

SKF Static Motor Analyzer Baker DX



User Manual

4 kV, 6 kV, 6 kV HO, 12 kV, 12 kV HO, DX-15 Models



SKF Static Motor Analyzer Baker DX

User Manual

*For use with 4 kV, 6 kV, 6 kV high output (HO),
12 kV, 12 kV HO and 15 kV (Baker DX-15) models*

User manual part number: 71-030E-EN

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CAUTION

Please read and thoroughly understand the contents of this entire manual before performing any tests with this product. Failure to follow the instructions and safety precautions in this manual can result in serious injury, damage to the product, damage to other

equipment, or a malfunctioning system. Keep this manual in a safe and ready location for future reference.

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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#US6,789,025	#US6,792,360	#US 5,633,811	#US 5,870,699
#WO_03_048714A1			



Declaration of conformity

Manufacturer's Name and Address:

SKF USA, Inc.

4812 McMurry Ave

Fort Collins, CO 80525

USA

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

Equipment Model Designations: DX

Application of Council Directive 72/23/EEC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits, as amended by: Council Directive 93/68/EEC and Council Directive 89/336/EEC on the approximation of the laws related to Member States relating to the electromagnetic compatibility, as amended by: Council Directive 93/68/EEC. Note: due to the phenomena being observed and the material properties being measured, this equipment does radiate radio frequency energy while in the active test mode.

Referenced EMC Standards

EMC Directive 2004/108/EC

IEC 61000-6-2, Second Edition: 2005

IEC 61000-6-4, Second Edition: 2006

CISPR 11:2004

EN 61000-3-2:2006

EN 61000-3-3:2005

Referenced Safety Standards

EN 61010-1:2001 Second Edition

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

A handwritten signature in black ink that reads "Steve Beitscher".

Printed Name: Steve Beitscher

Title: Engineering Manager

Intended use of instrument

This instrument is manufactured by SKF Condition Monitoring Center, Fort Collins (SKF USA). This product is intended for use in the detection of weak or defective insulation within industrial 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.

Technical assistance/authorized service centers

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

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

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1 About this manual

This manual uses the following conventions in formatting, and informational devices to help you more clearly identify specific elements and information.

Formatting

Interface items and hardware labels are set in **Initial Caps And Bold**.

Page, window, or screen names are set in *italics*.

File names are set in `courier font`.

Information devices

Information requiring special attention is set in the following format and structure:



NOTE

Indicates additional information about the related topic that deserves closer attention or provides a tip for using the product.



NOTICE

Indicates information about product usage that can result in difficulty using product, a loss of data, or minor equipment damage if not heeded.



CAUTION

Indicates a hazardous situation with potential for minor to moderate injury or property damage, or moderate to severe damage to the product.






WARNING

Indicates a hazardous situation with risk of serious bodily injury or death.

2 Safety and general operating information

Symbols on equipment

Table 1. Systems and labels used on equipment.

Symbol/Label	Description
	Protective conductor terminal. Located beside black ground test lead on front panel of instrument.
	Frame or chassis terminal. Located on rear panel of instrument by ground terminal.
	Warning about hazardous voltage and risk of injury or death from severe electrical shock. Located beside each red test lead on front panel of instrument and on back of unit.

Labels on equipment

The following Danger notice label appears on all four sides of the power pack units used with the Baker DX and on the top of the DX unit itself.



Figure 1. High voltage warning label.

The following safety labels are found on the right side of the power packs:



Figure 2. Power pack lead safety labels.

Safety precautions

Read and follow all safety precautions and safe operating practices in your manual. Do not exceed maximum operating capabilities of the Baker DX tester, power packs, or the Baker ZTX accessory.

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 SKF USA, Inc., the protection provided by the equipment may be impaired.



WARNING

Failure to heed the following safety precautions can result in injury or death from severe electrical shock.

Test related

- ┌ Two-party operation is recommended only when using proper equipment (such as the remote E-Stop) and when taking appropriate precautions so both operators are aware of all conditions at all times.
- ┌ 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.
- ┌ For capacitor-started motors or systems with surge arrestors/power factor capacitors, be sure to **disconnect** all capacitors from the test circuit **before** testing.
- ┌ Upon completion of any DC-HiPot, megohm, polarization index (PI), step voltage, or dielectric absorption (DA) tests, be sure to short the winding to ground and allow time for discharge before disconnecting the test leads. If you do not do this, voltage may build up on the

winding. Industry practices suggest allowing a winding to discharge four times the total amount of time that DC voltage is applied to the winding.

- ⌚ If the tester is removed from the windings before complete discharge, short winding leads together and ground them using appropriate jumper cables.
- ⌚ Make sure to disconnect the tester leads before energizing or powering up the motor.
- ⌚ Never attempt to test a winding with both host and power pack leads attached to the winding at the same time. Damage to the tester will occur.

General

- ⌚ **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.
- ⌚ Use appropriate safety equipment required by your organization, including high-voltage gloves and eye protection.
- ⌚ The devices covered in this manual are **not** waterproof or sealed against water entry.
- ⌚ The devices covered in this manual are intended for indoor use. If using outdoors, you must protect the device(s) from rain, snow, and other contaminants.
- ⌚ **Repair parts warning:** You must replace defective, damaged or broken test leads with factory-authorized parts to ensure safe operation and maintain performance specifications.
- ⌚ **Ground the product:** The devices covered in this manual are 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.



WARNING

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!



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.

Emergency stop button

The DX tester and the 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 the power pack's high-voltage circuitry.

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



Figure 3. Power pack showing Emergency Stop button.

Baker ZTX E-stop and remote E-stop

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

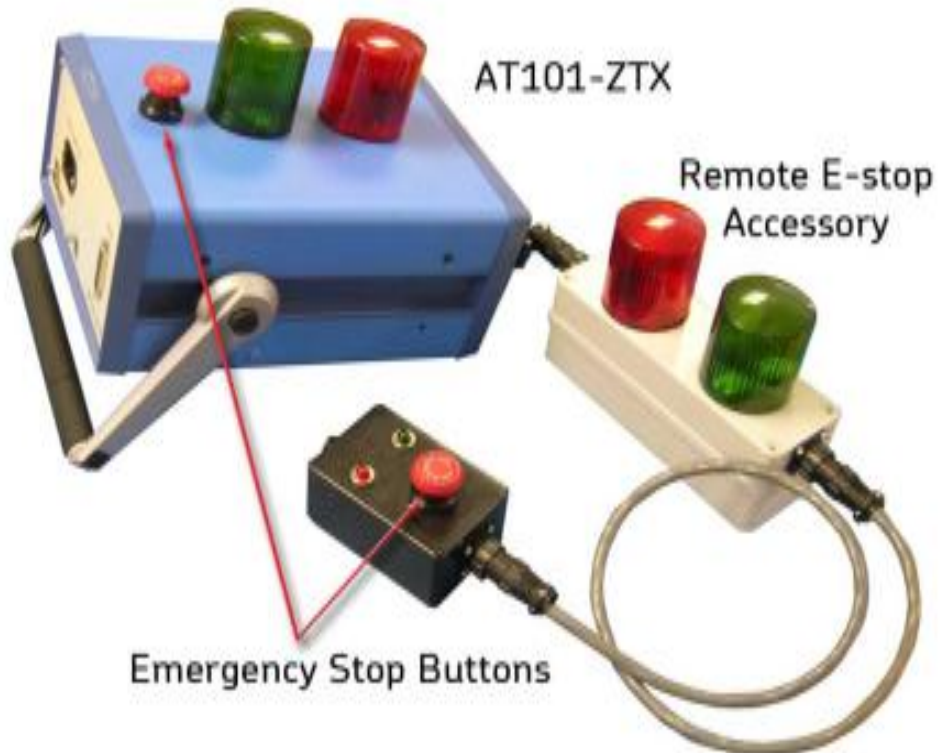


Figure 4. Baker ZTX unit and Remote E-Stop Emergency Stop buttons.

After being pressed, the button will remain locked in position until manually retracted by rotating the **Emergency Stop** button clockwise. A warning message will appear on the DX screen.

General operation, maintenance, and service 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.

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.

Power pack lifting and shipping

Lifting the instrument



CAUTION

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 5. Properly lifting the unit using straps.



CAUTION

The power pack is shipped as indicated by the shipping labels. Inspect the units after shipping and notify carrier immediately if damaged is found.

Confirm that the back panel of the power pack lists the Baker DX serial number before connecting to the power pack.

Operating and shipping positions

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

If the product must be shipped for any reason, 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.

3 Baker DX 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, Baker 30, and Baker 40 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.



Figure 6. Baker DX connected to large motor with low-voltage test connectors for RLC testing; high-voltage connectors in foreground.

Front panel controls

All Baker DX Series testers feature a large, 8-inch touch screen with a graphical user interface. 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.

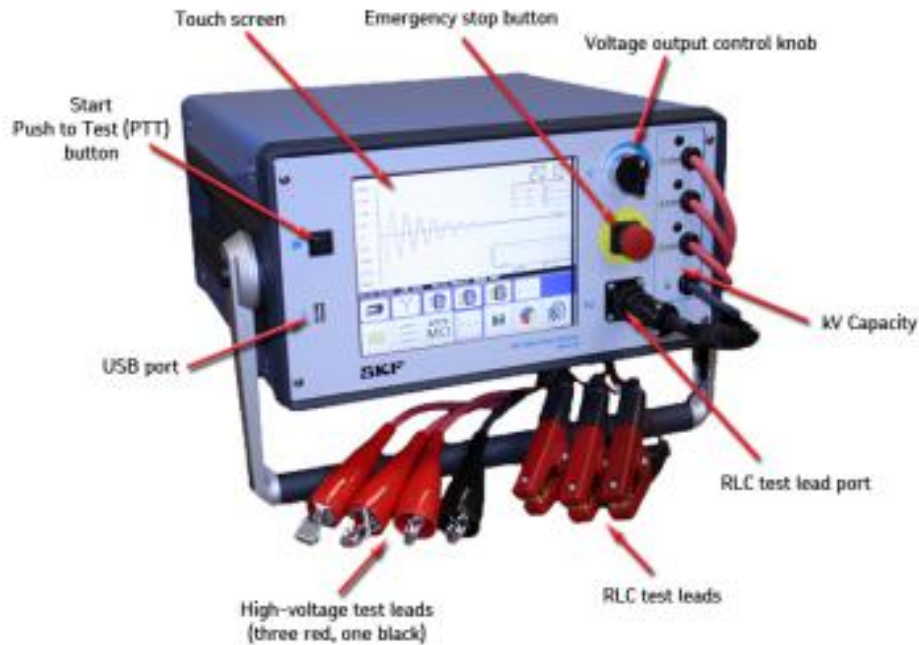


Figure 7. Front panel controls.

1. Touch screen

A high-resolution VGA color touch screen is the main user interface. Large, intuitive icons allow you to select and configure test types, and display and store test results. The screen also presents instrument configuration and report printing menus.

2. Start or Push-to-Test (PTT) button

The start or Push-to-Test (PTT) button works whether unit is in standalone mode, attached to a power pack, or operated with an auxiliary Baker ZTX unit. The PTT operates with a single button touch. A second touch of the button ends a HiPot test when the PTT lock is active. When high voltage testing is under way, the PTT conveniently enables voltage discharge of the high-

voltage leads. For tests that require repetitive starts or long duration, an optional foot-operated switch is available.

3. USB printer port

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

4. Voltage Output 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.

5. Emergency power shut-off

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

6. 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.

7. System unit kV capacity

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

8. Resistance, inductance, and capacitance test leads

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

9. High-voltage test leads

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

Rear panel connections

The graphic below identifies the connections found on the rear of the DX.



Figure 8. Rear panel connections.

Configuration options

The Baker DX host series includes six base models: DX4 (4 kV), DX6 (6 kV), DX6HO (6 kV), DX12 (12 kV), DX12HO (12 kV), and the DX15 (15 kV). They have common base functions, but vary by capacity.

The capacity and capability for these models can be augmented with easily-attached auxiliary units such as power packs that extend the output capacity up to 40 kV (Baker 30, Baker 40).

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 x85).

More information is provided in the following sections.

DX 15

The DX15 tester provides testing to 15KV and also includes the option of built in armature test capability with convenient front panel connections for the ATF-5000 armature test fixture. The maximum armature test voltage is 1500V.



Figure 9. DX 15A with built-in ZTX.

Power packs

The Baker power packs are high-powered impulse generators used to test very large, high-voltage windings. Output is controlled by a variable transformer that ranges from 2,000 volts up to a maximum of 40,000 volts (Baker 30 x85: 30,000V; Baker 40: 40,000V).

These units perform both surge and DC/HiPot tests when used with the Baker DX tester as the control and display. They incorporate a supply monitor for safe operation from a well-grounded supply. In addition, 60kV rated test lead cables are provided.

Voltage rise time is 100-200 nanoseconds, so the power packs comply with IEEE Standard 522-2004 and IEC Standard 34-15 when testing motor windings and coils.

The power packs are housed in a mobile case on pneumatic wheels. They provide power and accessory connections from the DX, as well as lead storage in a convenient portable unit. The Baker 40 power pack is shown in the image below.



Figure 10. Power pack example.

Baker ZTX

The Baker ZTX is a high-current surge test adaptor for DC motors, form coils, and other low-impedance windings. The following graphics show the Baker DX with the Baker ZTX unit along with several other options that can be used with the DX unit.



Figure 11. DX and Baker ZTX accessory.

Accessories

Footswitch

You can connect the footswitch (optional) to the Baker DX host or auxiliary units; it overrides the **Start (PTT)** button. The footswitch enables hands-free use of the unit and gives you additional operating position options.



Figure 12. Footswitch accessory.

Remote E-Stop and lights accessory

The remote E-Stop and lights accessory provide operators with the ability to monitor test conditions and stop testing in progress in the event of an emergency.

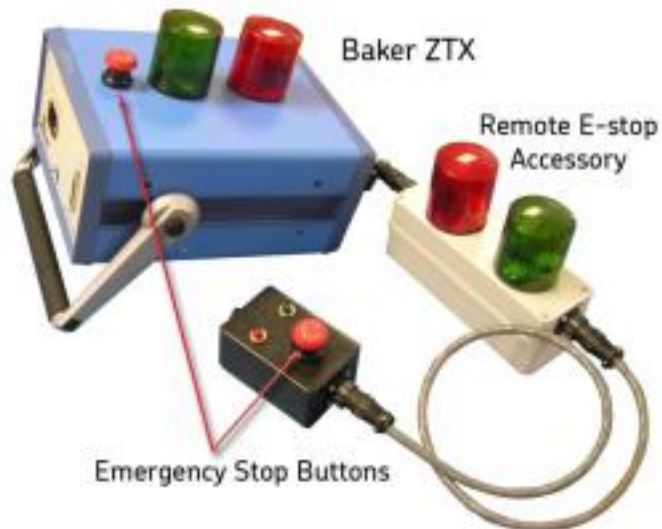


Figure 13. Remote E-stop and lights accessory.

Carrying case

Optional carrying cases provide durable protection for the Baker DX. The CC6/12 fiberglass case protects sensitive equipment with fully foam-lined, hard shell. This case has extendable handle and wheels for easy transport

The soft-side 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.



Figure 14. Soft-side carrying case; backpack option.

Test accessories

The Baker DX also features accessories that facilitate testing including the ATP02-C test clips and the ATP02-P test probes. Clips are used during interpole testing while the probes are used during armature span testing.

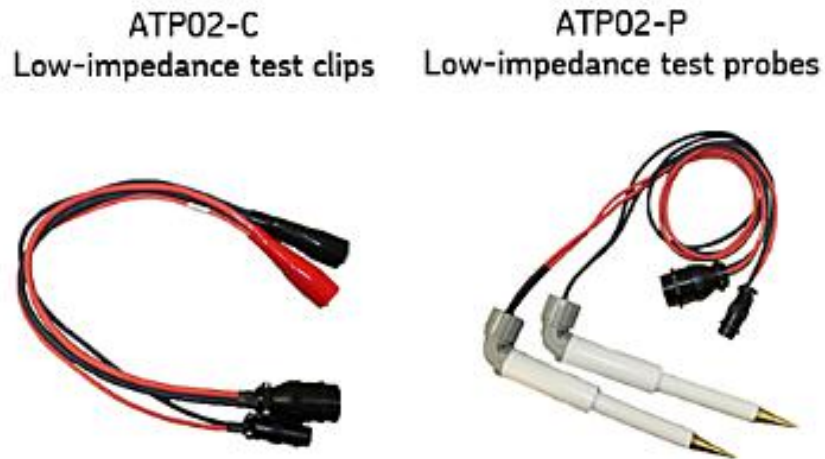


Figure 15. Clip and probe testing accessories.

Armature test fixture

The armature test fixture is used to conveniently perform bar to bar testing on armatures. This fixture is shown with the ZTX accessory, which adapts the DX for armature bar to bar testing.



Figure 16. Baker ZTX with armature test fixture.

Surveyor DX

Surveyor DX is a complementing desktop computer software application that provides added value to Baker DX users by uploading Baker DX test data stored on a USB drive for archiving and reporting purposes. Uploaded data is saved in a database on the desktop computer.

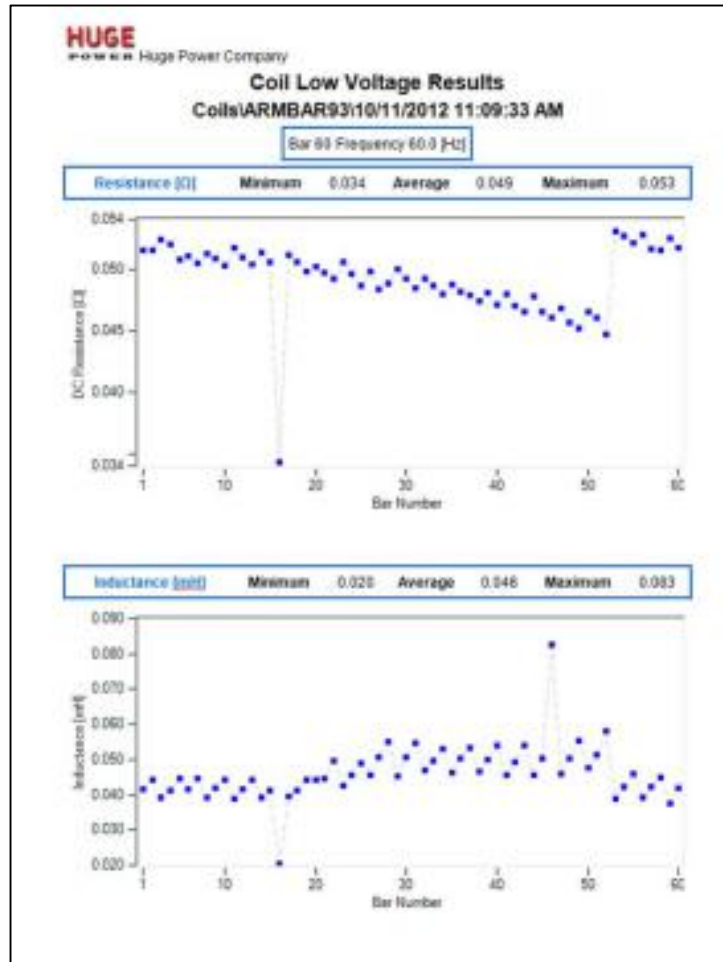


Figure 17. Example Surveyor DX report.

Surveyor DX reports

The Surveyor DX application generates the following types of reports, depending on the source data collected from the tester:

- ❏ RLC: Resistance, inductance, capacitance, D/Q, impedance.
- ❏ DC Tests: PI, DA, DC HiPot, step-voltage with DC graph.
- ❏ Surge 3 Phase: Surge waveform, LL and PP EAR. PD results and house plot.
- ❏ Surge Coil/Armature Bar/Span: reference vs. test EAR bar chart, thumbnails of each coil/bar vs. reference surge waveforms, PD percentage plot, and PD events coil statistics.

4 Baker DX user interface overview

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.



NOTICE

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.

Main elements

The graphic below shows the basic elements of the Baker DX user interface.

