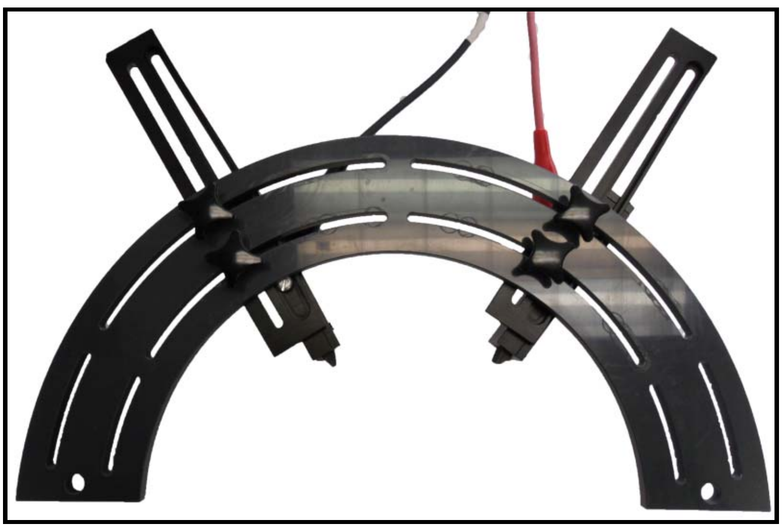
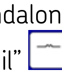


Figure 123. Span Probe Accessory.

10. The **DC IP** test is now ready for test start from the following screen.
    - For the DX standalone **DC FC** test or the Arm Span (**Arm Bar**) test or a "generic coil"  test, you can launch each test from this screen.

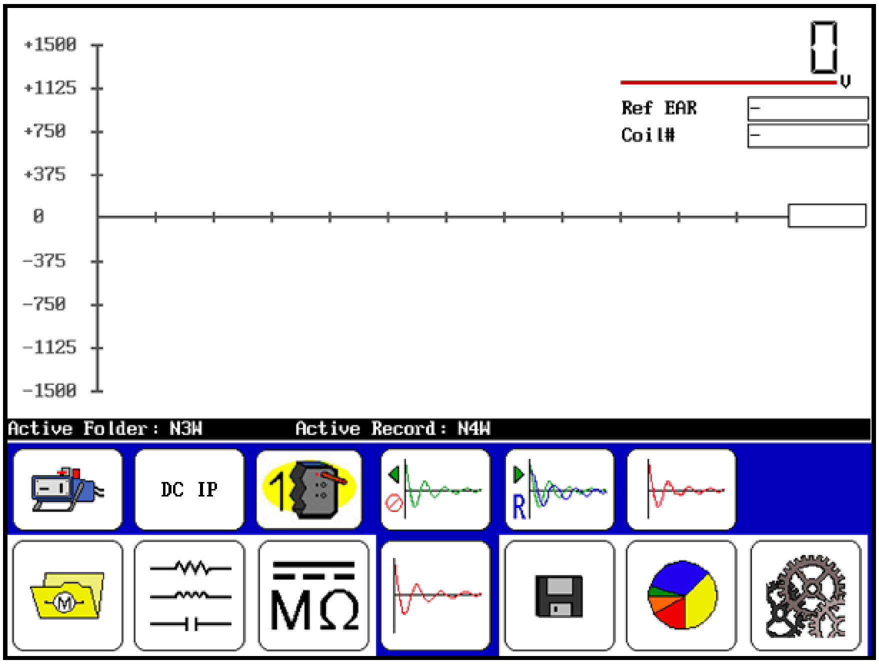


Figure 124. DC IP Test Start Screen.

11. Go to the DX host and press and hold the start button (or footswitch) and the scale control icons appear .

    Alternately use the speed control fast/slow icons  to control the rate of scaling while rotating the "Output Control" voltage knob to set the test voltage. For this example, set the voltage to 870 volts (typically add 300 volts for each turn).

    Use the time base icons  for scaling the horizontal axis to an appropriate time base.

12. Preferably using the footswitch, test several DC inter-pole coils for a sample.

    From a sample, select one to be the reference by selecting the reference icon  and then press the **ZS Override** icon and select **Yes** to the override message.