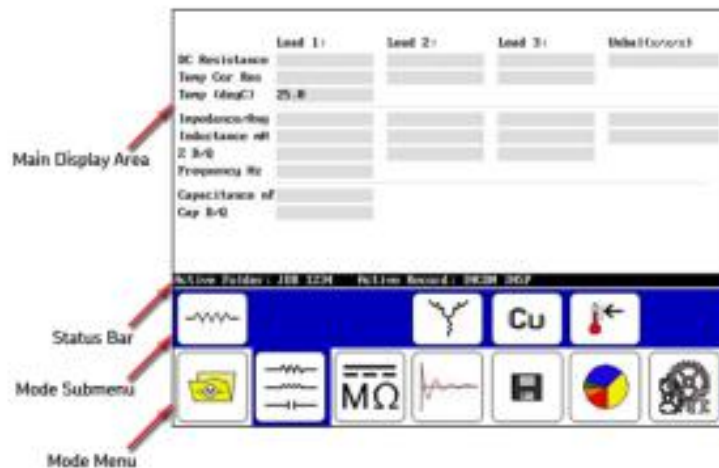


Figure 18. User interface main elements.

The **Main Display Area** displays all measurements, test results, and more as you execute your tests.

The **Status Bar** displays information about the Active Folder and Active Record. The elements show you where the information will be saved for the motor currently under test. The right third of the Status Bar is a dynamic display area that will at time provide additional information such as the date and time, a running clock, notice of active ZS Override mode, PPT Locked indicator, or a test counter.

You will use the **Mode Menu** to select the main mode of operation. Test and function modes are described below. The **Mode Menu** does not change, and is always available.

The **Mode Submenu** contents changes depending on the mode selected and other items selected via the **Mode Submenu** itself or popup menus that appear in the **Display Area**.

Test and function modes

The large icons in the mode 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 touched, the icon will be surrounded by a blue background that indicates which mode the unit is in. The blue background also connects the selected mode with its submenu above.

The graphic below identifies the test and function modes that become active when you touch the corresponding icons.

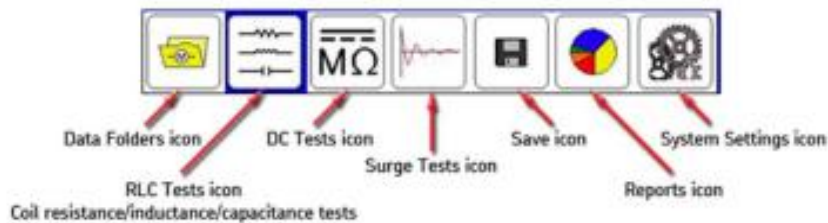


Figure 19. Mode menu icon descriptions.

Mode submenus

The control icons for each mode appear in the submenu just above the **Mode Menu**. The **Mode Submenu** icons correspond to the **Mode Menu** item selected. In the following example, we see the descriptions of the **Mode Submenu** icons that appear when the **RLC Tests** icon is touched.

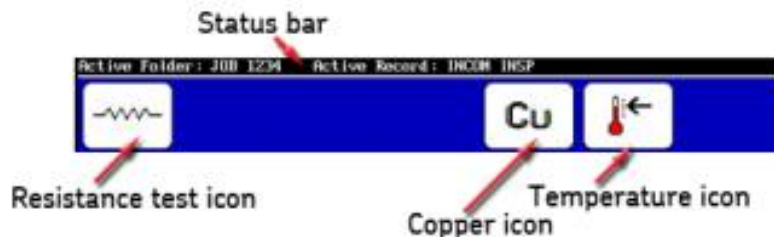


Figure 20. Mode submenu icons example.

A couple more examples of submenus follow to give you a better idea of how their content can change depending on the test or function selected.

The single-coil testing submenu is shown in the next example. This submenu appears during a surge test operation when a **Standalone Unit** is selected along with **Single-coil mode**. The third icon is used to select the active lead and the direction to start the surge flow—hot side. The **Backspace** icon is used to delete tests. The **Set Reference** icon is used to set the selected test as the reference. The **Waveform Selection** icon is used to select optional coil test displays. The **ZS Override** (Zero Start Override) icon is used to tell the tester to go immediately to the reference level, removing the need to ramp up and allowing the tester to reach the target voltage faster.

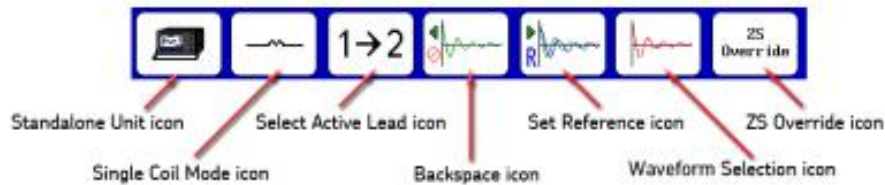


Figure 21. Single-coil testing submenu example.

In this example, the surge test submenu is shown.

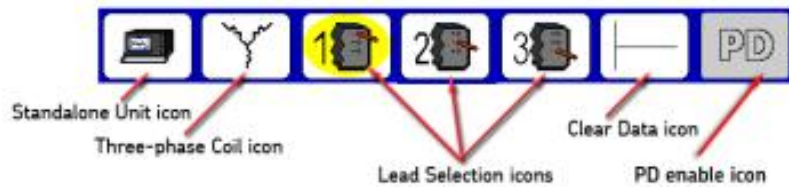


Figure 22. Surge test mode submenu example.

When you touch the **Reports** icon in the **Mode Menu**, the mode submenu displays the icons shown below. As you can see in this example, some icons are simply presented in text. Their functions are self-explanatory.

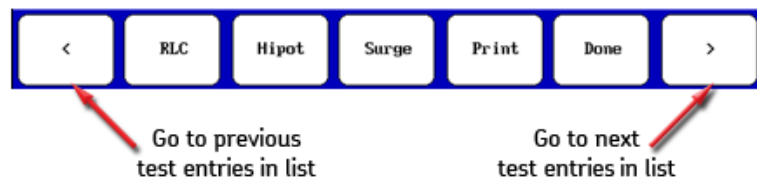


Figure 23. Reports submenu example.

Submenus and their description for each mode are provided throughout the manual as needed.

Popup menus

Popup menus appear when specific functions are selected during the testing process. In the example below, a popup appears in the **Display Area** when the mode icon (first icon from the left in the **Mode Submenu**) is touched.

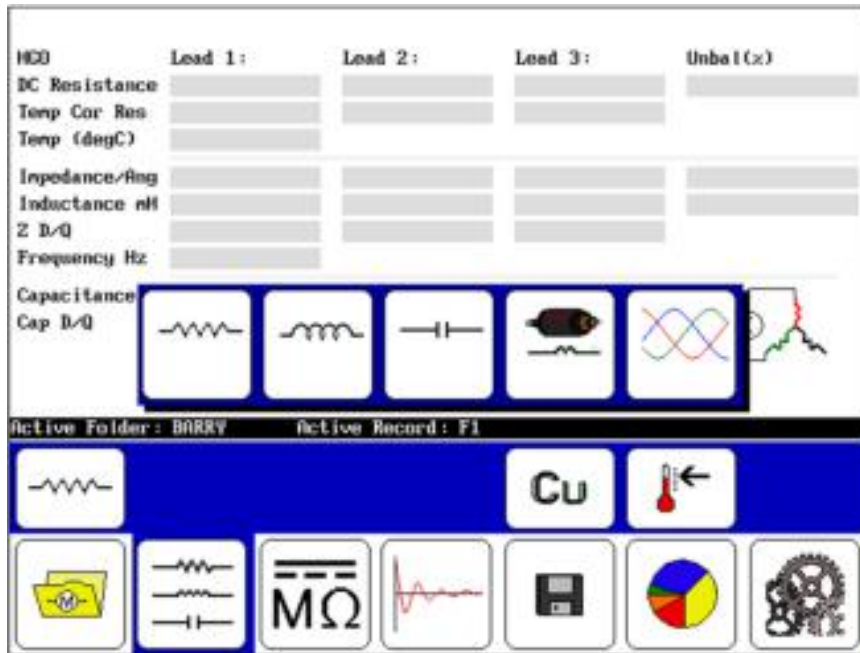


Figure 24. Popup menu appearing when the mode icon is touched.

The details of this popup menu are provided in the example below.

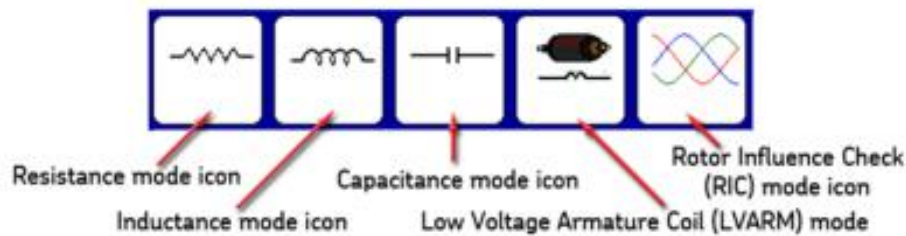


Figure 25. Popup menu icon descriptions for mode selection.

Descriptions of other popup menus are provided in each test description section as needed.

Other interface display features

The user interface includes a variety of features that help you navigate the processes more easily. Some of the more prominent features are shown here.

The first example shows that the elements on the X and Y axes change according to the mode the unit is in and the test type being conducted.

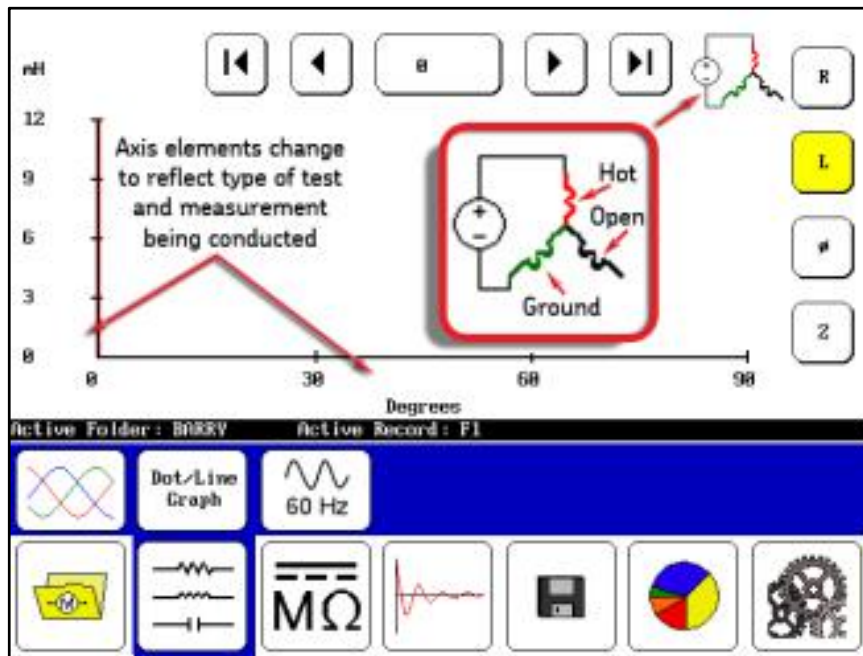


Figure 26. Axis elements change and connection graphic.

In some screens, you will see a graphic that shows you how the unit under test is being measured. The graphic above shows that the measurements being made are hot, ground, and open—the typical standard measurement configuration. In others, the connection and measurements will be hot-ground-ground, and the graphic will reflect that measurement type.

The following example shows controls that allow you to dynamically move through the tests being conducted.

At the top of the **Display Area**, a set of VCR-style buttons appear to facilitate movement from test measurement to test measurement; in this example, the buttons move you from coil to coil, and the X axis shows which coil measurement you are currently viewing.

The far left and far right buttons move you directly to the first and last measurements respectively.

The center button shows you which measurement (coil in this case) you are currently viewing. You can touch this button and select a specific measurement to jump to directly.

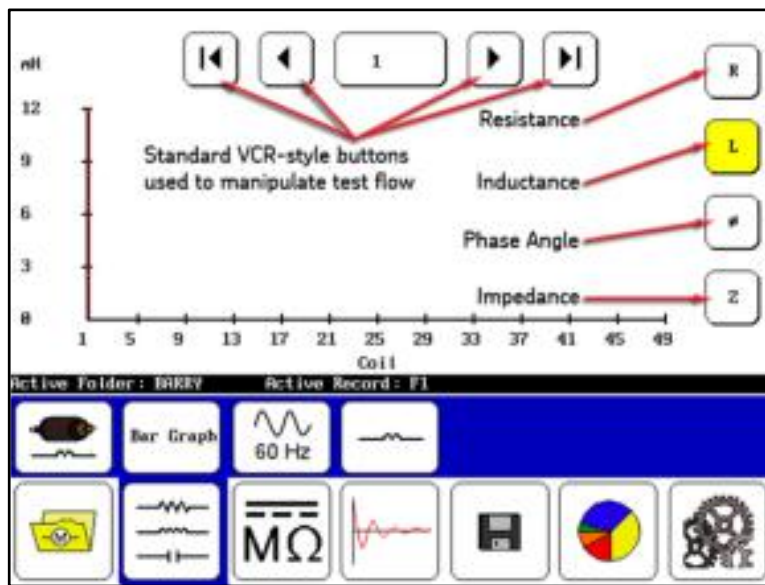


Figure 27. VCR-style buttons and test selection controls.

The buttons along the right side allow you to select the type of test results to view. In this example, the inductance tests are selected, which is indicated by the yellow highlighting.

During HiPot testing, the top bar is active and can display two of the three measurement types shown—either voltage and current, or voltage and megohms as shown in this example. The grayed-out type is inactive.

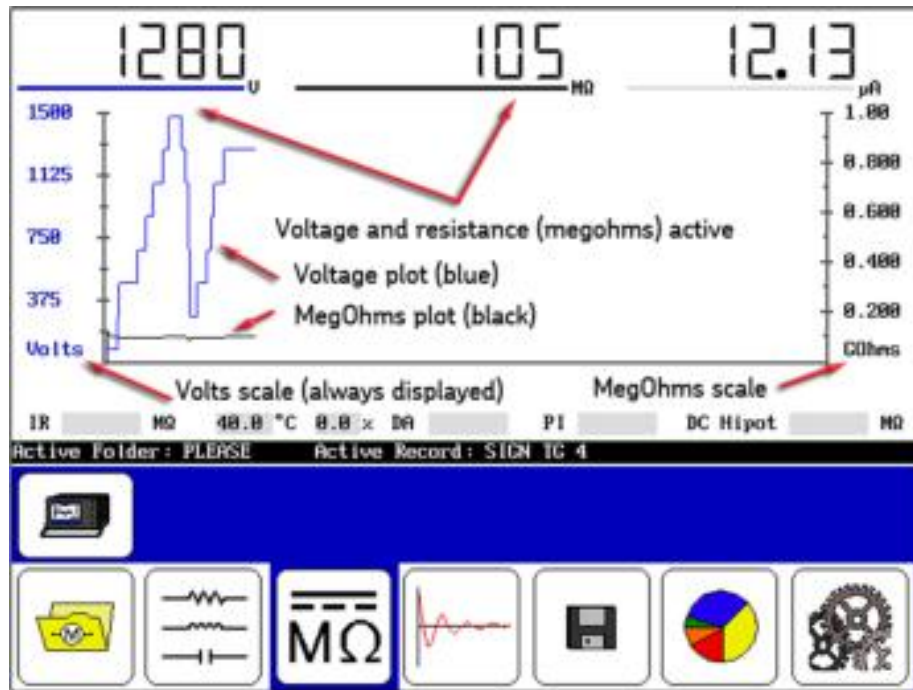


Figure 28. Top bar showing voltage and megohms active.

To select which measurement type to activate, simply touch either the megohms or current displays.

Depending on what is selected (megohms or current), the scale on the right side changes. The plot line in the **Display Area** also changes (black for megohms and red for current).

The voltage scale is always displayed and its plot color is blue.

NOTE

Touching the numbers shown at the top of the screen changes the units displayed for the results presented.

In surge mode, the elements change based on the type of coil selected for testing. In each mode, a pulse counter shows you the number of pulses applied at a specific voltage during the test. If the voltage changes (such as during ramp up) the counter starts over.

The pulse count also appears in the test report.

The following graphic shows the pulse counter and other display elements when used in three-phase mode.

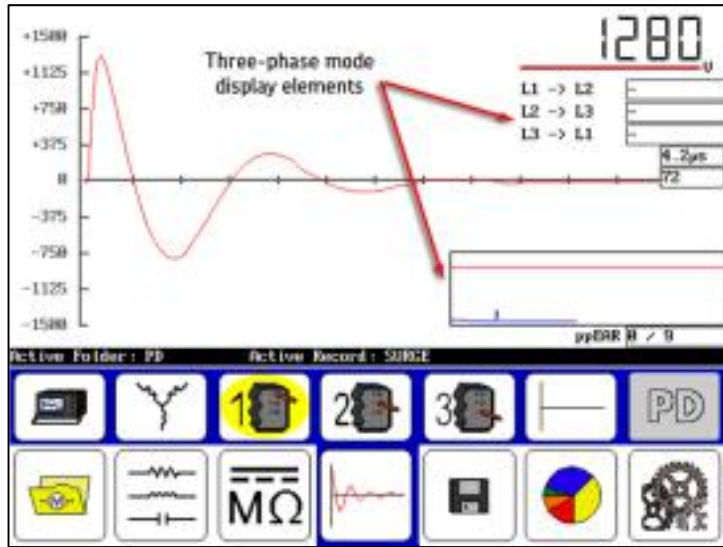


Figure 29. Pulse counter and display features in three-phase mode.

The following graphic shows the pulse counter and other display elements when used in single-coil mode.

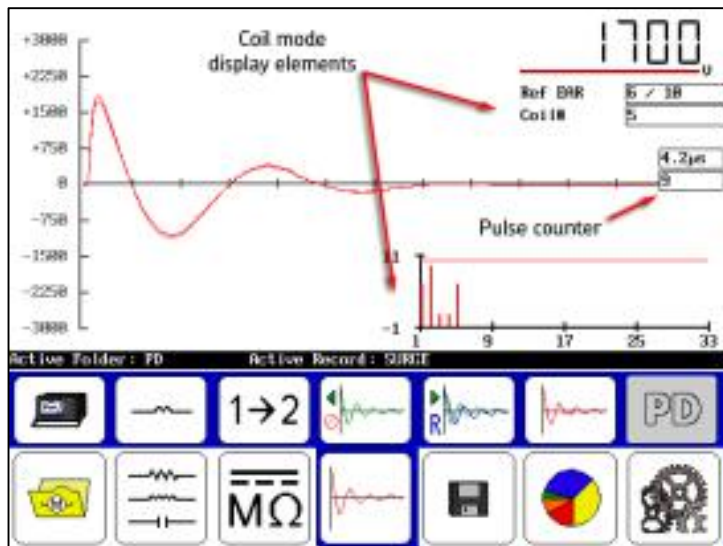


Figure 30. Pulse counter and display features in Single-coil mode.

5 Using Baker DX non-test functions

Data management operations

Managing data folders

Moving from left to right on the mode menu, the first mode is activated by pressing the **Data Folders** icon. Touching this icon brings the **Folder** and **Record** lists into the **Display Area** as shown below.

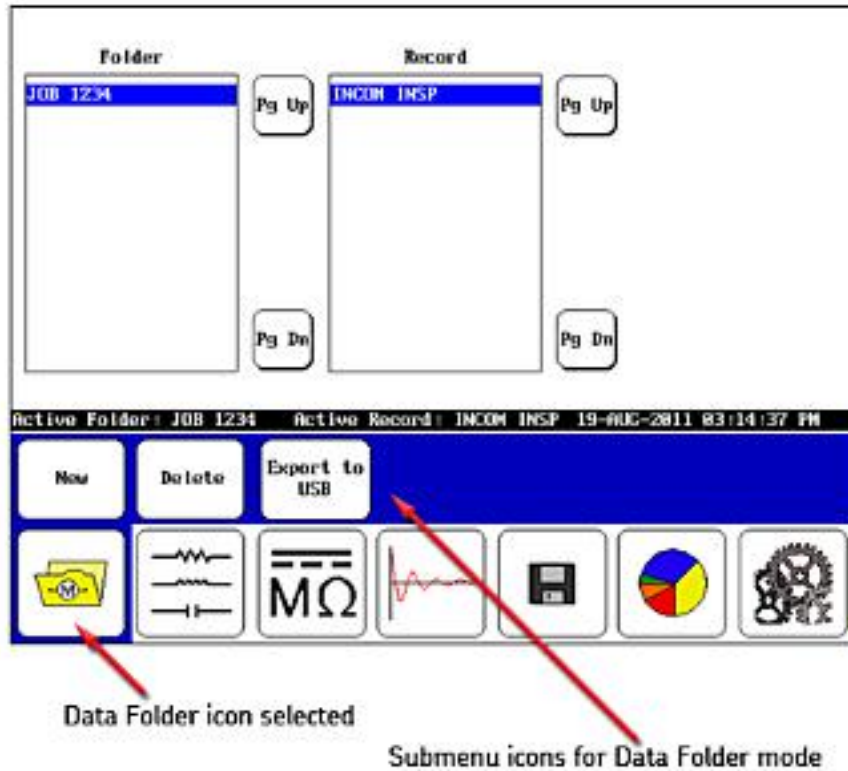


Figure 31. Data folder mode.