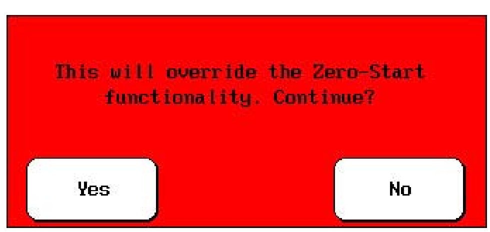


Figure 125. Override Message.

13. Starting from this DC inter-pole coil, test each one by connecting the clips to each coil and pressing and holding the start button (or footswitch) momentarily (greater than three seconds). Notice the scan results show a deviant DC inter-pole coil #4.

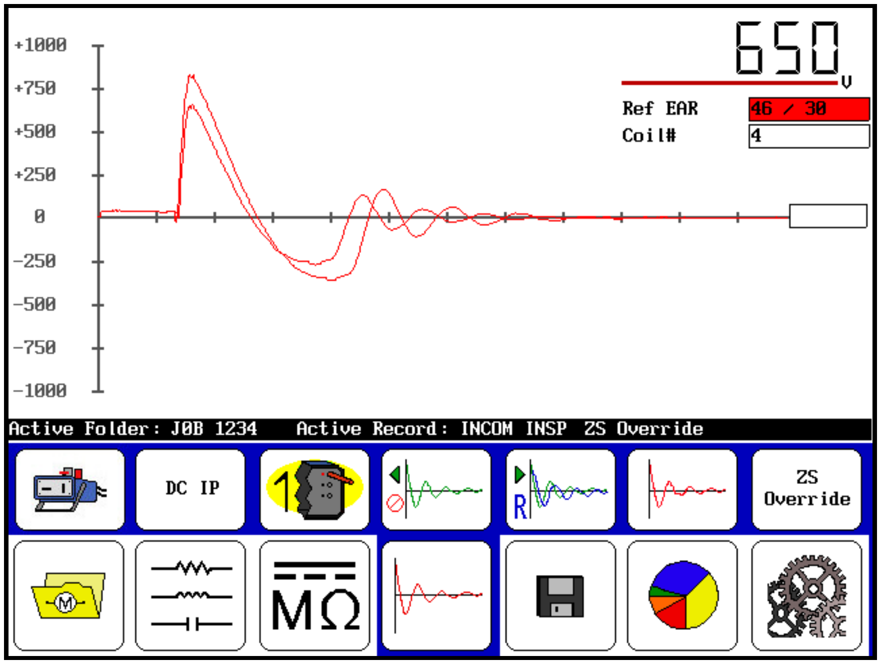


Figure 126. Scan Results.

14. Upon completion of the last test, release the start button (or footswitch).
    - ➢ If the DX host powers down prior to saving test data, it will result in the loss of all data.

If desired, save the test results  in the active folder/active record. It will save as **DC IP** test data and it will appear on the results as such. Running the test continues adding DC inter-pole coils. View below the four DC inter-pole coil results by selecting the report icon  and display icon to view results.