Managing test data

The submode icons for **Data Folders** mode are self-explanatory. Data management functions for a given test typically involve creating folders and records for new data, saving data, viewing, exporting or deleting existing data, or printing data.

Creating new folder and records

1. The Baker DX stores test information using a system of folders and records. To create new folders, and then the records (test results) that are stored in the folders, touch the **Data Folders** icon. A set of three buttons—**New**, **Delete**, and **Export to USB**—appear in the submenu.
2. Touch the **New** button. Two new button icons pop up: **Folder** and **Record**. Folders hold records; you cannot save records without a having a folder to save them in. You must create a new folder or have an existing folder highlighted to create and store a new record.
3. Select whether you want to create a new folder (**Folder**) or a new record (**Record**). You can only create a new record within the highlighted (active) folder if multiple folders exist.
4. In either case, a touch screen keyboard appears to help you type in the folder or record name you want to create.



Figure 32. Touch screen keyboard.

5. You may name a folder using up to 10 characters. After entering the folder name, touch **Done**.
6. Newly-created folders and/or records appear in their respective lists in the **Display Area**. All records are time stamped when you save them to provide you with a record of when a given test was performed.

Current test results are saved in the highlighted folders and records. The active folders and records also appear in the **Status Bar** as shown in the example below.

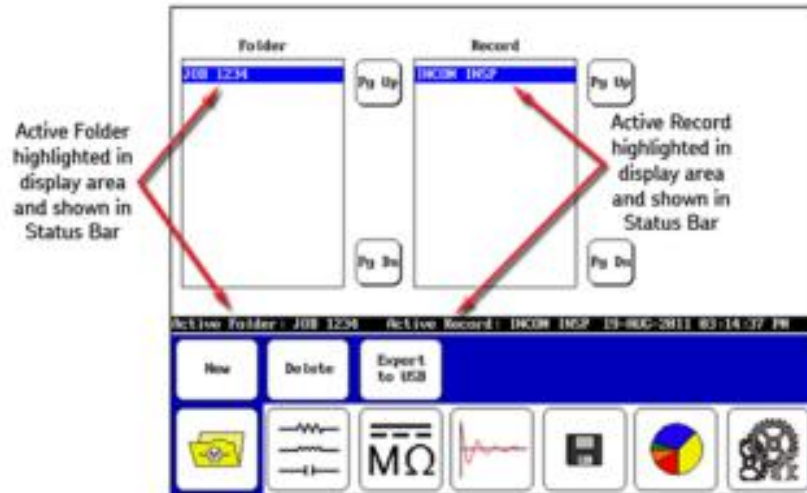


Figure 33. Active Folder and Active Record display example.



NOTE

Ensure that you 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 avoid potential confusion that can occur with redundant or forgotten file names.

Viewing existing data

1. To view existing data, touch the **Data Folder** icon in the mode menu.
2. When you touch a folder in the **Folder** list, such as the JOB 1234 folder in the following example, the folder will be highlighted and all associated records that are in that folder will appear in the **Record** list.
3. Touch the **Report** icon and the results associated with the highlighted record will appear in the **Results** list.

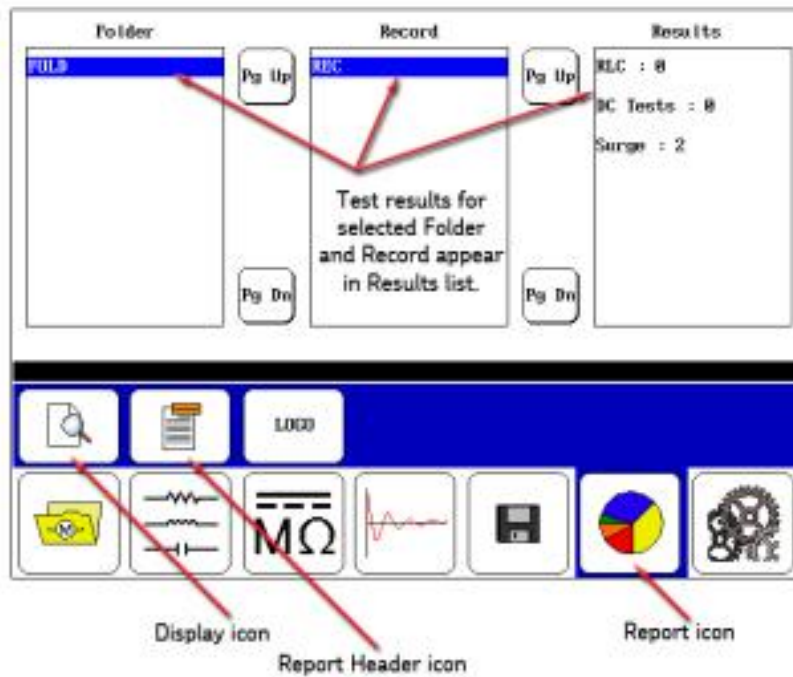


Figure 34. Record results.

- When you touch the **Display** icon (functions like a print preview), submenu items appear that allow results shown in the **Display Area** to be viewed according to test type, or to be printed.

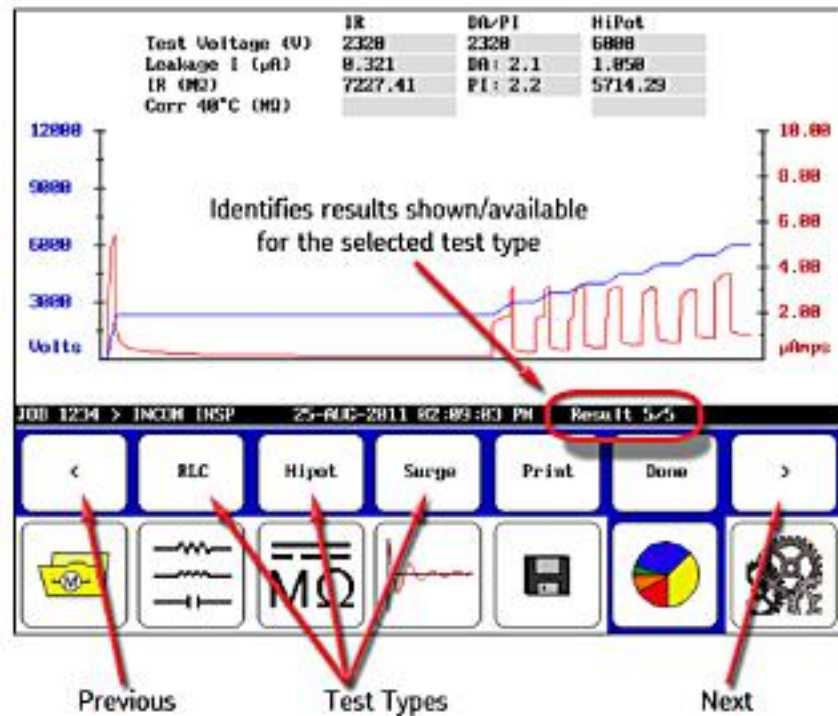


Figure 35. Display submenu icons.

- The **Previous** and **Next** arrows allow you to go through the results that are available for the selected test type.



NOTE

The test type selection icons are located just above their corresponding icons in the **Mode Menu**.

- An entry on the right side of the **Status Bar** shows you which result is displayed out of the total number of available results.
- Touch the **Print** button to print your report to a printer attached to the USB port.
- Touch the **Done** button to return the **Display Area** to the report panel.

Deleting existing data

You can delete existing data, but you cannot delete individual test results within a record. To delete existing data, you must delete an entire record that contains the data.

1. Start by touching the **Data Folder** icon in the mode menu.
2. Touch the **Delete** button and then the **Record** button to delete the record selected. A popup dialog box will prompt you to confirm that you want to delete the record.



Figure 36. Delete record confirmation dialog.



NOTICE

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

Deleting a folder

Deleting a folder follows a similar procedure.

1. Touch the **Data Folder** icon in the mode menu.
2. Touch the **Delete** button and then the **Folder** button to delete the selected folder.
3. A popup dialog box appears to prompt you to confirm that you want to delete the record.

Saving data

1. To save data after a test, touch the **Save** icon, then respond **Yes** to the prompt. Data is saved to the active folder and record (the folder/record combination highlighted when 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.



NOTICE

If you power off the unit before saving data, any unsaved test results will be permanently lost.

Exporting data

Touching the **Export to USB** icon saves the data for the current test to the storage device connected to the USB port. The popup menu shown below appears so you can select the data you want to export.

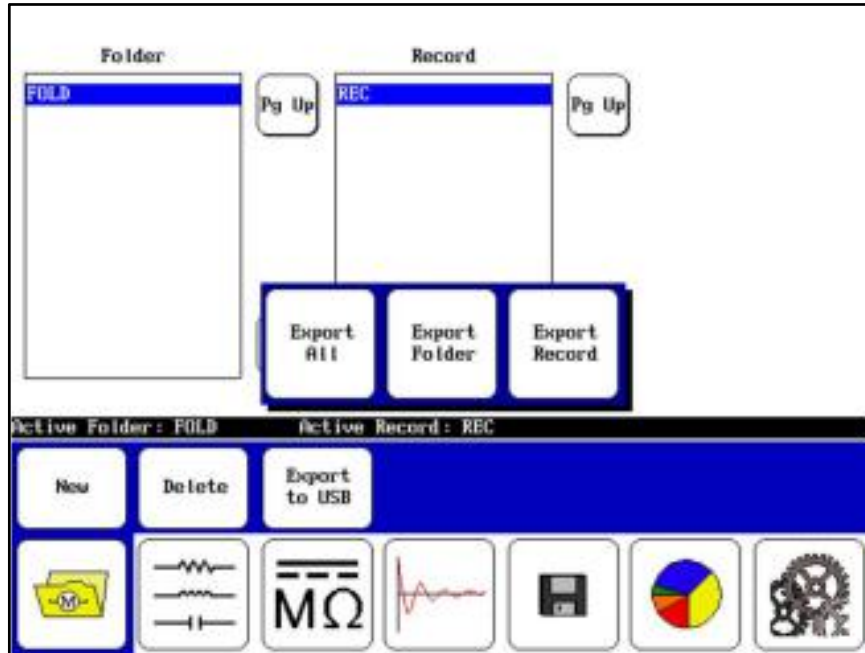


Figure 37. Exporting data to the USB port.

Managing report printing operations

Most reports are essentially screen captures with additional information included (such as the pulse counter) and potentially additional tables depending on the test conducted.

You can also include a logo in your report along with header information. The best practice for generating reports involves adding the logo to the system (if desired) then defining the header information you will want to use. When these preparations have been completed, all reports you generate will include these elements.

Inserting a logo in reports

The Baker DX can store a logo for printing on test reports. To include a logo in a report, you will check the **Include Logo** box in the report header form described below.

1. Acquire the logo file and save it on a computer. The logo must be 100 pixels wide by 100 pixels high, so you might need to resize the logo or add space before you can use it. Resize or edit a logo using a photo editor of your choice.
2. If you haven't done so already, load the *DXUtility* software (which you can obtain from the Baker DX documentation CD, or from the SKF website: <http://www.skf.com/group/products/condition-monitoring/software/electric-motor-testing/index.html>) and save it in an easily accessible location on your computer. After you have loaded and opened the utility program, connect a USB flash drive or other portable USB memory device to your computer.
3. Click on the **Load Logo Bitmap** button. Browse to and select the logo file from your computer, click **Open**, and then click the **Create DX Logo** button.



Figure 38. Using DX Utility software to load logo bitmap.

4. The file will be named “Logo” and stored in the root directory on your computer’s C:/ drive. Copy or move the image file to the USB drive, then remove the drive and insert it into the USB port on the front panel of the Baker DX. Go to the *Reports* screen and wait for the transfer to complete.
5. Now touch the **Report** icon then the **Logo** icon.
6. Remove the USB drive and connect a USB printer to the port.
7. Touch the **Print** icon then check the printout to see if the logo was included.



NOTE

Whenever information is re-entered in the report header form, be sure that the logo box is checked before pressing **Done** if you want to include a logo.

Defining report header information

1. To define the information that will appear in the header of your reports, touch the **Report** icon then the **Report Header** icon when the **Reports** submenu changes as shown below.

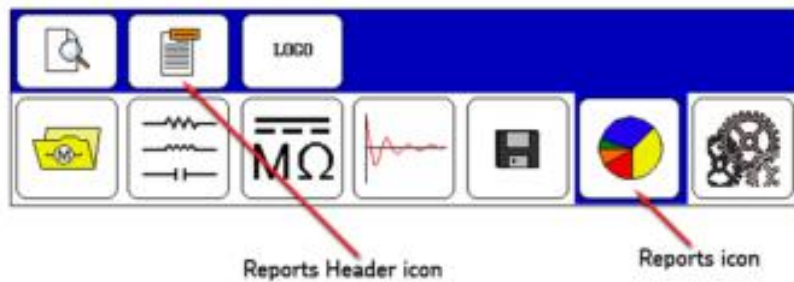


Figure 39. Starting reports mode.

2. This opens a form like the one shown below, which you will use to define the information you want to include in your reports.


Tested By :	<input type="text"/>	Company Name :	<input type="text"/>
Job Number :	<input type="text"/>	<input checked="" type="checkbox"/> Include Logo	
Notes :	<input type="text"/>		
Nameplate :			
SN :	<input type="text"/>		
Mfr :	<input type="text"/>		
HP/kW :	<input type="text"/>		
Voltage :	<input type="text"/>		
Clear All		Done	

Figure 40. Report header form.

3. You can also include a logo in the printout if you like by checking the **Include Logo** box. Loading a logo is addressed in the preceding section.

- Touching any of the highlighted fields produces a touch screen keyboard like the one shown below that you will use to enter or edit information. In this example “Motor Rebuilders Inc” is being added to the **Company Name** field in the form. When you finish typing the name in the field, touch **Done** on the keyboard and you will return to the report header form and the information will be loaded into the field you selected.



Figure 41. Touch screen keyboard.



NOTE

The report header information remains unchanged and will be used for all reports, even if other folders or records are opened. You will need to change this information when needed (for example, creating reports for a different customer with their logo, company name, and so on).

- Touch **Done** on the submenu bar when you complete the form.



NOTE

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

Printing reports

1. To print data, select the folder and record that you want to print (remember, selections are highlighted).
2. After the data is loaded, touch the **Report** icon then the **Display** icon.
3. Connect a USB printer to the USB port (installation of a printer driver is not necessary). When the printer is powered on and ready, touch the **Print** button.
4. The report will print with a logo (if used; SKF in this example) just to the left of the company name as illustrated below.

SKF GROUP

SKF

Folder Name: JOB 1234	
Record Name: IMODI 1HG7	Test Date/Time: 22-09-2011 01:08:09 PM
Tester Type: B0260	Tester SN: 101
Job Number: JOB 1234	Tested By: TECH 123
Notes: EXCESS OIL INSIDE	

NamePlate Information	
SN: 00C1233	Mfr: XYZ
HP/AM: 15	Voltage: 230V

RLC Tests Results				
	Lead 1	Lead 2	Lead 3	Units(%)
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/mag	37.886/ 69.4	37.955/ 69.1	36.948/ 69.3	0.2/1.4/1.2
Inductance(mH)	93.897	94.852	91.665	0.1/1.3/1.2
Z L/O	0.376/ 2.662	0.382/ 2.618	0.378/ 2.648	
Frequency (Hz)	68.0			
Capacitance (nF)	2.5			
Cap L/O	0.114/ 0.0			

Figure 42. Report example.



NOTE

Printer support information is provided in an appendix at the end of this manual.

Exporting 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. Push the red **Emergency Stop** button and rotate it to release.
2. Wait for the file to save then touch **OK**.
3. When you finish collecting desired screen shots, remove the USB drive and insert it into a computer.
4. Acquire the *DX Viewer* utility from the Baker DX product documentation CD or the SKF website (<http://www.skf.com/group/products/condition-monitoring/software/electric-motor-testing/index.html>) and install it on your computer where you can easily access it.
5. Execute the *DX Viewer* utility (`DXUtility.exe`) then click on the **Load DX Image** button and browse to the USB drive where the screen shots are stored (the files are assigned a “.dxb” file extension).
6. Click on the **Save Image As** button to rename the file and store the file where you want it on your computer.

Using system settings

Touching the **System Settings** icon in the **Mode Menu** opens the screen shown below.

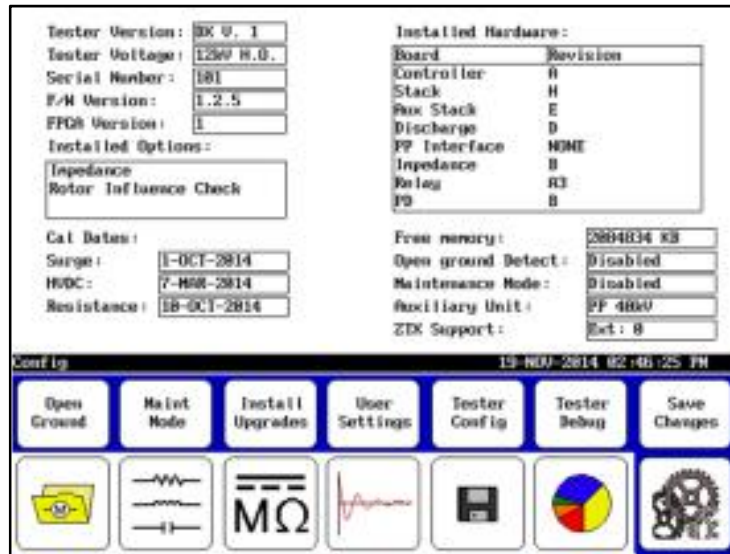


Figure 43. System settings opening screen.



NOTICE

The System Settings functions are reserved for personnel with Maintenance Mode access and privileges; basic operators will not have access to this area.

The Tester Config and Tester Debug icons are for use by SKF personnel only and provide access for hardware configuration functions used only during product assembly and updating.

Some of the information presented here is for reference only such as the tester version, tester voltage, serial number, and firmware version shown in the upper left corner of the first screen.

Touching the **Open Ground** icons opens a popup menu that you would use to enable or disable open ground detect. This is typically used in situations such as testing on a ship where there is no earth ground. Generally, this should be enabled. When enabled and an open ground is detected, the unit will stop performing tests until the problem is resolved.



WARNING

When this setting is disabled, testing can continue even if an open ground situation is present. Therefore, you must ensure that a proper ground connection is made under any circumstances.

Touch the **Maint Mode** (maintenance mode) icon to open the popup menu shown below, which you use to enable or disable maintenance mode, or change the maintenance mode password. (BAKER is the default password.) After maintenance mode is enabled and the maintenance mode password has been entered, you can access the **User Settings** area to make needed adjustments.

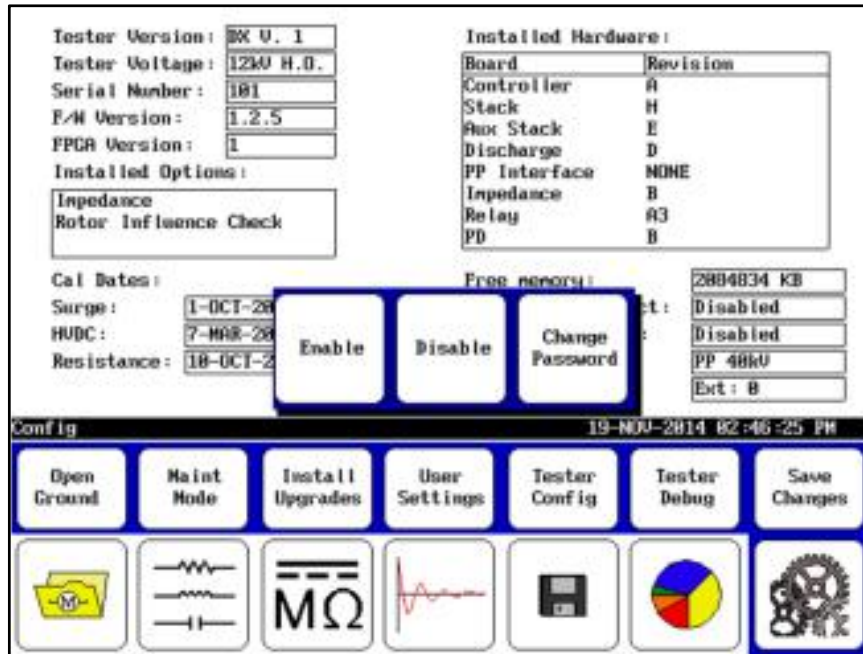


Figure 44. Maintenance Mode popup menu.

i NOTE

This area can also be used to enter system settings in admin mode, but that mode is reserved for SKF personnel. The admin password is based on hardware specific to the machine and cannot be changed.

Touch the **Install Upgrades** icon to open an *Enter Activation Code* dialog in which you enter codes for new software upgrades purchased. The upgrades appear in the **Installed Options** list after they are added to the system.

Touching the **User Settings** icon (with maintenance mode enabled) opens the screen shown below. Using this screen, you can change several of the parameters used during testing.

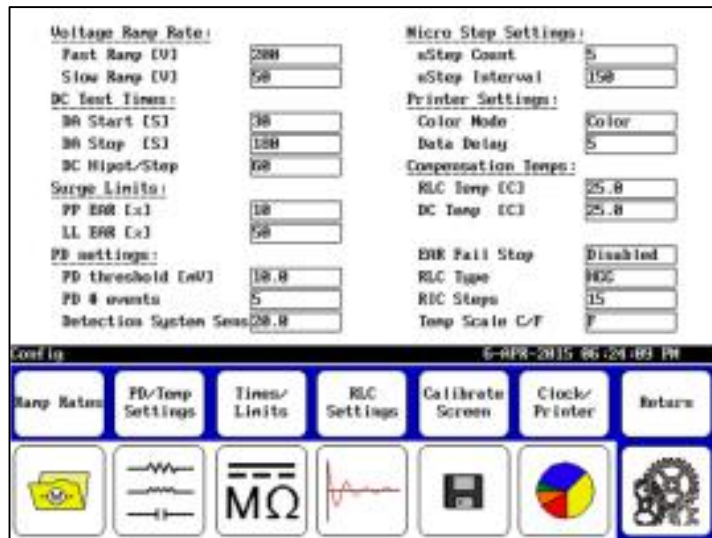


Figure 45. User Settings screen.



NOTICE

To avoid creating problems with the tester, **Micro Step Settings** should not be changed without first consulting SKF support. These fields are usually locked out.

Use this screen to adjust the **Voltage Ramp Rate**, **Temperature Scale** (Celsius vs. Fahrenheit), **DC Test Times** (in seconds), and **Surge Limits** (Pulse-to-Pulse EAR and Line-to-Line EAR maximum limits in percent).

The **RLC Steps** are the degree step increments used when plotting the RLC (rotor influence check) tests. Increments are 2, 5, 10, and 15 degrees.

The **Compensation Temperatures** (in Celsius) set here are the “compensate to” temperatures (standards) used in testing. The “compensate from” temperatures are current winding temperatures defined during the actual RLC or DC test procedures.

The **EAR Fail Stop** field is used to determine whether tests should stop if they exceed the EAR limits defined under **Surge Limits**. When this is disabled, the test will not stop but a “warning” appears in a red box within the test display area when a limit threshold is crossed. If this is enabled, the test will stop when the threshold is crossed.



NOTICE

If you are concerned about potential damage to the unit under test—such as coil arcing—when EAR limits are exceeded, you should consider enabling EAR Fail Stop.

The **RLC Type** field identifies the connection settings you will be using (HGG: Hot Ground Ground, or HGO: Hot Ground Open).

Use the **Printer Settings** section to define your printer color mode and data delay settings. All successfully tested printers had the following DX printer settings:

- 📄 Color Mode: Color
- 📄 Data Delay: 5



NOTE

For more information about using printers with the DX, refer to “Appendix E—Printer compatibility list.”

As the graphic below illustrates, some popup menus are multi-level and will change depending on the function selected. In this example, when the **DC Test Times** icon is touched, the popup menu changes to display the options for DC test times.

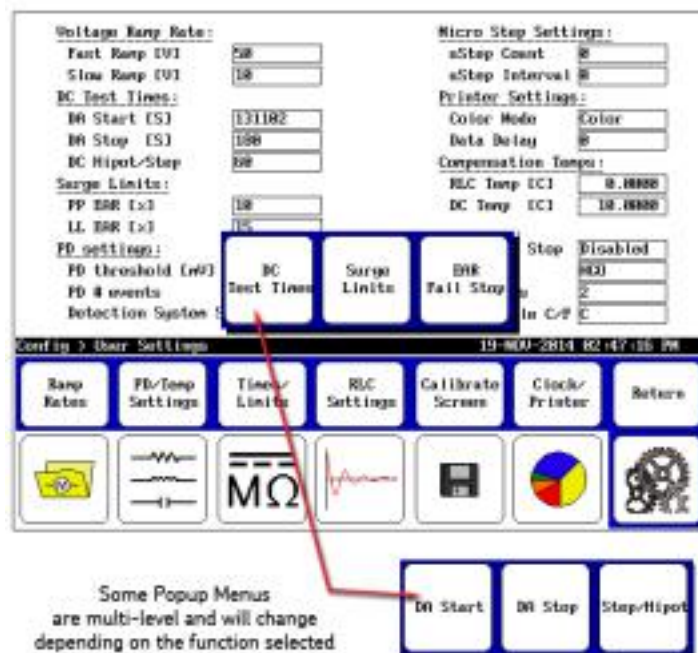


Figure 46. Multi-level Popup Menu example.

Partial discharge testing uses settings in both the **Voltage Ramp Rate** and **PD settings** sections. Application of these parameters for PD testing is explained in more detail on the next page.

Setting parameters for partial discharge testing

Partial discharge measurements—and their resulting indications—are dependent on the magnitude and intensity of activity that you want or need to measure. The magnitude of the partial discharges refers to the PD threshold level (also referred to as **PD event threshold**—set in millivolts), a minimum level that the discharge activity reaches or exceeds during any given pulse to qualify as PD. The frequency or intensity of the partial discharge refers to the amount of activity (number of PD events—**PD # events**) occurring during any given surge pulse. A combination of these two metrics determines what level of partial discharge is considered significant for the unit being tested.

These levels are set in the *User Settings* screen under the **PD settings** heading on the lower left portion of the screen.

NOTE:

For more information on partial discharge testing, refer to “Partial discharge detection in chapter 14

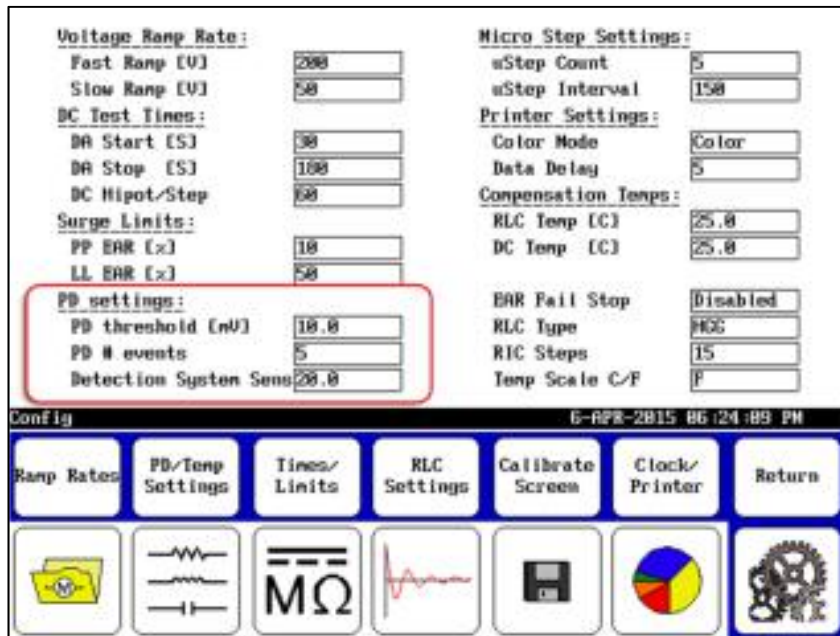


Figure 47. PD settings in User Settings screen.

Coils rated for higher voltages will exhibit higher magnitudes of PD than coils rated for lower voltages, so this setting should be adjusted in accordance with the nameplate voltage rating of the coil, the baseline noise level of the PD signal, and the surge voltage to be used for testing.

Partial discharge testing relies on the accurate detection of four key metrics: partial discharge inception voltage (PDIV), repetitive partial discharge inception voltage (RPDIV), partial discharge extinction voltage (PDEV), and repetitive partial discharge extinction voltage (RPDEV).



NOTE

The RPDIV and RPDEV voltages are determined by using data from multiple previous surge pulses and comparing them to the current pulse.

If the voltage step is too high, you might step over the point where PD events first occur, so it is important that voltage ramping occur in controlled and slowly-increasing steps to obtain inception voltages.

Likewise, extinction voltages should be acquired using slowly decreasing steps. Test time will increase slightly, but you will obtain more accurate results.

From the user settings screen, select a fast ramp rate of no more than 50 volts and a slow ramp rate of no more than 10 volts to increase repeatability of RPDIV and RPDEV measurements.

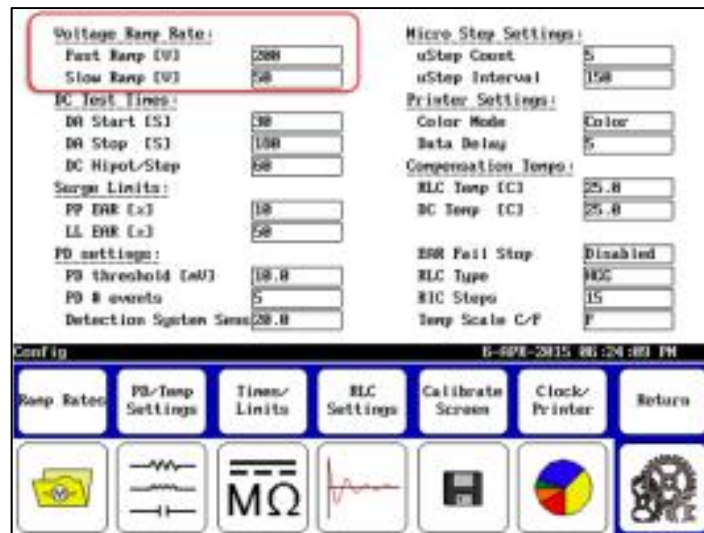


Figure 48. Setting ramp rates for PD testing.

6 Setting up the Baker DX tester

Positioning the Baker DX

The unit may be oriented for operation on any clean and level bench, shelf, cart, or table surface in the following positions:

- ┌ Laid flat with the bottom of the unit on a flat surface.
- ┌ Upright with the front panel facing upward.
- ┌ Held at an angle using the rotating handle with face panel upright (not upside down).

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 Baker DX 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.
- ┌ Avoid stacking objects of any kind on or near the Baker DX.
- ┌ Avoid placing the unit on other items other than power packs or flat surfaces.
- ┌ To prevent shock hazard, do not expose the Baker DX to rain, snow, or moisture. Avoid locations with high levels of dirt or dust.

Baker DX setup procedures

1. Place the Baker DX directly on a suitable surface as described above. Before you attach 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.
2. Plug the female end of the power cord into the connector on the rear of the unit.
3. Plug the other end of the power cable into a grounded wall socket. The unit operates between 85–264 V AC, 50/60 Hz.
4. 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.

7 Setting up power packs

General information

The Baker DX testers can 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 cannot operate alone; Baker DX control functions are required.

The Baker DX testers work with the Baker 30, Baker 40, and Baker x85 (30 kV, 40 kV) power packs.

The Baker DX testers also work with the Baker ZTX high-current surge test adapter. Baker x85 power packs and the Baker ZTX accessory provide armature testing capability for low-impedance DC motor armature windings, as well as other low-impedance coils. These tester configurations are commonly used for armature, span, bar-to-bar, DC IP (interpole), and DC FC (field coil) testing.



NOTICE

Review the instructions for stand-alone operation of the Baker DX before attempting to operate with a power pack.

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

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, is certified to work only with that power pack.



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 to prevent injury or death from electrical shock.

Power pack setup

The power pack setup procedure is relatively straightforward. The following graphics and steps walk you through the procedure.

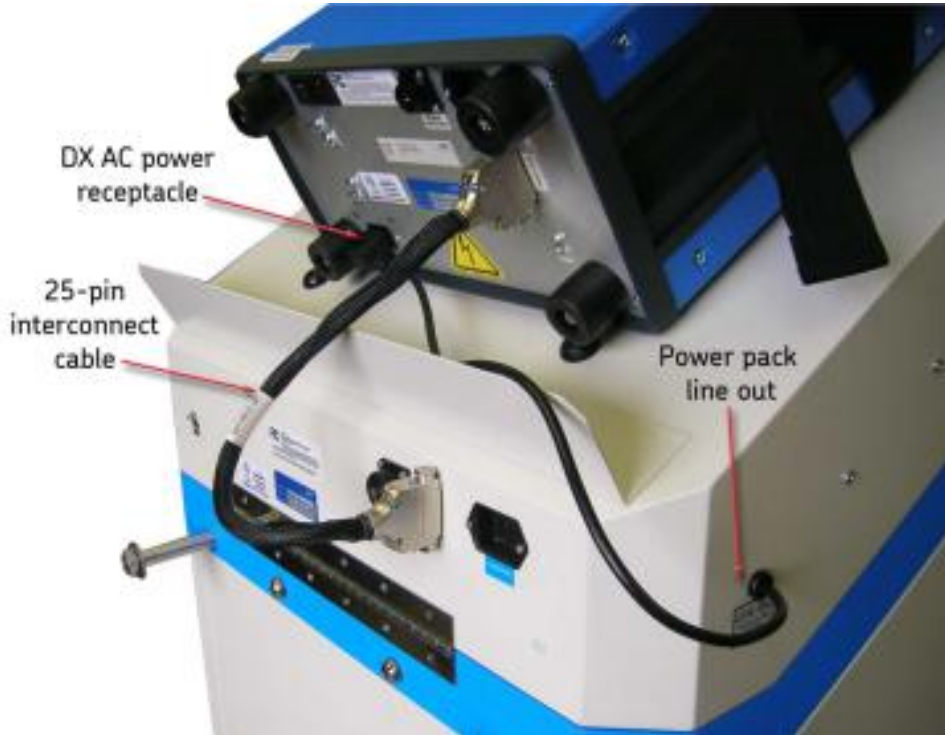


Figure 49. Power pack setup.

1. Connect the power pack to the tester. Use the *short* AC line out cord on the power pack rear side panel to connect to the Baker DX's AC power receptacle.
2. Connect the 25-pin interconnect cable to the receptacles on the power pack and the DX.



NOTE

Be sure to store Baker DX test leads out of the way when not in use. Wrapping around the support bar on the top of the unit is one common solution.

3. If you will use the remote E-Stop and safety lights accessory, and/or the footswitch accessory, connect them to the indicated locations on the back of the power pack as shown below.



Figure 50. Attaching accessories to the power pack.

4. 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 chapter 2 for appropriate power requirements.

Connect long AC power cord to front panel receptacle and appropriate power source



Figure 51. Connect power pack to AC source.

5. Power up the Baker DX and the power pack. After a five-minute warm up period, the power pack will be ready for operation.



NOTE

The Baker DX is equipped with an open ground monitor. If an open ground is detected, a red “Open Ground” banner will appear in the **Display Area**.

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 is hooked up to the USB port.
- ❏ The power pack, when equipped with the **Test Select** switch option, is not rated for operation in any position other than standing vertically, with all four wheels down on a level surface.
- ❏ The Baker DX gets its AC power from the power pack, so if the power pack is off, the Baker DX is also off.

During use:

- ❏ Do not switch the test leads or change the **Test Select** switch while a test is in progress.
- ❏ If the power pack connection to the Baker DX is maintained and the power pack is turned off, I/O lines are influenced. This will cause problems with Baker DX operation.

Three-phase test lead selector switch

The Baker 30 and Baker x85 power packs are supplied with three-phase test leads. Use the **Test Select** switch located on the right side of the main body below the front panel to switch between the different leads.

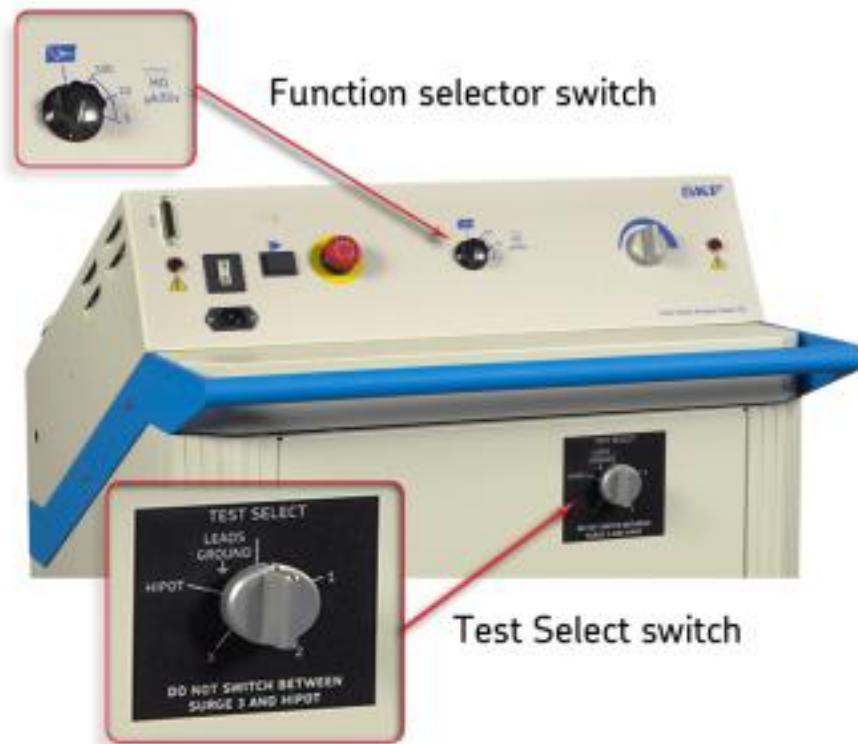


Figure 52. Three-phase lead Test Select switch.

The options on this knob are (test lead) **1, 2, 3, HiPot, and LEADS GROUND.**

With the three-phase test lead option, you are only required to connect the three leads once to the motor. For power packs that only have the single-phase test lead, you must manually move a red test lead between the motor's different leads.



CAUTION

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

Power pack lead internal configuration

Baker 30 and Baker x85

- ┌ Three red output cables, with insulated jacket rated at 60 kV DC, appropriately marked
- ┌ One black ground cable, with insulated jacket at 60 kV DC, appropriately marked
- ┌ One black ground cable with braided jacket appropriately marked.
- ┌ Baker x85 has an additional set of braided cables with circular connectors for attaching to high-current test accessories.

Table 2. Baker 30/x85 internal connections during HiPot testing.

Test Select Position	Test Lead 1 60 kV Red	Test Lead 2 60 kV Red	Test Lead 3 60 kV Red	Ground Lead 60 kV Black	Black Braid
HiPot	High Voltage	Open	Open	Ground	Motor Frame or Station Ground

Table 3. Baker 30/x85 internal connections during surge testing.

Test Select Position	Test Lead 1 60 kV Red	Test Lead 2 60 kV Red	Test Lead 3 60 kV Red	Ground Lead 60 kV Black	Black Braid
Test Lead 1	High Voltage	Ground	Ground	Ground	Motor Frame or Station Ground
Test Lead 2	Ground	High Voltage	Ground	Ground	Motor Frame or Station Ground
Test Lead 3	Ground	Ground	High Voltage	Ground	Motor Frame or Station Ground



NOTICE

For Baker 30 and Baker x85 power packs, you must place the power pack control panel Function selector switch into the HiPot position to perform a HiPot test. Be sure to switch the power pack Test Select switch 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 erroneous.

Baker 40

- ┌ 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
- ┌ One black ground cable with braided jacket appropriately marked.

Table 4. Baker 40 HiPot and surge internal connections.

60 kV Red	60 kV Black	60 kV Black	60 kV Black	Black Braid
High Voltage	Ground	Ground	Ground	Motor Frame or Station Ground

**Power pack configuration for DC-HiPot tests
(Three-phase test lead option Baker 30 and Baker x85 only)**

1. Ensure that the power pack setup procedure described earlier has been followed.
2. Turn the power pack **Voltage Output Control** knob on the power pack to **MIN** (full counterclockwise).
3. Select the 100 μ A/div HiPot setting on the power pack **Function** selector switch.