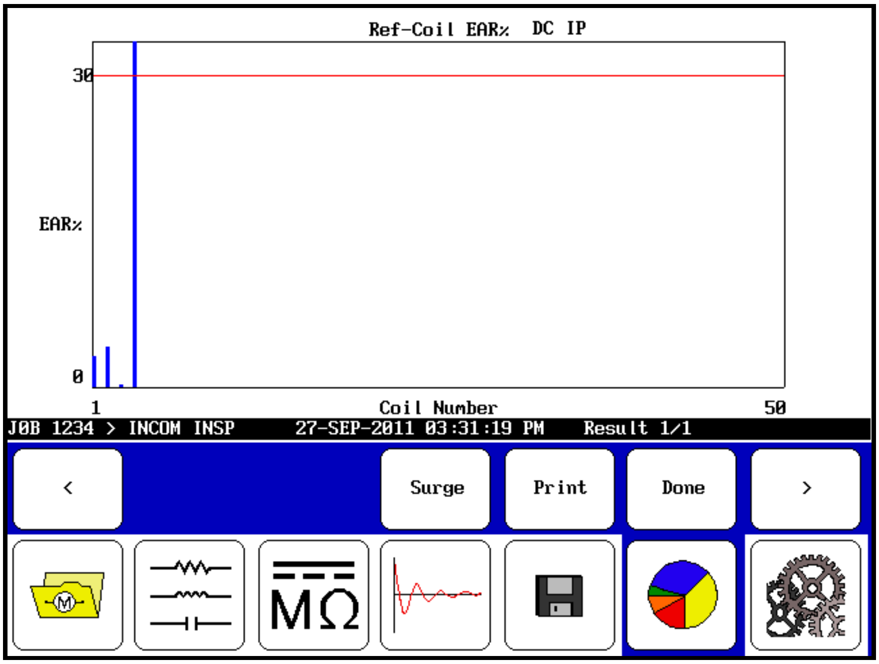


Figure 127. Test Results Screen.

- As indicated by scans, DC inter-pole coil #4 is out of criteria.
- For the DX standalone **DC FC** test or the "Arm Span" (**Arm Bar**) test or a "generic coil"  test, each test would display respectively labeled in a like manner.

Lifting the Instrument

WARNING! You should lift the unit using two 3,6 m *(12 ft.)* lifting straps placed under the unit, as shown in the photos below. Do not use the handle of the instrument to lift the unit.

Figure 128. Lifting Instructions.

Appendix A
Winding Faults

Determination of Winding Faults

For initial determination of winding faults, refer to the following figures. We typically see these wave patterns for three-phase, wye-connected, lap-wound induction stators. They provide a reference for associating a characteristic wave pattern with a fault type.

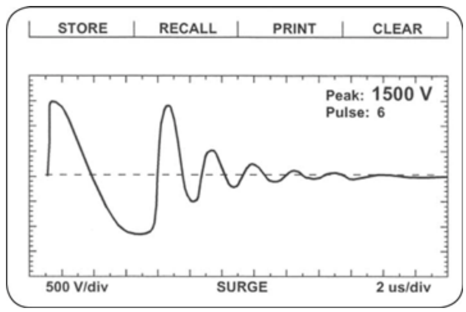


Figure 129. Good Coil.

- Variation from these wave patterns is to be expected. Do not consider these wave patterns as absolute. Remember that due to the variety of motor windings and connections that exist, each motor winding will have its own signature wave pattern. Memorization or exact matches to the following patterns is not necessary when testing.

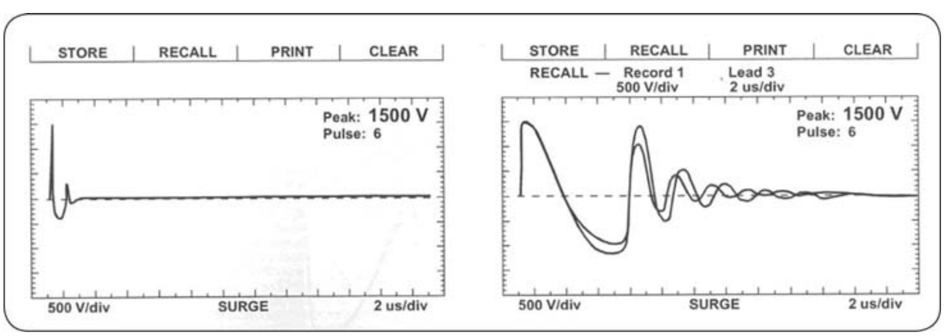


Figure 130. Shorted Single Winding (left) and Short Partial Ground (right).