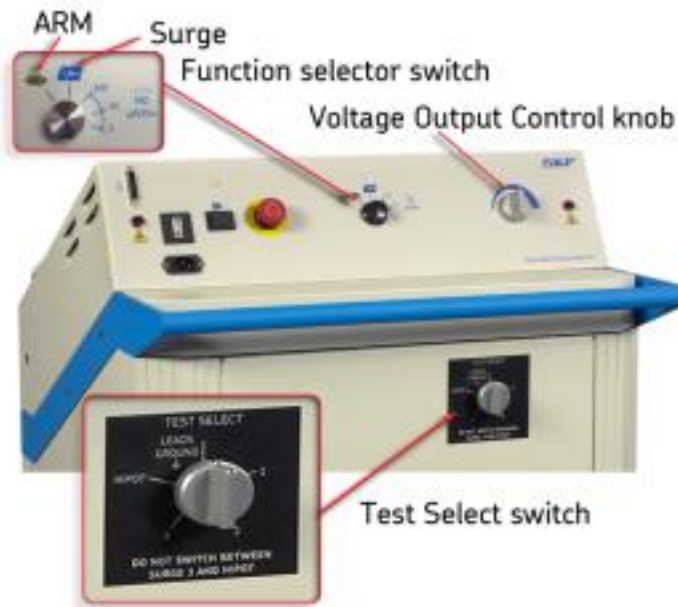


Figure 53. Power pack DC HiPot testing settings.

4. For the Baker 30 and Baker x85, ensure that the **Test Select** switch is set to **Ground** (**Test Select** switch not available on the Baker 40).
5. Connect the power pack leads to the test motor.

Table 5. Baker 30/x85 motor connections for surge and HiPot testing.

Test Lead 1 60 kV Red	Test Lead 2 60 kV Red	Test Lead 3 60 kV Red	Ground Lead 60 kV Black	Black Braid
Motor Phase A	Motor Phase B	Motor Phase C	Motor Frame	Motor Frame or Station Ground

6. 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.

**NOTE**

If you are *not* using the Baker 40 power pack, skip the next step.

7. When using the Baker 40 power pack (single-phase testing), connect test lead No. 4 to ground and test lead No. 1 to any of the winding phase connections.
8. Leave test leads No. 2 and No. 3 disconnected/open.
9. Connect the safety ground to the motor frame.

Table 6. Baker 40 motor connections for HiPot testing.

60 kV Red (Energized)	60 kV Black (Ground)	60 kV Black (Ground)	60 kV Black (Ground)	Black Braid (Ground)
Motor Phase A	No Connect	No Connect	Motor Frame	Motor Frame or Station Ground

When using the Baker 40 power pack for single-phase testing of three-phase windings, move connections as follows:

Table 7. Baker 40 motor connections for surge testing.

Surge Motor Phase	60 kV Red (Energized)	60 kV Black (Ground)	60 kV Black (Ground)	60 kV Black (Ground)	Black Braid (Ground)
A	Motor Phase A	Motor Phase B	Motor Phase C	Motor Frame	Motor Frame or Station Ground
B	Motor Phase B	Motor Phase A	Motor Phase C	Motor Frame	
C	Motor Phase C	Motor Phase B	Motor Phase A	Motor Frame	

10. Power up both the Baker DX and the power pack. For some test types, you will normally hear a loud relay noise.
11. Check that the open ground detect warning banner does not appear in the **Display Area**.

Power pack configuration for armature tests

The armature test feature is built into the power packs and can be selected by placing the **Function** selector switch on the front panel into the Armature (**ARM**) position.

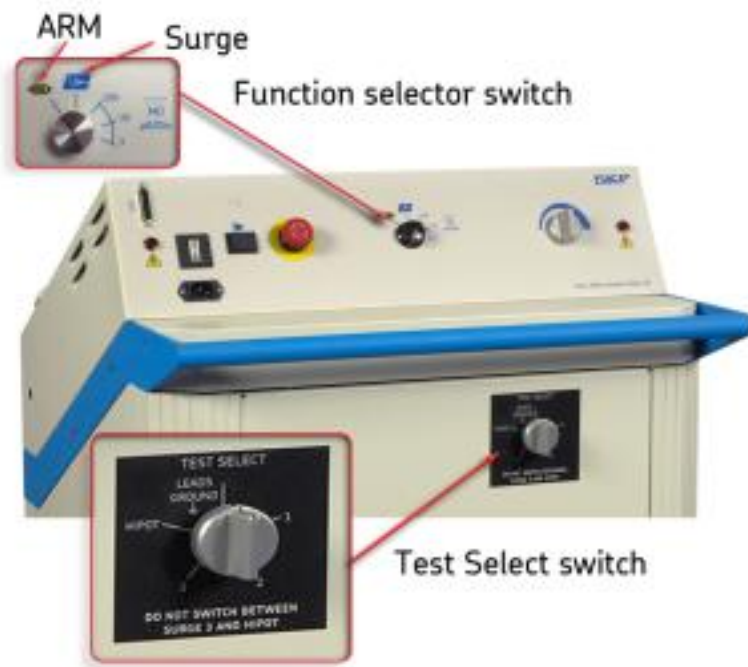


Figure 54. Power pack Test Select and Function selector switches.



CAUTION

Do not switch the Test Select switch or the Function selector 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.

1. Ensure that the power pack setup procedure has been followed as described earlier.
2. Turn the power pack **Voltage Output Control** knob on the power pack to **MIN** (full counterclockwise). Set the **Function** selector switch to Armature (**ARM**).
3. For the Baker x85, ensure that the **Test Select** switch is set to **LEADS GROUND**.



NOTE

The 60 kV voltage test leads are not used during ARM testing. The black braided test leads with black circular plastic connectors are active instead.

Armature fixture attachment

1. Connect the test head cable from the Baker x85 to the test head fixture.

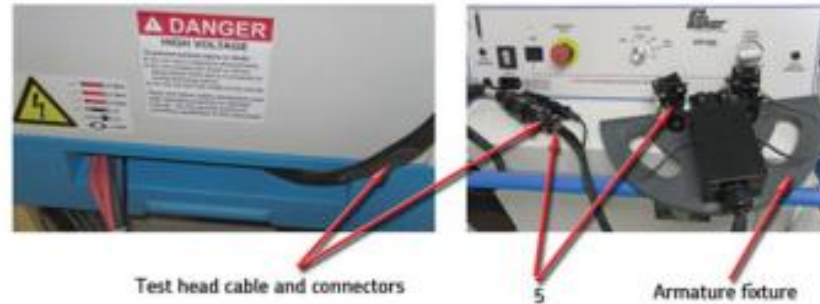


Figure 55. Test head cable and connectors, and armature fixture.

2. If you will use the remote E-Stop, connect it to the indicated location on the back of the power pack.
3. Ensure the DX and power pack setup procedures have been completed as described earlier.
4. Power up the Baker DX and the power pack. After a five-minute warm up period, both units will be ready for operation.

Power pack configuration for surge tests

1. Connect the safety ground (the smaller braided black ground) to the test winding's frame or station ground and not the coil ground lead.



NOTE

For the Baker 30/Baker x85, you need only connecting the power pack's test leads to the motor leads once. The Baker 30/x85's Test Select switch internally configures the test leads for HiPot and Surge testing.

Because the Baker 40 has only a single active lead, you will need to manually move the active lead between the different motor leads for each test operation.

2. Ensure that the power pack setup procedure has been followed as described earlier.
3. Turn the power pack **Voltage Output Control** knob on the power pack to **MIN** (full counterclockwise).
4. Select the **Surge** setting on the power pack **Function** selector switch.

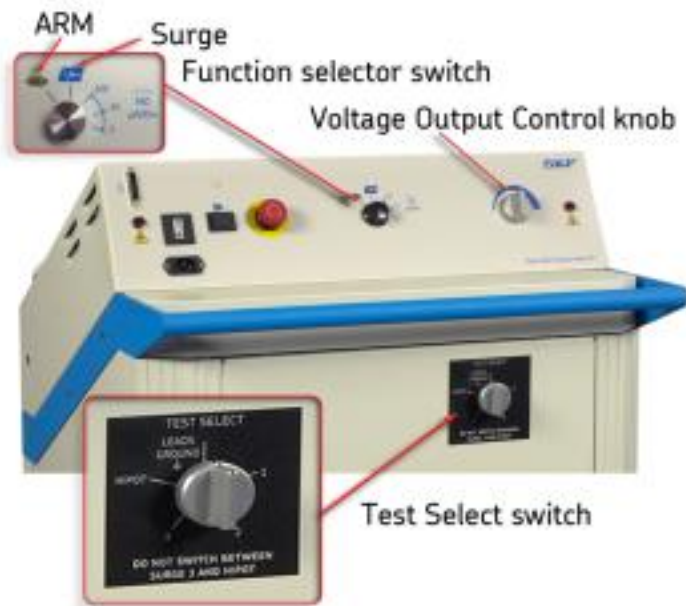


Figure 56. Power pack surge test settings.

5. For the Baker 30 and Baker x85, ensure that the **Test Select** switch (upper right front panel) is also set to **Ground** (not available on the Baker 40).
6. Connect the power pack (Baker 30/x85 only) leads to the test motor.

Table 8. Baker 30/x85 motor connections for surge and HiPot testing.

Test Lead 1 60 kV Red	Test Lead 2 60 kV Red	Test Lead 3 60 kV Red	Ground Lead 60 kV Black	Black Braid
Motor Phase A	Motor Phase B	Motor Phase C	Motor Frame	Motor Frame or Station 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.
- When using the Baker 40 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.

Table 9. Baker 40 motor connections for HiPot testing.

60 kV Red (Energized)	60 kV Black (Ground)	60 kV Black (Ground)	60 kV Black (Ground)	Black Braid (Ground)
Motor Phase A	No Connect	No Connect	Motor Frame	Motor Frame or Station Ground

When using the Baker 40 power pack for single-phase testing of three-phase windings, move connections as follows:

Table 10. Baker 40 motor connections for surge testing.

Surge Motor Phase	60 kV Red (Energized)	60 kV Black (Ground)	60 kV Black (Ground)	60 kV Black (Ground)	Black Braid (Ground)
A	Motor Phase A	Motor Phase B	Motor Phase C	Motor Frame	Motor Frame or Station Ground
B	Motor Phase B	Motor Phase A	Motor Phase C	Motor Frame	
C	Motor Phase C	Motor Phase B	Motor Phase A	Motor Frame	

- Power up both the Baker DX and the power pack. For some test power packs, you will hear a loud relay noise. After five minutes, the power pack will be ready for testing.
- Check that the open ground detect warning banner does not appear in the **Display Area**.

Baker PP40 manual surge range switch

This Baker PP40 Power Pack is equipped with a manual range switch for performing surge tests. This switch provides positive control of the surge test voltage and eliminates dependency upon automatic range switching during a test.

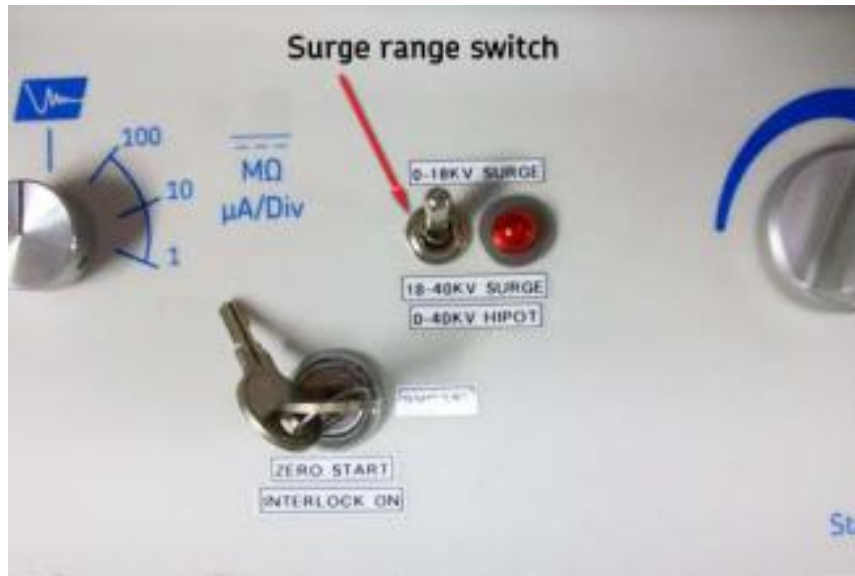


Figure 57. Manual surge range switch on PP40.

Flip the **Surge range switch** up for tests requiring voltages less than 18 kV.

If the **Surge range switch** is in the “up” position and the **Voltage adjust knob** is rotated to increase the voltage above 18 kV, *the analyzer will not generate any surge pulses.*

Flip the **Surge range switch** down for tests requiring voltages greater than 18 kV.

If the **Surge range switch** is in the “down” position and the **Voltage adjust knob** is rotated to decrease the surge voltage below 18 kV, *the analyzer will not generate any surge pulses.*

For DC HiPot tests using the Baker PP40, the **Surge range switch** must be in the “down” position. HiPot testing will not work correctly with the switch in the “up” position.

8 Setting up the Baker ZTX



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating the Baker ZTX.

1. Connect the 25-pin interconnect cable to the two units. The cable is marked on each end.
2. Connect the footswitch to the Baker ZTX front panel connector labeled as such (not shown in graphic).

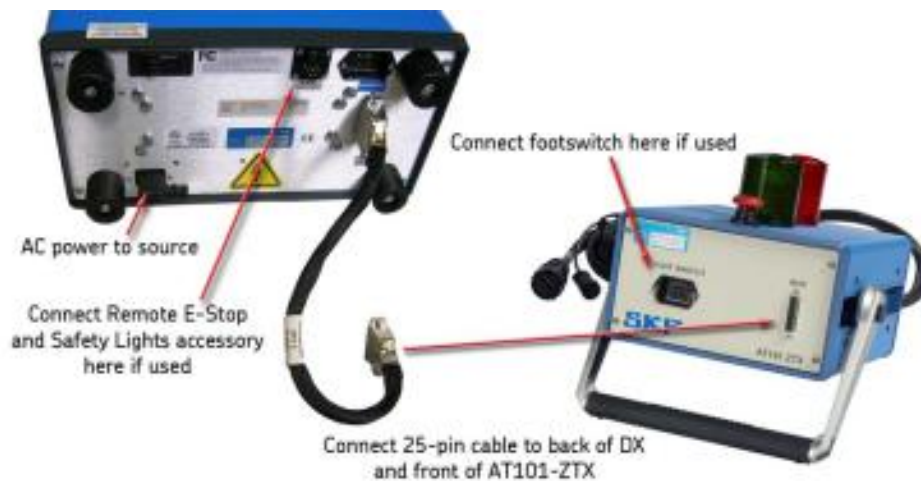


Figure 58. Baker ZTX connections to DX and accessories.

3. If using the remote E-stop, connect it to the indicated location on the back of the Baker DX.

4. Connect the high-voltage test leads of the Baker DX to the Baker ZTX unit's recessed bars located on the rear of the unit as follows:
 - ❑ Connect test lead No. 1 to the bar labeled "Test Lead 1."
 - ❑ Connect test leads No. 2 and No. 3 to the recessed bar labeled as such.
 - ❑ Connect the ground lead to the recessed bar labeled as such.

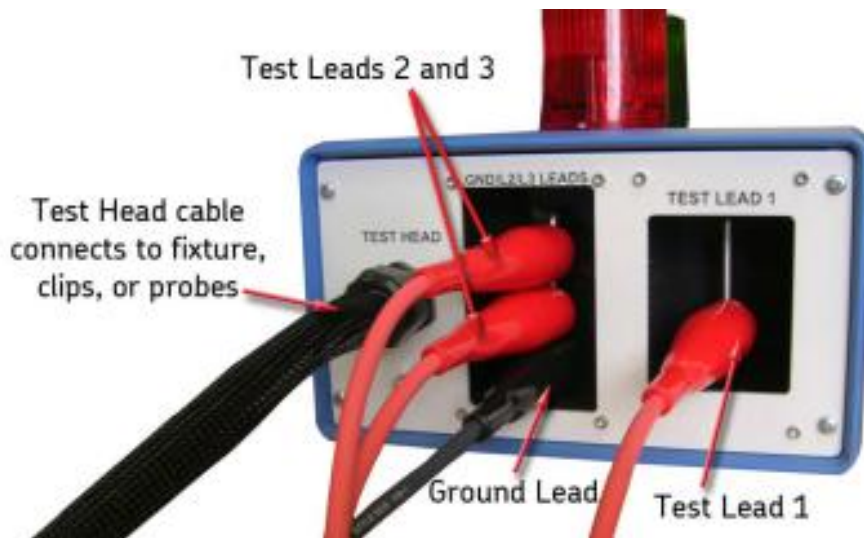


Figure 59. DX leads and fixture connections to Baker ZTX rear panel.

5. Connect the bar-to-bar test head accessory to the black braided test head cable. There are two connectors: a small circular one and a large one. Be sure both connections are properly made.



Figure 60. Baker ZTX connected to armature test fixture.

6. After completing the setup process, ensure that the Baker DX is plugged into a good grounded source (the Baker ZTX is powered by the DX).



NOTE

The Baker DX includes an open ground detect feature. If an open ground is detected, a banner appears in the **Display Area**.

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.
- 📌 Make sure no printers are connected to the USB port.

9 Setting up fixtures and test accessories

Introduction

There are two types of armature tests that Baker products can perform:

1. Armature span testing
2. Armature bar-to-bar testing

A bar-to-bar test requires the use of an impedance matching transformer (ZTX) as found in an Baker ZTX accessory or a Baker x85 power pack with built-in ZTX. Additionally, the ZTX is built into the new 15kV DX15A unit (A is for armature).

A test head or set of special test leads plug into the high-current output leads of each of these instruments/accessories. These test heads or special test leads are the:

- └ Bar-to-bar armature test fixture
- └ ATP02 armature test probes
- └ ATP02-C test clips

Any one of these can be used for testing the coils found in DC motors. The bar-to-bar fixture and test probes are used for armature tests while the clips are used to test other low-inductance coils often found in DC motors.

Bar-to-bar armature test fixture

For armature bar-to-bar testing, the bar-to-bar test fixture is required. This fixture has one set of carbon brushes that makes contact with two adjacent bars on the commutator of a DC motor's armature. Through these two brushes, a surge pulse is applied. The coils connected to these two adjacent bars are then surge tested. A second set of carbon brushes are used to ground the commutator several bars to the left and right of the two adjacent bars being tested. These brushes are on the "grounding arms" of the fixture.

During bar-to-bar testing, adjacent bars on the commutator are tested. In turn, all adjacent bars around the circumference of the commutator are tested. For example, bars 1 and 2 are tested, then bars 2 and 3 are tested, then bars 3 and 4 are tested. The pattern continues until all commutator bars are tested.



Figure 61. Baker ZTX with bar-to-bar armature test fixture.

DX zero start circuit

To ensure the waveforms for each of the bars tested can be compared in amplitude, the tester must be set up so that the same test voltage is applied to the test fixture every time a test is performed. This is done by disabling a “zero start” circuit in the tester.

The zero start circuit is designed to force the operator to start at zero volts every time a test is run. Doing so allows the operator to ramp up the test voltage from zero while observing the surge waveform for the indications of an arcing turn-to-turn insulation failure—the holy grail of surge testing AC induction motor windings and most windings in general. However, when testing DC motors, it is not desired to have to start at zero volts every time a test is run, this is mostly for operator convenience. It would be awkward to have to ramp up the voltage from zero to the required test voltage for every bar on a commutator, which can have many hundreds to thousands of bars.

Span testing

Span testing can be done with any of Baker’s surge testers; no special impedance matching transformers are required. To span test, pointed probes are attached to the surge tester’s high-voltage test leads. The pointed probes are used to make contact with commutator bars that are 5–15 bars apart. The number of bars between the probes is called the *span*. The probes themselves can be something as simple as large Philips screwdrivers as long as they have properly insulated handles and offer proper protection for the operator; more on the probes in a moment.

To test the armature windings with the span test, the probes are placed on the commutator, the test button or foot switch on the surge tester is pressed and a surge test is applied between the probes. Again, it is necessary to have

the zero start circuitry disabled so that the test voltage will go straight to the test voltage without the operator having to manually ramp up the voltage.



NOTE

Thinking about this logically, if the operator's left hand is on one probe, the right hand on the other probe, and one foot operating the footswitch, how can the operator ramp up the voltage? Without a second person to assist, this is not possible. So this is why the zero start circuit has to be disabled for span testing.

Again when span testing, every bar is tested around the circumference of the commutator. For example, if a span of 7 bars is being used, bar 1 and bar 7 are tested. The probes are moved to bar 2 and bar 8 and the test repeated. The probes are moved to bar 3 and 9 and the test repeated. This pattern continues until all bars around the commutator have been tested.