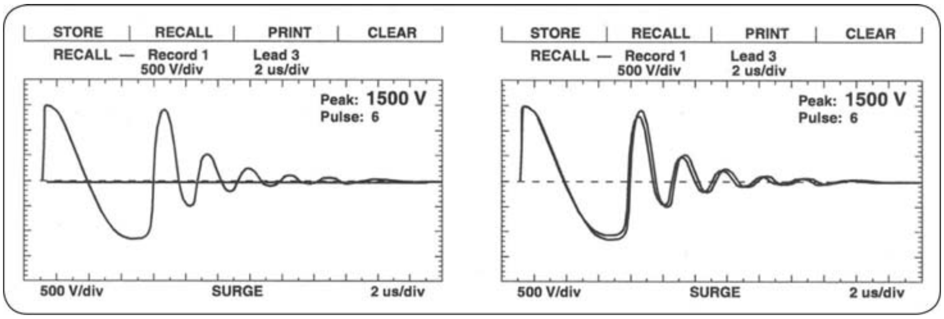


Figure 131. Solid Ground Coil (left) and Solid Turn-to-Turn Short (right).

If all three wave pattern comparisons (surge testing) show considerable separation when testing three-phase windings, the motor has a phase-to-phase short. Because two phases are faulty, we will not achieve a good wave pattern.

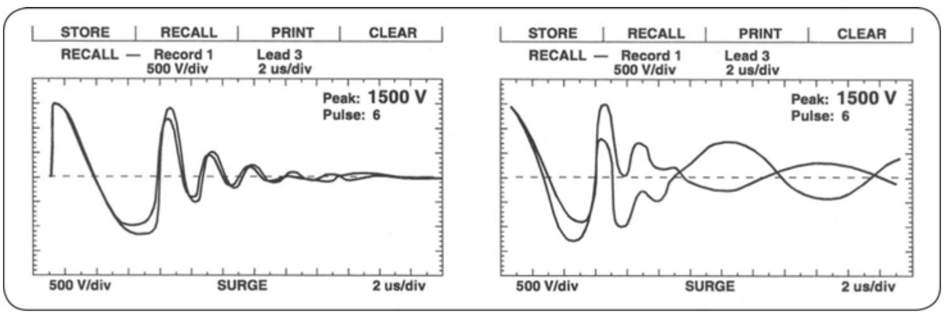


Figure 132. Coil-to-Coil Short (left) and Phase-to-Phase Short (right).

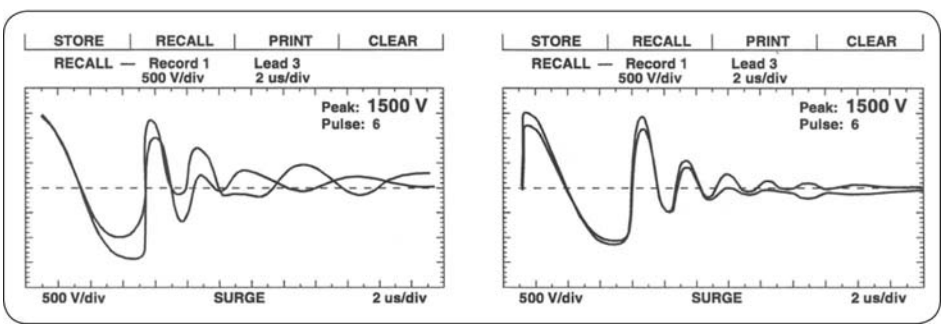


Figure 133. Group-to-Group Short (left) and Reversed Coil (right).

Appendix B
Troubleshooting

Please review this section before calling SKF or returning the unit.

Self-Help and Diagnostics

Problems in testing may sometimes crop up. If experiencing a problem and the problem might be with the analyzer, please take the following steps before calling or returning the unit.

By performing these procedures and having the requested information available, SKF Service or Applications departments will be able to better analyze the situation and provide an appropriate response. You may reach either department at (970) 282-1200 or toll-free at 1 (800) 752-8272 for assistance.

Step No. 1: Basic Information

Take down all basic instrument information, including the following:

- Product
- Model number
- Serial number
    - ➢ All information above is located on the rear panel product label. If the tester has special options installed, please note these. Any information concerning the instrument is helpful. A great tool would be a print or sketch of the waveforms displayed on the tester.

Step No. 2: Applications or Service Problem?

Generally, if you note a problem *only* when testing a specific motor/generator or other coil type, then Applications would be involved (refer to the *Applications: What to do First* section). Please call SKF at (970) 282-1200 or toll-free at 1 (800) 752-8272 for applications assistance.