Test clip and probes

Regarding test probes, any insulated probe that will allow the operator to safely make contact with two commutator bars can be used for the span test.

Baker makes a set of test leads called ATP02-P low-impedance test probes that can do a span test; however, these probes connect to the high-output leads of a ZTX equipped instrument or accessory. These probes can be used for span testing, assuming enough voltage can be obtained when spanning the coils, but most span testing is conducted using the high-voltage leads of the tester where the ATP02-P armature test probes cannot be used.

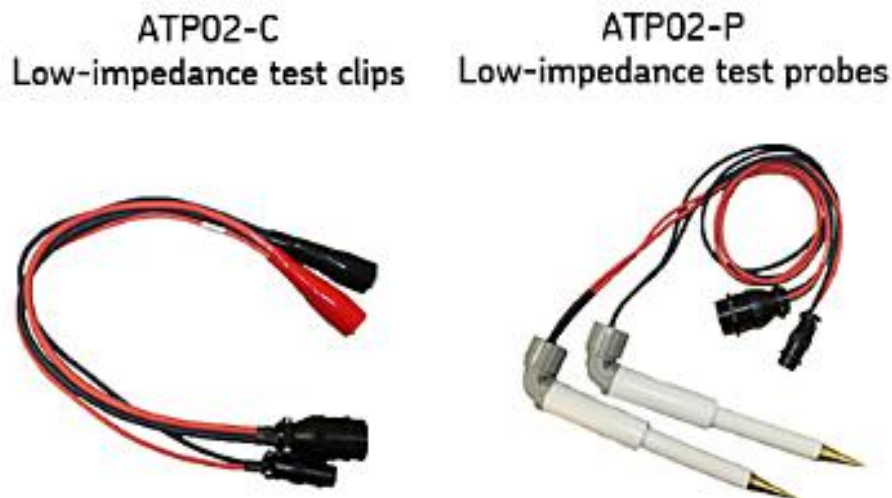


Figure 62. Test clips and probes.

Low-impedance coil testing

Testing low-impedance coils, such as the interpoles of a DC motor, is done with a set of special test leads called ATP02-C test clips. These clips also

attach to the high-current output leads of a ZTX accessory such as the Baker ZTX or ZTX equipped testers. Tests performed with the ATP02-C test clips are made in the same manner as bar-to-bar or span testing. Specifically, the clips are attached to the first of many coils to be tested and a test is performed. The waveform of this first test is saved so that subsequent tests of the remaining coils can be compared to this first reference coil. Again, the zero start circuitry is disabled so that the same test voltage is used every time for each of the coils to be tested. The test is repeated until all coils have been tested. Compared to commutator bar-to-bar testing or span testing, there are considerably fewer coils to test; for example, six interpoles instead of hundreds of bars.

Low-impedance test probes

The low-impedance test probe set is an accessory that you can attach to the test cable leads instead of the armature fixture. Although the probes can be used for bar-to-bar testing, they are more commonly used in span testing.



Figure 63. ATP02 armature test probes.



NOTE

The test probe accessory is used only for low-voltage testing.

Armature test fixture setup

1. Mark and number the armature face as shown to help identify current testing location.
2. Position the armature fixture on the armature at a selected starting point. Use the **Hot brush adjustment knobs** to adjust contact for bar-to-bar spacing. Center the brushes on the selected bars.
3. Center the ground brushes on the selected bars by adjusting the ground arms then lock the arms in place with the **Ground arm locking knobs**.

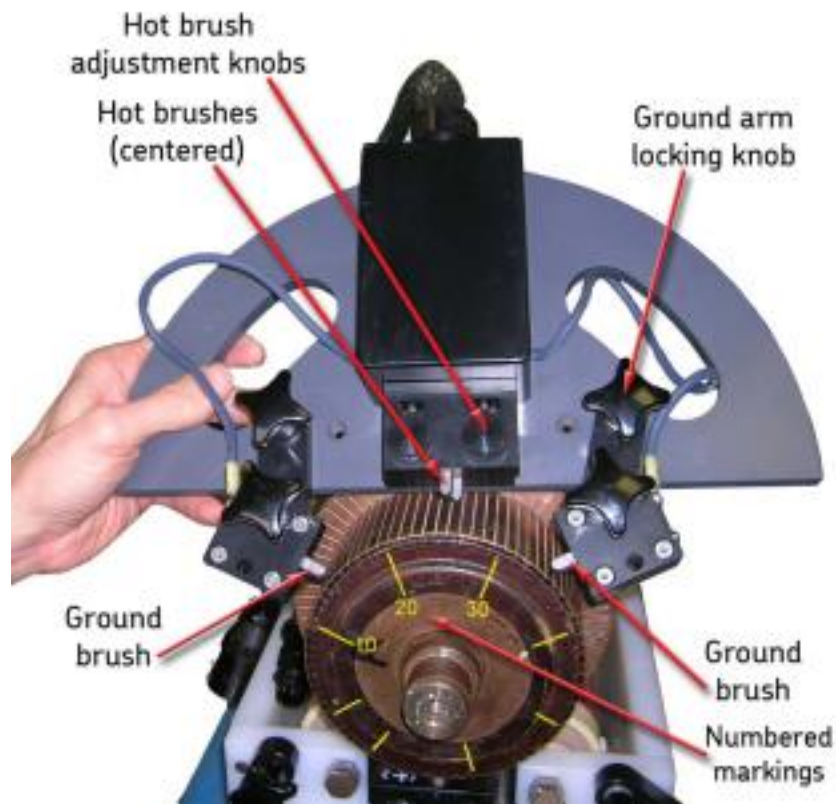


Figure 64. Positioning the armature fixture on the armature.

4. Ensure the test lead cable is properly connected to the armature test fixture.

Using clip accessory

1. Connect the test lead cable to the clip accessory. For the DX standalone DC FC/Arm Span test, connect the high-voltage leads directly to the coils.



Figure 65. Connect test lead cable to clip accessory.

2. Power up the DX host unit—the Baker ZTX unit also powers up from the DX host.
3. Ensure that the Baker DX plugs into a good ground source. An open ground detect will keep the unit from operating. Touch the **Settings** and **Open Ground** icons to see the ground status.
4. Connect the clips to the coil to be tested; for example, a DC interpole coil.



Figure 66. Connect clips accessory to DC interpole coil.

Low-voltage coil connection

1. Connect the low-voltage cables to a coil under test and proceed.
2. Ensure cables do not touch each other or a ground source during testing.



Figure 67. Connecting low-voltage cables to a coil.

Connecting high-voltage leads to a motor



NOTE

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

1. Ensure motor leads are properly labeled to provide accurate test data.
2. Connect the high-voltage test leads to each of the motor leads. Motor lead 1 connects to test lead 1, motor lead 2 connects to test lead 2, and motor lead 3 connects to test lead 3.
3. Connect the ground cable to motor ground.
4. Ensure test/motor leads do not contact each other or the motor chassis during testing.



Figure 68. Connecting high-voltage test leads to motor leads.

Connecting low-voltage leads to a motor



NOTE

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

1. Ensure motor leads are properly labeled to provide accurate test data.
2. Connect the tester's RLC test leads to each of the motor leads. Motor lead 1 connects to test lead 1, motor lead 2 connects to test lead 2, and motor lead 3 connects to test lead 3.
3. Connect the ground cable to motor ground.
4. Ensure test/motor leads do not contact each other or the motor chassis during testing.
5. Keep high-voltage test leads away from motor and RLC leads during testing.



Figure 69. Connect RLC test leads to motor leads.

RIC test setup

1. Make a copy of this template and print or paste it on heavier stock then cut it out and place the template over the motor to indicate angle changes during testing.
2. Larger versions of the template (in two increments) are available in the appendix or from files located on the Baker SKF site at: <http://www.skf.com/group/products/condition-monitoring/software/electric-motor-testing/index.html>.
3. Connect the RLC test leads to the motor under test as described earlier.



Figure 70. RIC test motor template.

10 Test procedures

Recommended testing sequence

To test three-phase AC inductor motors adequately and to have effective and 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 practice 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:

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

Low-voltage armature and rotor influence check (RIC) tests are special procedures that conduct resistance, inductance, and impedance measurements.

Determining a known-good coil to use as a reference

If you have not already established a reference (and known-good coil), this process shows you how to identify a known-good coil so that you can set the reference test for comparisons to other coils to be tested. The process locks in the reference waveform, which will be used to perform subsequent tests.

1. Select a coil that you expect is good and connect it to the tester.
2. Push and hold the **Start (PTT)** button and the **Ramp Rate and Waveform Zoom** popup menu appears.

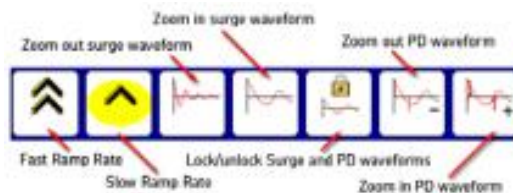


Figure 71. Ramp rate and waveform zoom icons.

3. Alternately use the **Fast/Slow Ramp Rate** icons to control the rate of voltage change while rotating the voltage knob to set the test voltage for the series.
4. Use the **Waveform zoom** icons to adjust the display scale of the surge waveform. When you have obtained a good waveform, release the **Start (PTT)** button.
5. Test the coil several times to see if the connections, the system, and the coil produce consistent closely-repeatable results. If not, recheck connections and the coil for damage and replace the coil if necessary with one that you expect is good.
6. When you have determined that you have a good coil, and you are satisfied with the voltage level established at the last test, touch the **Set Reference** icon.
7. Touch the **ZS Override** icon to establish its settings at the reference level.
8. Touch **Yes** when the following message appears:



Figure 72. Override zero-start functionality message dialog.

9. After you set the ZS Override level, the voltage knob on the unit will no longer control the unit's output voltage.

**WARNING**

To avoid injury or death from sever electrical shock, take precautions because subsequent tests will immediately apply the test voltage to the coil. Voltage will not start at zero.

10. You can now test a group of "identical" coils by sequentially connecting the test leads to each coil, pushing the **Start (PTT)** button and holding it (for more than two seconds).

Resetting test reference

1. If for some reason you need to reset the reference (for example, you ran a few more tests and realized that your "known good" coil was not what you expected, you can simply touch the **Set Reference** icon again when you have the preferred waveform.
2. When a reference has already been set, you will see a dialog box like the one shown below asking if you want to clear all and use the new reference. Select **Yes**.



Figure 73. Reset test reference dialog box.

3. You can now test a group of "identical" coils by sequentially connecting the test leads to each coil, pushing the **Start** button and holding it (for more than two seconds).

Using the recall reference feature

If you come in fresh to this screen, you have to create a reference. If you test a coil and touch the **Set Reference** icon, that data becomes your reference. But if you have not tested anything yet, and you already have a reference saved, you touch the **Set Reference** icon and the following dialog box appears so you can locate and select a previously-saved reference. Select folder, record, then reference. You will see a dialog confirming that the reference was set.

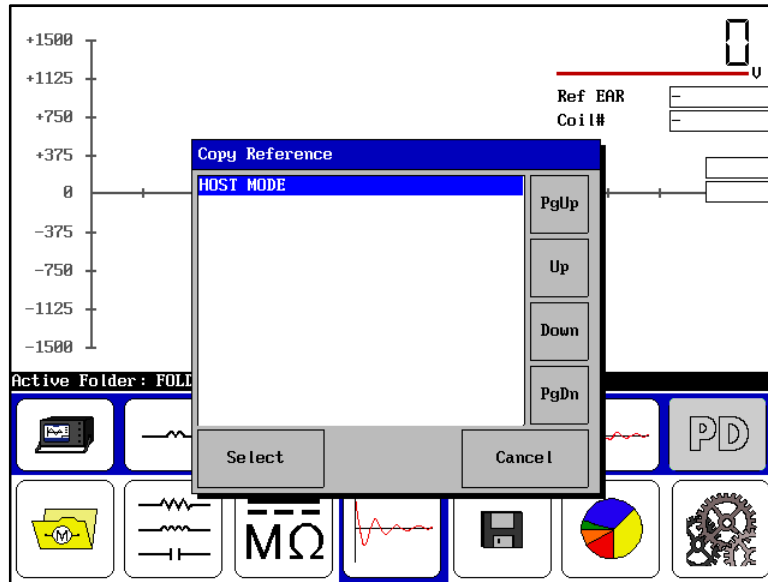


Figure 74. Using the recall reference feature.

You can now test a group of “identical” coils by sequentially connecting the test leads to each coil, pushing the Start button and holding it (for more than two seconds).

Coil resistance, inductance, and capacitance tests using the DX host

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

Coil induction tests look for changes in a winding's inductance brought about by shorted turns in the coils. Inductance readings for three-phase motors can be compared to each other with the knowledge that the inductance for the three phases should be very close to each other unless there is a short in one of the coils. Inductance measurements can also be compared to previous measurements or values specified by the original equipment manufacturers.

In addition, the DX capacitance tests only measure capacitance and D/Q. No impedance values or phase angle values are induced.



NOTE

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.



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the Baker DX setup procedure has been followed. Refer to chapter 6 “Setting up the Baker DX tester” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



CAUTION

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.

Resistance test procedures

1. Select the folder and record to use and check the **Status Bar** to ensure that the **Active Folder** and **Active Record** display the desired folder and record to be used for the subsequent RLC tests.

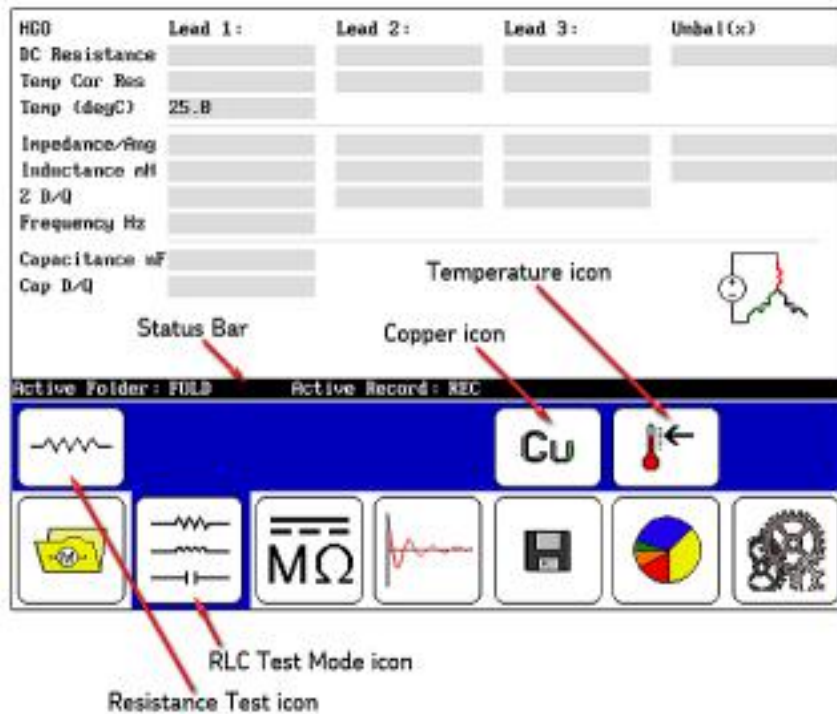


Figure 75. Resistance test start screen.

2. Touch the **RLC Test Mode** icon.
3. Touch the **Resistance Test** icon.
4. If performing temperature compensation, touch the icon for the proper type of conductor metal: aluminum or copper (**Copper** icon shown above).



NOTE

In the test start screen as shown above, the value that first appears in the **Temp (degC)** field is originally defined in the system settings. You can change this value in the next step.

- If you need to define temperature compensation, touch the **Temperature** icon, then use the popup keypad to input actual temperatures. Otherwise, skip this step and the next.



Figure 76. Popup keypad.

- The default temperature is 25 °C; key in the actual temperature to calculate compensation and touch **Done**.
- Push and release the **Start (PTT)** button to run the resistance test. The resistance test will be run for all three phases automatically. The “Leads Energized” message will appear at the top of the display. When the test finishes, the unbalance will display in the results.

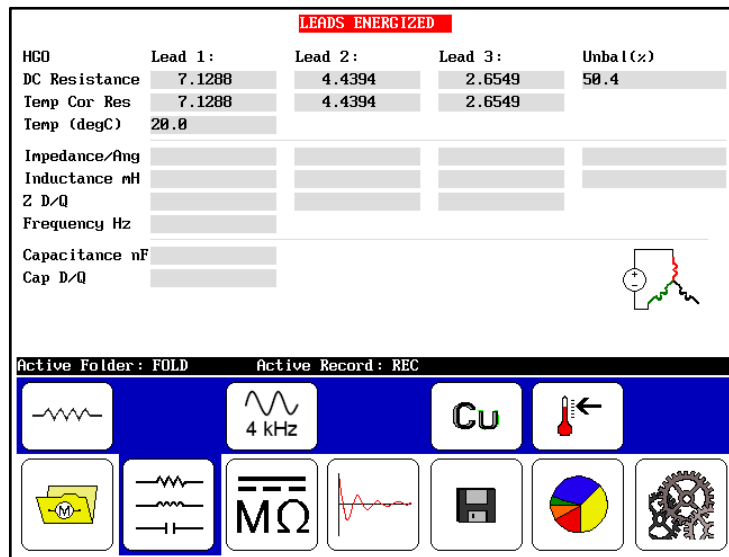


Figure 77. Resistance test results screen.

- If this resistance test was run as a standalone test, save the results. Saving resistance data at this time is not necessary if you plan collect inductance and/or capacitance tests data as well; then you can save all together.



NOTE

If you require another resistance test, running this test again will overwrite the current results unless you save it.

Inductance, impedance, phase angle, and D/Q tests procedures

This procedure starts where the resistance test was completed.

With coil inductance tests, the Baker DX looks for imbalances and variations between the coil phases. The DX performs these tests at a single specified frequency.

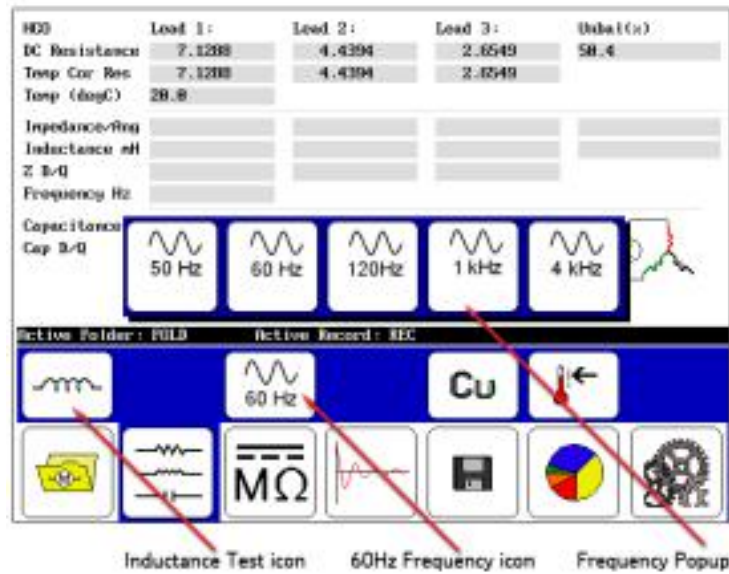


Figure 78. Inductance test start screen.

1. Touch the **Test Mode** icon to change it to show the **Inductance Test** icon.
2. The submenu changes as shown in the example above with a **Frequency** icon in the options if you are running AC tests. In this case, touch the **Frequency** icon and a popup menu appears with the selection of available frequencies.
3. Touch the **60 Hz** frequency icon for this example.

4. Push the **Start (PTT)** button to run the inductance test. Inductance measurements will automatically be made for all three phases. 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.

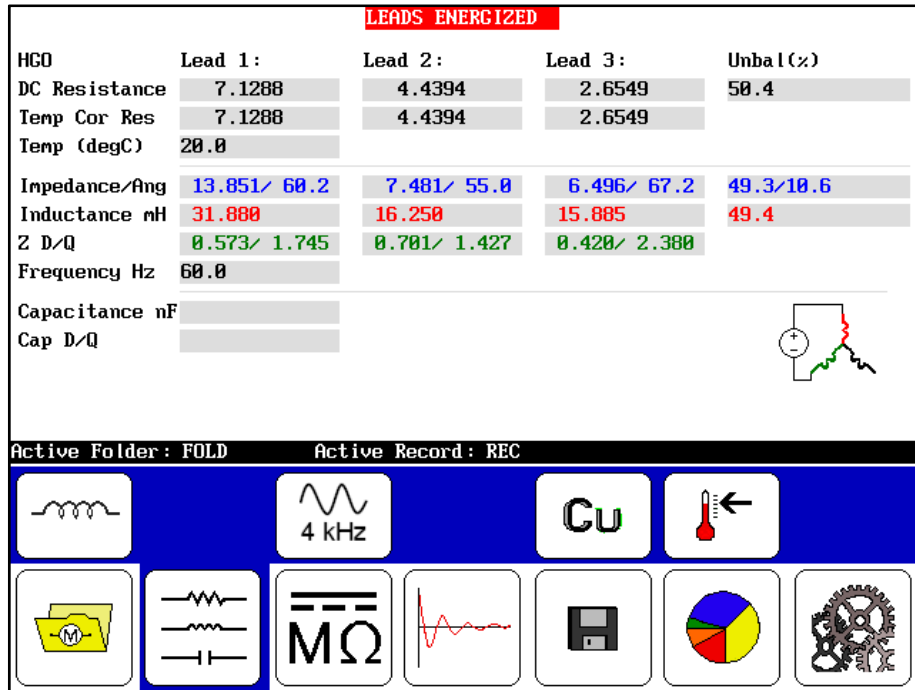


Figure 79. Inductance test results screen.



NOTE

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 procedures

This procedure starts from the end of the inductance test, but can start from the end of the resistance test as well.

The DX measures the capacitance of the core across the ground wall insulation.

As noted above, lead cautions still apply, but you must modify connections of the RLC test leads to a capacitor test configuration.

1. Connect RLC test lead No. 1 to any motor lead.
2. Connect RLC test lead No. 2 to ground.
3. Disconnect RLC test lead No. 3 *and leave disconnected.*



Figure 80. Capacitance test lead connections.

- Select 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.

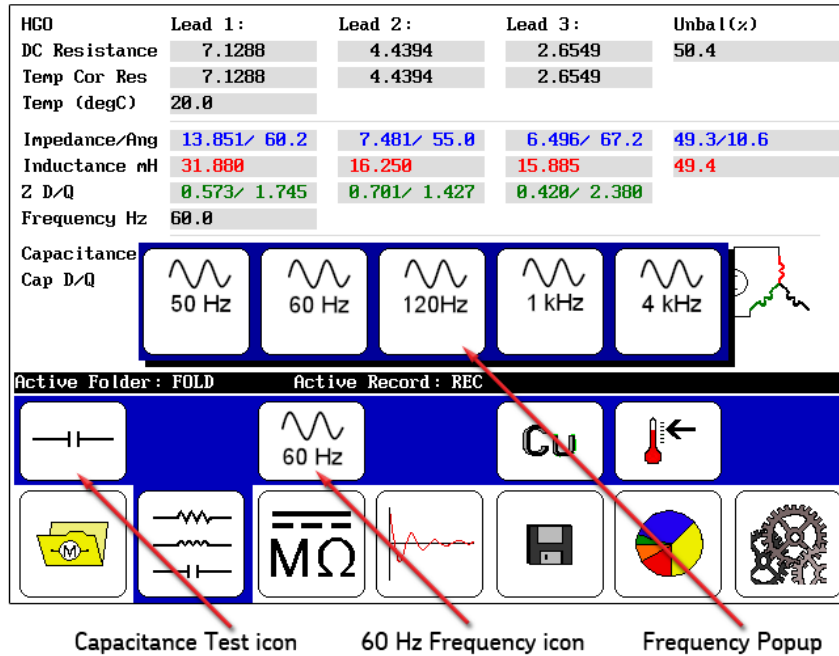


Figure 81. Capacitance test start screen.

- Touch the **Test Mode** icon to change it to show the **Capacitance Test** icon.
- The submenu changes as shown in the example above with the 4 Hz frequency icon shown to identify the frequency at which the tests are conducted if you are running AC tests.

- Push and release **Start (PTT)** button 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.

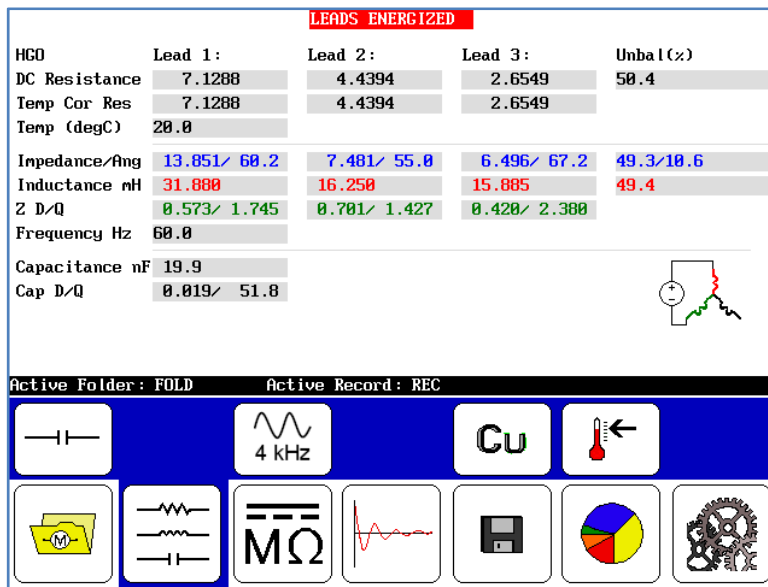


Figure 82. Capacitance test results screen.

- Touch the **Save** icon to save your data, unless you plan to conduct more capacitance tests (data will save to the selected folder). In any case, be sure to save your data before going on to the next set of tests. **The next test will overwrite unsaved test data.**
- Ensure that the active folder and/or active records are the intended location(s) for the test data. Touch the **Save** icon the touch **Yes** in the *Confirmation* dialog.

DC tests using the DX host

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 high potential (HiPot)
- ↳ step voltage
- ↳ polarization index (PI)
- ↳ dielectric absorption (DA)

Each test type was designed to answer specific questions regarding the properties or integrity of the ground wall insulation system. The following example includes procedural details.

1. Always begin DC testing by conducting a megohm test using a test voltage based on the motor's operating voltage and the appropriate standards and/or company testing guidelines.
2. Look for an unusually low megohm value when compared to previous measurements or industry accepted limits for the type of insulation in the motor.
3. If a low megohm value is measured, inspect the motor for ground wall insulation damage or determine if some part of the ground wall insulation has failed. Possible problems include the following:
 - ↳ Either the slot liner insulation or enamel wire insulation might be burned or damaged.
 - ↳ The motor might be full of dirt, carbon dust, water, or other contaminants.
 - ↳ Connections to the actual coils might be bad.
 - ↳ The wrong insulation might have been used to connect the coils to the motor's junction box.



NOTE

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 7, DC testing principles and theory,” which has supporting information and details about DC testing capabilities and methods.

DC test procedures



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the Baker DX setup procedure has been followed. Refer to chapter 6 “Setting up the Baker DX tester” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



CAUTION

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.



WARNING

DC tests of high-voltage motors will be automatically discharged when releasing the Start (PTT) button (unless PTT lock is active). To avoid injury or death from electrical shock, wait for discharge to reach zero before removing any leads.

Industry practices suggest allowing a winding to discharge four times the total amount of time that DC voltage is applied to the winding.

1. Select the folder and record to use and check the **Status Bar** to ensure that the **Active Folder** and **Active Record** are those that you want to use for the subsequent DC tests.

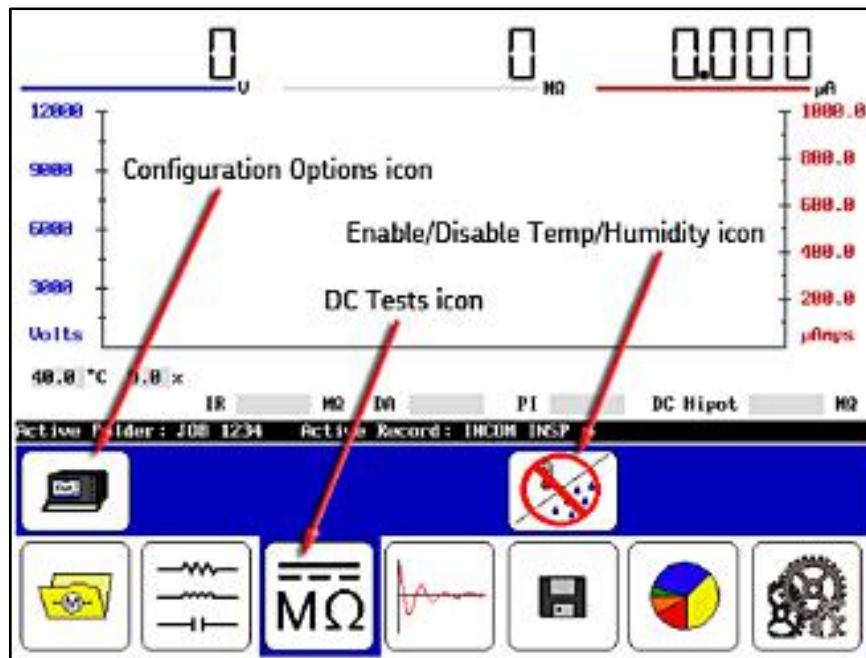


Figure 83. DC Tests start screen.

2. Touch the **DC/megohm** icon then the **Configuration Options** icon when it appears in the submenu. Icons for installed options will appear in a popup menu, presenting a choice of operation as a standalone unit or power pack unit.

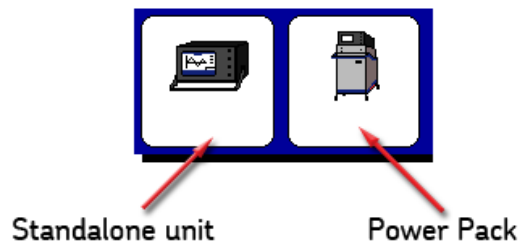


Figure 84. Configuration Options popup menu.

3. If an optional interface board/option is *not* installed, a dialog will appear with a message alerting you to that fact.
4. For the following example, touch the **Standalone Unit** icon.

Compensating temperature and recording humidity

5. To compensate temperature and/or record humidity, touch the **Temperature/humidity** icon; otherwise, skip to Step 7.
6. The following popup menu is used to enable/disable temperature and humidity compensation and to select the compensation needed for these test elements when compensation is enabled.

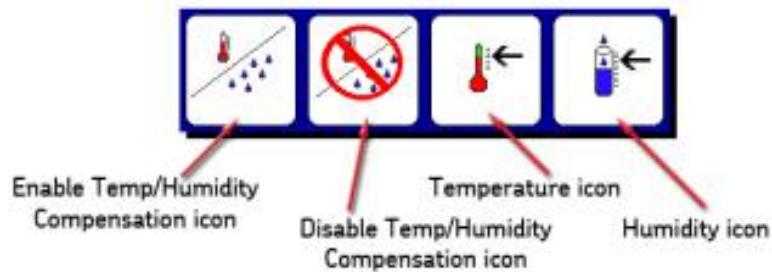


Figure 85. Temperature and humidity compensation popup menu.

- a. Touch the **Enable Compensation** icon then the **Temperature** icon.
- b. The default temperature is 40 °C; use the keypad to enter the actual temperature then touch **Done**.
- c. For reference purposes, specify the humidity by touching the **Humidity** icon then use the keypad to enter the percentage of relative humidity.
- d. Touch **Done** after making your entry.

Because this is a comprehensive test, you must predetermine the necessary values to input during the test before the test start (refer to the “Recommended test voltages” section in “Appendix C — DC and surge tests voltages.”)



NOTE

Step times, ramp rates, and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

- ❏ The value for the IR, DA, and PI tests would be operating or line voltage V_{LL} . For this example, we use 480 volts.
 - ❏ The value for the DC-HiPot would be $2 \times (V_{LL}) + 1,000 = 1960$ volts for this example.
 - ❏ The increments for the DC step voltage are derived from $1,960 - 480 = 1,480$. Using three increments for this example, $(1,500 / 3 = 500 \text{ v})$, each increment for the step DC-HiPot would be 500 volts (500 v, 1000 v, and 1500 v).
 - ❏ To run a final DC-HiPot, set the voltage at 2000 v.
7. Push and hold the **Start (PTT)** button and the following controls appear.

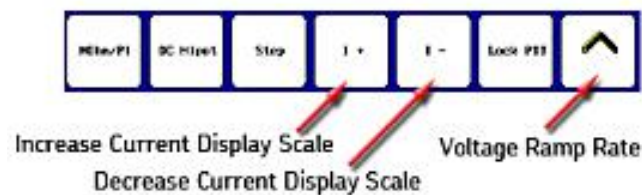


Figure 86. Test submenu items.



NOTE

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

- a. Rotate the **Voltage Output Control** knob on the front panel to raise the voltage level to 2,300 volts and use the **Fast** or **Slow Ramp Rate** controls as needed to quickly fine tune the level.



Figure 87. Ramp Rate controls.

- b. Touch the **MOhm/PI** icon to start the megohm insulation resistance (IR), dielectric analysis (DA), and polarization index (PI) tests.
- c. If hands-free testing is desired, touch the **Lock PTT** icon. When the icon changes to a yellow highlight as shown in the example below, release the **Start (PTT)** button.
- d. Yellow highlights identify locked controls. The submenu will look like the following while the tests are running:

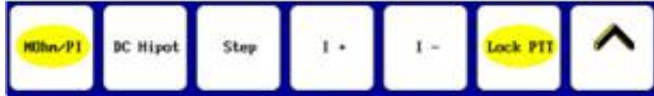


Figure 88. Test submenu items with yellow highlights.

8. Use the **Increase Current Display Scale (I+)** or **Decrease Current Display Scale (I-)** icons as needed to adjust the current's scale.
 - a. The **Status Bar** displays a countdown timer for each of the megohm, step-voltage, and standard DC-HiPot tests as shown in the following example.



Figure 89. Status Bar with Countdown Timer.

- b. 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.



NOTE

DA start/stop and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

Conduct step voltage or DC HiPot test

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

9. Touch the **Fast** or **Slow** icons as desired.
10. Use the **Voltage Output Control** knob to raise the voltage to the next step.
11. Touch the **Step** icon to program/set a 60-second test. Repeat the steps until you achieve the desired voltage variable.



NOTE

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.

Step and HiPot intervals and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

Conduct standard DC HiPot test

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

12. Touch the **Fast** or **Slow** icons as desired
13. Use the **Voltage Output Control** knob to set the voltage to the desired DC-HiPot voltage.
14. Touch the **DC-HiPot** icon to program/set a 60-second test.
15. When the test is complete, push the **Start (PTT)** button, and *allow the unit to discharge completely before disconnecting test leads.*



NOTE

The HiPot overcurrent trip indicator detects any arc-over in the insulation and puts an immediate stop to testing. The overcurrent 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 touch the **Test** button, it resets the trip circuitry, removes the HIPOT TRIP message, and readies the tester for a new test.

16. Touch the **Save** icon to save the test results to the active folder and active record.

17. View the test results by touching the **Report, Display, and DC Tests** icons.
18. Use the submenu icons to find and view results.



Figure 90. Report results submenu icons.

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 preferred.

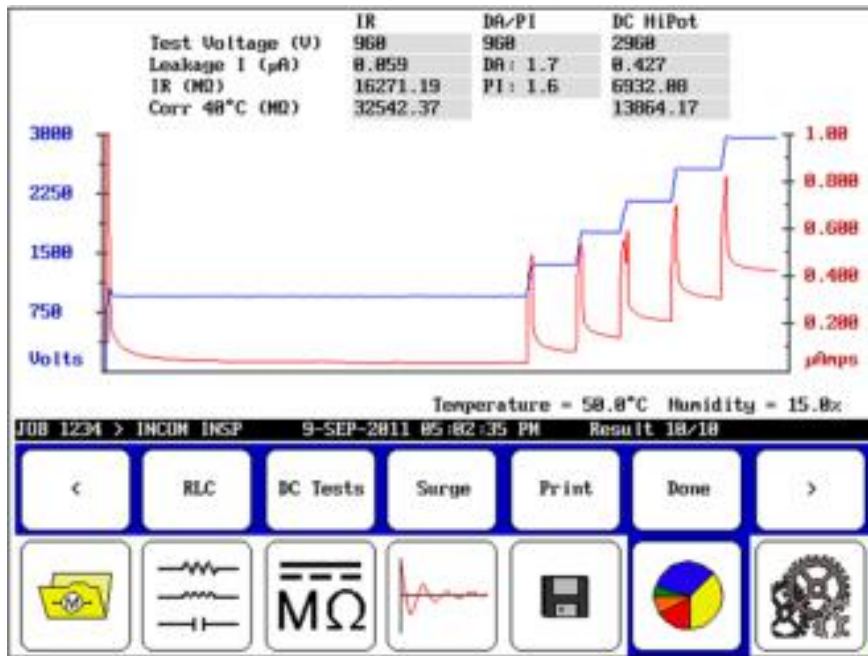


Figure 91. DC Tests results screen.

Surge tests using the DX host

Surge testing detects insulation damage between the turns of a motor's winding. This type of insulation problem cannot be detected 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 between adjacent loops of wire within the winding. If the insulation between the two loops 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 detects arcs by observing a shift in the surge waveform produced by the test.

On the Baker DX, the surge test is performed with an impulse generator and the waveform is displayed on touch screen. The surge waveform is a representation of the voltage present across the tester leads 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 involves multiple coils configured into windings. Another common test evaluates an individual coil. Other tests involve field and armature coils



NOTE

Refer to chapter 15 for more information and details on surge testing capabilities of the Baker DX.

Refer to “Determining a known-good coil to use as a reference” found at the beginning of this chapter for information about known good coils and using the reference recall feature.

Surge test procedures



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the Baker DX setup procedure has been followed. Refer to chapter 6 “Setting up the Baker DX tester” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



CAUTION

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

To avoid potential for injury or death from electrical shock, 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.

1. Select the folder and record you want to use, and check the **Status Bar** to ensure that the **Active Folder** and **Active Record** are those that you want to use for the subsequent tests.
2. Touch the **Surge** icon to bring up the *Surge Test Start* screen as shown below. The first submenu item is the **Configuration Options** icon.

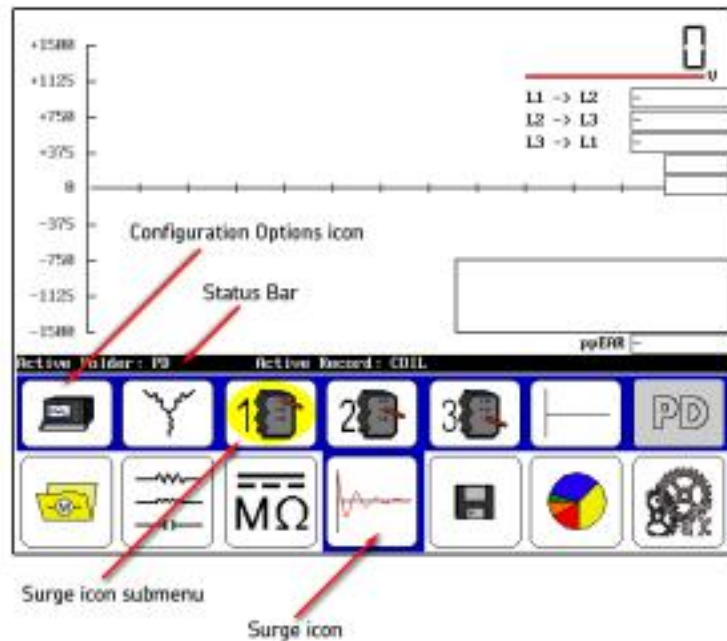


Figure 92. Surge test start screen.

3. Touching the **Configuration Options** icon shows you the options that are installed such as operation as a standalone unit, with a power pack, with a Baker ZTX, or with a power pack containing a built-in ZTX. 7

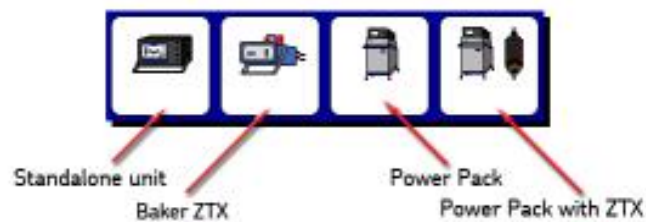


Figure 93. Configuration options popup menu.

4. If optional interface boards *are not* installed, a message dialog will appear alerting you to that fact.
5. For the following example, touch the **Standalone unit** icon.