If you cannot determine that the problem is associated with any one type of motor/generator or other coil type, then Service would be involved (refer to the *Service: What to do First* section).

Applications: What to do First

Review the section below 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 personnel in determining a solution to the problem. Examples include:

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

In short, any information that the motor nameplate can provide is helpful. A great tool is a print out 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

Following are the common application-related problems. Please review the following cases.

1. **The surge tester will not give the desired output test voltage for the apparatus under test.**

The test motor may be too large for the instrument in use. The impedance of the windings may be too low.

The tester may be too small in this case. **Do not** continue testing until contacting the SKF Applications department.

2. **Separation of compared wave patterns is seen when surge testing on coils that are assumed to be good, even on brand new motors or windings. Often, separation is seen in all three comparisons for three-phase motors, but to varying degrees. There may not be separation throughout the whole wave pattern.**

You can see this situation in DC fields or rotating poles. Be sure the coils you are comparing are being tested in identical configurations, e.g., both coils are wound clockwise beginning to end.

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 GRD lead removed from the motor frame. If the separation is now gone, capacitance to ground was effecting the test.

3. **There is no dampened sinusoidal wave pattern on the display when surge-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.**

The coil under test is probably too high of an impedance to get a good working pattern. The coil may be very high in resistance and turn counts. The inability to perform a surge test on this coil, or group of coils in series, will remain unless they you can break them down to smaller units of lower impedance.

A broken test lead or poor connection may be the cause. Recheck connections, or try using a different test lead selection (e.g., lead No. 2 or lead No. 3). Under heavy use, check test leads weekly to make sure 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.

4. **Open ground detected.**

The instrument has an earth ground safety detect circuit. In certain situations, such as aboard a ship, the detector may discover there is no safety ground present. You can disable the detector in the settings menu.

5. **How to test using the instrument with a generator to supply AC power at a remote site.**

The instrument will require a driven or earth ground to operate at a remote site, and will need to have the safety ground detector disabled (#4 above).

6. **Test lead clips open.**

With the unit in RLC test mode, connect an ohmmeter to the high-voltage test leads. Each lead should read less than 10 ohms to any other high voltage test lead on the tester.

7. **How and why to test from the motor's star point.**

When testing very large, high capacity motors, it may be impossible to reach the desired test voltage. Wye-wound machines usually have an externally-connected star point. It is often possible to apply 25 to 50 percent more voltage to a single-phase of a winding, if you disconnect it at the star point and test end to end. The downside is the fact that you need to break the connection and re-tape after the test, which can take several hours. The upside is you can use a smaller, lighter, less expensive tester to perform tests on a larger selection of equipment.

8. **Cleaning a dirty display.**

Use a water-dampened, soft, clean cloth (cotton) to gently wipe the LCD touch screen. Steel wool or sandpaper will destroy the monitor screen.

9. **Doing high voltage testing with a printer attached to the printer port.**

The surge pattern seen may show distortion from the interference. Additionally, it is possible to damage the printer port with the PP30D 30 kV power pack. Quite high levels of RFI/EMI may generate when the PP30D is doing a surge test. Print the results after testing is complete; doing so will prolong the instrument's service life and any peripheral devices, such as printers or laptops/personal computers.

Service: What to do First

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

Open Condition Display

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

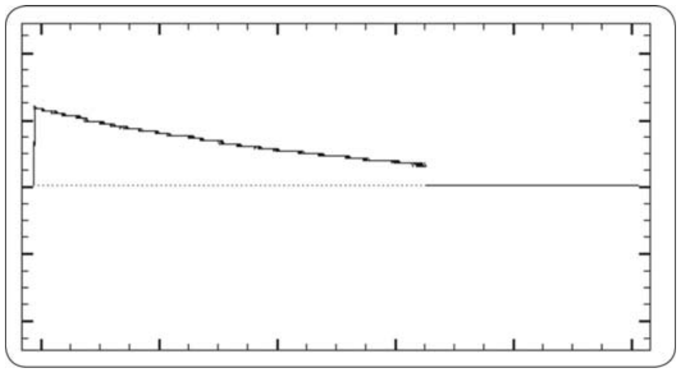


Figure 134. Open Condition Display.

If yes, the unit may have at least one broken test lead causing an open condition. With the unit in RLC test mode, connect an ohmmeter to the high-voltage test leads. Each lead should read less than 10 ohms to any other high voltage test lead on the tester.

DC Test Display Checks

If no voltage or current shows, one of three problems might exist:

- The item being tested is in fact faulty and has either low insulation resistance or open connections
- The tester has an internal problem
- The tester has a test lead problem, as described 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 run a DC test with an open lead condition. The display should indicate a rising voltage trace. The current trace may rise slightly, but fall back to zero when stopping the output increase.

➢ It is not necessary to run the output control at a high level to determine if the analyzer is working properly.

If the display still shows **no** voltage trace, call the Service department. Use a meter to confirm the insulation resistance of the device being tested.

Test current trace operation by shorting test lead No. 1 and the ground lead together. Under this condition, the voltage trace will **not** move off the zero line and the current trace should rise **very rapidly** and activate the DC test over-current trip. If the DC over-current trip does not occur, check for open test leads at either test lead No. 1 or the ground lead (refer to *Open Condition Display*). If the problem persists, contact the Service department.

Open Ground Check

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 operating in a situation where the AC power source is unknown?
3. Is the unit operating on a scope cart that has its own outlet or power source?
4. Is the unit operating using a two-wire extension cord?
5. Is the unit operating on a transformer isolated circuit?

If you answer any of these questions with “yes,” the unit is probably operational and indicates an 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. For number 4, if possible use a two-wire (with ground) extension cord. For number 5, or any of the conditions noted above, use a grounding strap to a good earth ground.

In the case of number 5, call the Service department for assistance. There is an override available, but you should take precautions.

Limited Output Surge Waveform

The display shows a limited output (amplitude) surge waveform. The display rises normally but stops at some point. Alternatively, 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.

Warranty Return

Please review the warranty note and shipment sections at the beginning of this manual before sending the tester to SKF for warranty repair.

You must **fill out and return** the Warranty Return Form on the following page with the tester to obtain warranty service. This form will help SKF identify the problem, quickly repair the unit, and return it.

Warranty Return Form

Please call warranty support at (970) 282-1200 before you return any instrument. Once you have discussed the warranty issue with SKF, please completely fill out all the following form and include this form with the tester you are returning. Make a copy for your records before sending this to SKF.

- Be sure to follow the guidelines for shipping when sending the tester to SKF.

Company Name: ______________________________________

Your Name: ____

Mailing Address: _____________________________________

____

Shipping Address: ____________________________________

____

Phone Number: _______________________________________

Fax: ____

From the nameplate on the back of the instrument:

SKF Product Number: __________________________________

Model Number: _______________________________________

Serial Number: _______________________________________

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 SKF by phone. Use the back of this form if necessary.

____

____

____

____

____

____

Person Contacted at SKF: ______________________________

Ship the tester to:

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

Appendix C
Technical Specifications and Calibration

Technical Specifications

	Model DX4	Model DX6/6HO	Model DX12/12HO
Surge Test			
Output voltage	0 to 4,000 Volts	0 to 6,000 Volts	0 to 12,000 Volts
Max output current	190 amps	340/450 amps	600/800 amps
Pulse energy	0.18 joules	0.72/1.8 joules	2.88/7.2 joules
Sweep range	24 µsec to 6.5 msec	24 µsec to 6.5 msec	24 µsec to 6.5 msec
Volts/Division	250/500/1,000/ 1,500	250/500/1,000/ 1,500	500/1,000/2,000/ 3,000
Repetition rate	5 Hz	5 Hz	5 Hz
Voltage measure-ment and accuracy	±11%	±11%	±11%
DC High Potential (HiPot) test			
Output voltage	0 to 3,000 Volts	0 to 6,000 Volts	0 to 12,000 Volts
Max output current	5 mA	5 mA	5 mA
Current resolution	0.1/1/10/100 µA division	0.1/1/10/100 µA division	0.1/1/10/100 µA division
Over-current trip settings	1.4 mA	1.4 mA	1.4 mA
Full scale voltage and current measurement and accuracy	±3 % voltage ±5% current	±3 % voltage ±5% current	±3 % voltage ±5% current
Megohm accuracy	±8%	±8%	±8%
Max megohm reading	100,000 MΩ	100,000 MΩ	100,000 MΩ
Physical characteristics			
Weight	15.4 kg *(34 lbs)*	15.4 kg *(34 lbs)*	15.4 kg *(34 lbs)*
Dimensions	42 × 20 × 45 cm *(16.5 × 8 × 17.7 in.)*	42 × 20 × 45 cm *(16.5 × 8 × 17.7 in.)*	42 × 20 × 45 cm *(16.5 × 8 × 17.7 in.)*
Power requirements	85 to 264 V AC, 50/60 Hz	85 to 264 V AC, 50/60 Hz	85 to 264 V AC, 50/60 Hz
Resistance measurement display	0.002 to 200,000 Ω	0.002 to 200,000 Ω	0.002 to 200,000 Ω
Memory and storage characteristics			
Data memory	1 GB	1 GB	1 GB

Accuracy of Measurements – Coil Resistance Test

Approximate range resistance	Full scale accuracy
100 to 200,000 Ω	±3%
0.2 to 100 Ω	±2%
0.002 to 0.2 Ω	±4%

Calibration Information

Please contact Baker Instrument Company, an SKF Group Company, for current calibration information. Contact the Service department at (970) 282-1200 or (800) 752-8272.

Appendix D
Recommended Test Voltages – DC Tests and Surge Tests

Recommended Test Voltages

SKF has a recommended standard (see table) for test voltages for DC and surge testing a motor, generator, or transformer to be twice the AC line voltage plus 1,000 volts. This test voltage is consistent with NEMA MG-1, IEEE 95-1977 (for test voltage greater than 5,000 volts) and IEEE 43-2000 (test voltages less than 5,000 volts).

View other standards in the tables below for a comparison of IEEE 95, EASA DC-HiPot, IEEE 522 surge testing, IEC 34-15, and SKF recommended testing voltages.

- ➢ The tables list representations of motors, as well as the formulas to calculate voltages so that you can calculate test voltage of any size motor.

IEEE 95-1977

V Line	Per Unit	Min Test, V Line × 1.25 × 1.7	Max Test, V Line × 1.5 × 1.7
480	392	1,020	1,224
575	469	1,222	1,466
600	490	1,275	1,530
2,300	1,878	4,888	5,865
4,160	3,397	8,840	10,608
6,900	5,634	14,663	17,595
13,800	11,268	29,325	35,190

EASA DC-HiPot

V Line	Per Unit	New, 3.4 × V Line + 1,700	In Service, 65% of New
480	392	3,332	2,165.8
575	469	3,655	2,375.75
600	490	3,740	2,431
2,300	1,878	9,520	6,188
4,160	3,397	15,844	10,298.6
6,900	5,634	25,160	16,354
13,800	11,268	48,620	31,603

IEEE 522 Surge Testing

V Line	Per Unit	New, 3.5 × Per Unit	In Service, 75% of New
480	392	1,372	1,029
575	469	1,642	1,232
600	490	1,715	1,286
2,300	1,878	6,573	4,930
4,160	3,397	11,890	8,917
6,900	5,634	19,719	14,789
13,800	11,268	39,438	29,578

IEC 34-15

V Line	Per Unit	V Line × 4E + 5,000	0.2 us, 65%
480	392	6,920	4,498
575	469	7,300	4,745
600	490	7,400	4,810
2,300	1,878	14,200	9,230
4,160	3,397	21,640	14,066
6,900	5,634	32,600	21,190
13,800	11,268	60,200	39,130

Baker Instrument Company, an SKF Group Company

V Line	Per Unit	In Service, 2E + 1,000
480	392	1,960
575	469	2,150
600	490	2,200
2,300	1,878	5,600
4,160	3,397	9,320
6,900	5,634	14,800
13,800	11,268	28,600

- Use the “Peak Voltage” value shown on the screen to obtain the proper test voltages.

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