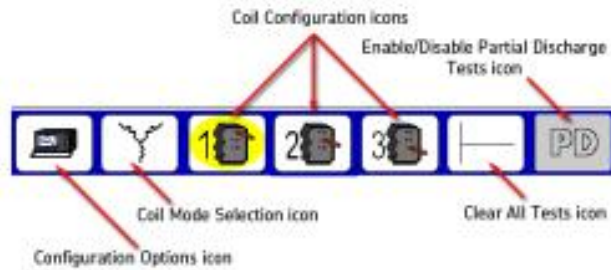


Figure 94. Surge Mode Submenu icons.

6. Touching the **Coil Mode Selection** icon in the **Mode Submenu** brings up the popup menu shown below. You will then select from a choice of modes: three-phase mode, Single-coil mode, field coils mode, and armature span mode.

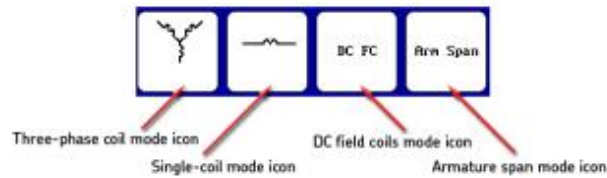


Figure 95. Coil Mode Selection popup menu.

7. In this example, touch the **Three-phase coil mode** icon (other options are addressed later in this manual).
8. The **Lead Selection** icons default to coil No. 1 to start the test.
9. You must predetermine the input values for the test before starting the test. Refer to the “Recommended test voltages” section in “Appendix C — DC and surge tests voltages” for recommended test voltages for DC-HiPot and surge tests. The operating voltage is the basis for the test voltage; for example, $V_{LL} = 480$ volts. Using this example, the value for the surge test would be:

$$2x(V_{LL}) + 1,000 = 1,960 \text{ volts for this example.}$$

10. Press and hold the **Start (PTT)** button and the **Scale Control** popup menu appears.

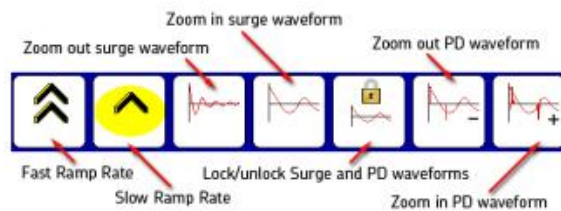


Figure 96. Ramp rate and waveform zoom popup menu.

11. Alternately use the **Fast/Slow Ramp Rate** icons to control the rate of voltage change while rotating the voltage knob.
12. Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform.
13. If the winding is a wye or delta configuration, select coil No. 2 and repeat Step 11 then repeat for coil No. 3.

**NOTE**

Ramp rates, EAR limits, test times, and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

14. The results of the 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.

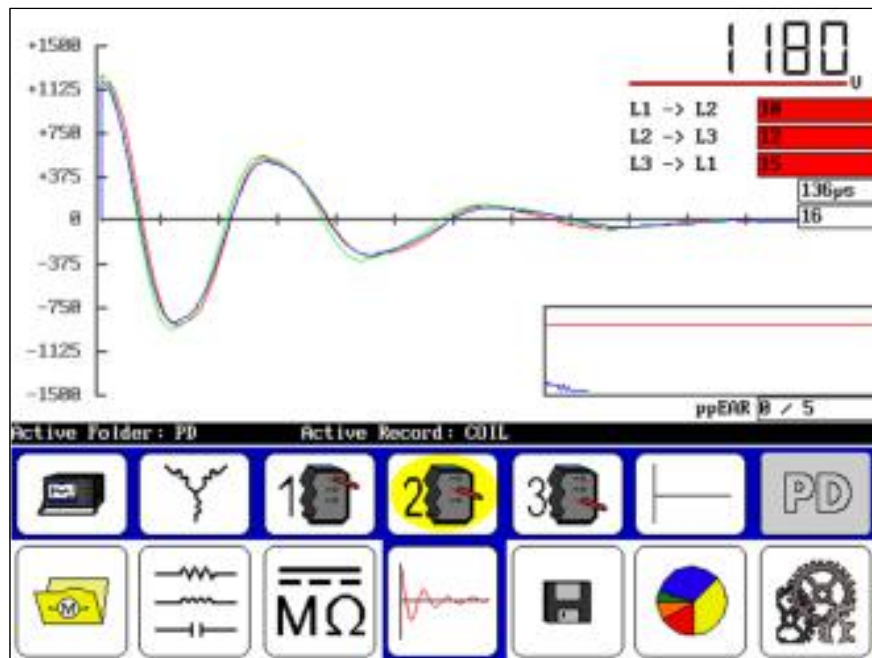


Figure 97. Surge test results screen.

15. You can clear all test results by using the **Clear All Tests** icon.

**NOTICE**

Selecting the Clear All Tests icon immediately and permanently deletes all data and the reference test.

Partial discharge testing—three-phase mode

Partial discharge (PD) testing involves detecting localized, partial bridging between conductors due to dielectric breakdown caused by high-voltage stress that does not fully short the two conductors. These discharges, when severe enough, can create a persistent visible glow known as corona, while less severe breakdowns can cause smaller invisible partial discharges.

NOTE

For detailed information on partial discharge detection theory including common terminology used, refer to “Partial discharge detection in chapter 14

For more information on partial discharge testing application on the Baker DX, refer to “Partial discharge detection” in chapter 15

Preparing for tests

Partial discharge testing relies on the accurate detection of four key metrics: partial discharge inception voltage (PDIV), repetitive partial discharge inception voltage (RPDIV), repetitive partial discharge extinction voltage (RPDEV), and partial discharge extinction voltage (PDEV).

The RPDIV and RPDEV voltages are determined by using data from several surge pulses and comparing them to the current pulse. To ensure that these values are accurately detected, voltage ramping should occur in controlled, and slowly-increasing and slowly-decreasing steps.

From the *User Settings* screen, we suggest using a fast ramp rate of no more than 50 volts and a slow ramp rate of no more than 10 volts.

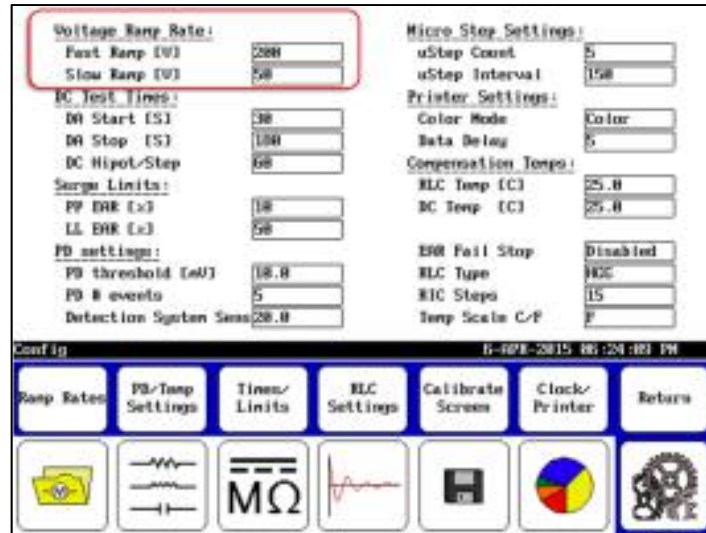


Figure 98. Setting ramp rates for PD testing.

As the voltage approaches the maximum test voltage, use the slow ramp to obtain greater accuracy. When possible, run a test with a known good coil or stator of similar insulation and ratings to determine a baseline noise level of the partial discharge signal. This helps you select a threshold level that clearly indicates partial discharge activity and reduces the occurrence of false positive readings during testing.

Temperature and humidity

Measurements collected during PD testing can be affected by temperature and humidity. For example, PD activity often increases with higher humidity. For these reasons, you should record the temperature and humidity when conducting PD testing to ensure that you have consistent conditions for reliable and comparable results. Ideally, the testing environment should be controlled to provide consistent temperature and humidity. In any case, you should record the ambient temperature and humidity levels during PD testing in case they vary from test to test.

NOTE:

The temperature and humidity recording in this case is different from that described earlier for compensating temperature and recording humidity for DC testing. PD testing does not use the DX features for DC testing compensation and recording; so for PD testing, recording ambient temperature and humidity is a manual process.

Checking and recording system noise level

The DX Partial Discharge feature includes the ability to measure and record the level of system noise present for different test setups. Different coils and stators, along with the difference in overall noise in the earth ground, will present different noise signals that should be recorded to determine the sensitivity of the Partial Discharge detector. The threshold for PD event magnitude must be above this value to function correctly.

NOTE

To record the system level noise follow the procedure below, this procedure should be followed for every different load for the most accurate PD records.

1. Connect the test leads to the device under test as normal for a surge/PD test in either three-phase mode or coil mode.
2. Surge into the device under test with the initial surge voltage (do not ramp up). Keeping the voltage low ensures that no PD is present on the load.
3. Observe the magnitude of the PD signal in comparison to the threshold value and position on the display.
4. Enter into maintenance mode and adjust the user setting **PD threshold (mV)** so that the PD signal is just below or just exceeding the threshold indicator line. Press the **PD/Temp Settings** button then the **PD threshold** button in the popup menu to change the **PD threshold (mV)** value.

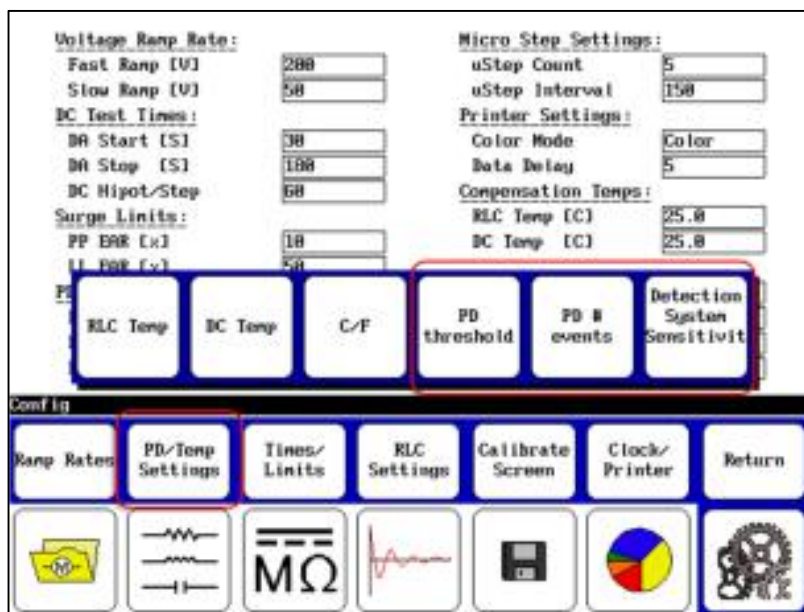


Figure 99. User Settings screen, PD value settings menus.

5. Return to the surge screen.
6. Surge into the device under test with the initial surge voltage (do not ramp up).
7. Observe the new relative positions of the PD signal and the threshold line. If the two are not at an equivalent level, enter into maintenance mode again and re-adjust the user setting **PD threshold (mV)**.

<u>Voltage Ramp Rate:</u>		<u>Micro Step Settings:</u>	
Fast Ramp [V]	200	uStep Count	5
Slow Ramp [V]	50	uStep Interval	150
<u>DC Test Times:</u>		<u>Printer Settings:</u>	
DA Start [S]	30	Color Mode	Color
DA Stop [S]	180	Data Delay	5
DC Hipot/Step	60	<u>Compensation Temps:</u>	
<u>Surge Limits:</u>		RLC Temp [C]	25.0
PP EAR [x]	10	DC Temp [C]	25.0
LL EAR [x]	50	EAR Fail Stop	
<u>PD settings:</u>		Disabled	
PD threshold [mV]	10.0	RLC Type	HCC
PD # events	5	RLC Steps	15
Detection System Sens	20.0	Temp Scale C/F	F

Config 6-APR-2015 06:24:09 PM


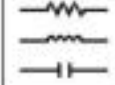





Ramp Rates	PD/Temp Settings	Times/Limits	RLC Settings	Calibrate Screen	Clock/Printer	Return
						

Figure 100. User Settings window, PD settings.

8. When the signal and threshold are at the same level, record the level of the threshold in the **Detection System Sens** user setting—this is the system level noise. This information will be reported with partial discharge tests that are saved along with the date the sensitivity was last recorded. Press the **PD/Temp Settings** button then the **Detection System Sensitivity** button in the popup menu to change this value.
9. Re-adjust the **PD threshold (mV)** so that it is above the detected noise floor so that only PD will trip the event indicator.

Performing PD tests—three-phase coil mode

PD testing follows a similar procedure to surge testing. If you are not already there, ensure that the tester is in surge testing mode.

1. For this example, touch the **Standalone Unit** icon then the **Coil Mode Selection** icon in the **Mode Submenu**.
2. From the **Popup Menu**, select the **Three-phase coil mode** icon.
3. The **Lead Selection** icons default to coil No. 1 to start the test.
4. Touch the **Enable PD** icon on the right side of the screen. This activates the detector circuit and tells the tester to display PD data on the surge graph.

NOTE

When **Enable PD** is pressed the first time, the screen will not update to PD specific fields. This happens when the **PTT** button is first pressed after enabling the feature.

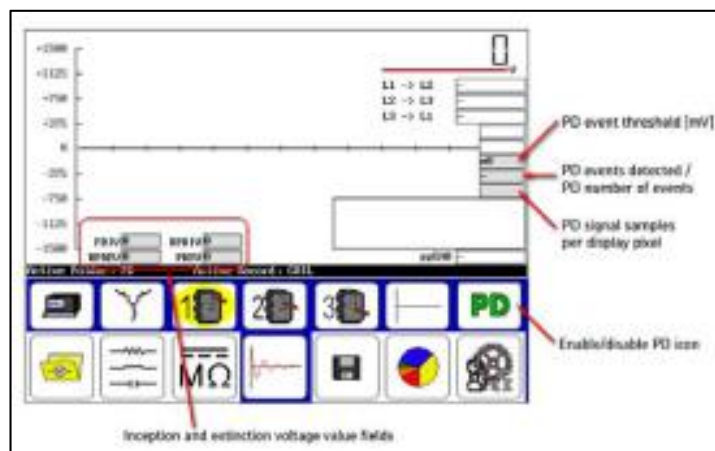


Figure 101. Enabling PD testing adds elements to the start screen.

The **PD event threshold** field (PD threshold [mV] set in the *User Settings* screen) shows the voltage level of the PD signal detected— value displayed in millivolts.

The **PD events detected / PD number of events** field shows the number of PD events that exceeded the PD number of events value (PD # events set in the *User Settings* screen). When the PD events detected value exceeds the PD number of events value, a red PD indicator will appear just outside the left edge of the X axis, indicating that a PD pulse has occurred.

The **PD signal samples per display pixel** field shows the number of PD signal samples gathered per display pixel and indicates the resolution of the displayed PD waveform. The PD measurement system is approximately five times faster than the surge measurement system, so more PD signals are

measured within a surge than can actually be displayed. The measurement is faster because PD detection is measuring higher frequency information.

5. Hold down the PTT button and use the Voltage Control knob to ramp up the voltage slowly and evenly.
6. Touch the **Fast Ramp Rate** icon to ramp at the higher rate if desired, but ensure that ramping is slow enough to allow observation of PD events as described above.

As the voltage increases, if there is partial discharge the PD waveform will display pulse activity (indicating that partial discharge is occurring) when the expanded view is selected as shown in the example below. The default view shows the PD waveform fully zoomed in.

NOTE:

Refer to the “PD data display options during testing” section below for more information on display options for the PD and surge waveforms.

If these pulses are occurring and not meeting the threshold criteria, you might need to adjust the PD threshold and PD # events values in the *User Settings* screen to appropriately indicate PD.

When PD activity exceeds the threshold value, a PD pulse occurs, the PDIV level is reached, and the surge voltage value is recorded as PDIV.

A red **PD** indicator also begins to flash just left of the X-axis.

As you continue to increase the voltage, the activity will become more pronounced and more frequent. At the point where more than 50% of the surge pulses have a PD pulse, the software records the current surge voltage level as RPDIV.

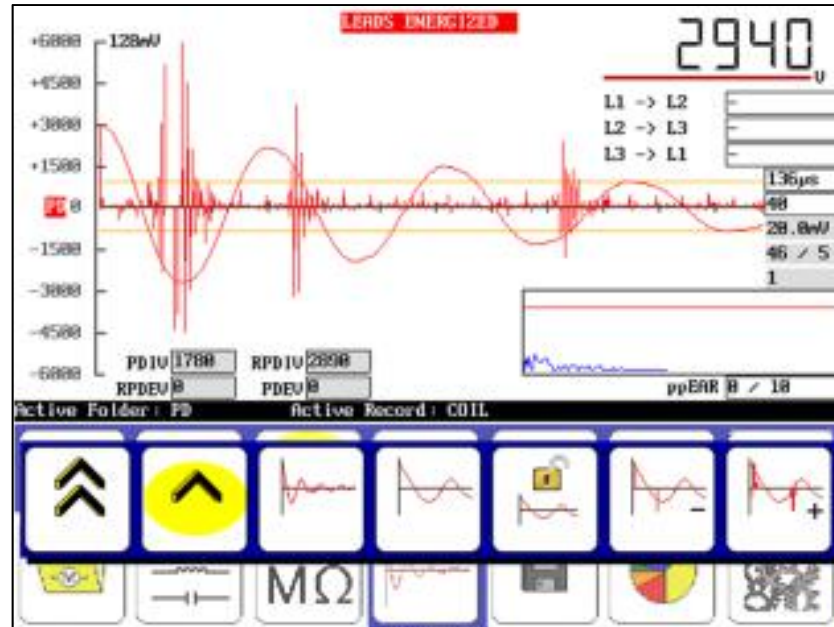


Figure 102. Example of acquired inception voltages (PDIV and RPDIV).

7. To acquire the extinction voltages, hold down the **PTT** button and use the **Voltage Control** knob to ramp down the voltage slowly and evenly.
8. Touch the **Slow Ramp Rate** icon to ramp down at a slower rate if desired.

As the voltage decreases, the PD pulses decrease. At the point where less than 50% of the surge pulses have a PD pulse, the software records the current surge voltage level as RPDEV. As the voltage continues to ramp down, the software continually records the current surge voltage level at which a PD pulse is detected. The last recorded value is saved as the PDEV (the lowest voltage at which the detector sees a PD pulse).

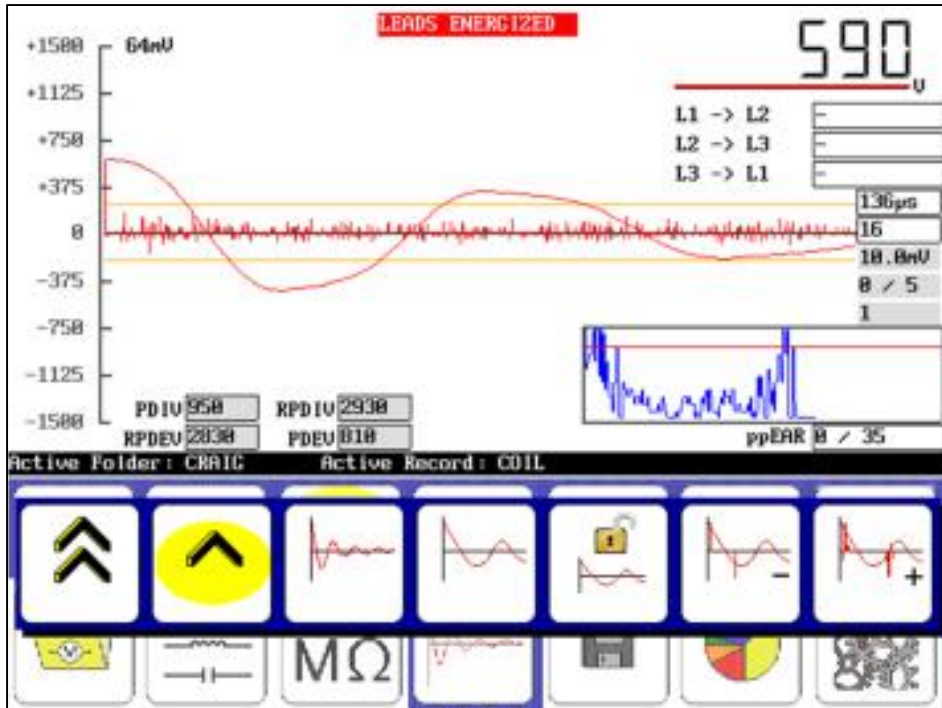


Figure 103. Example of acquired extinction voltages (PDEV and RPDEV).

9. When you acquire the extinction thresholds for the first phase, discontinue the test and save the results.
10. Touch the **Lead 2** icon and repeat the process for the second phase then **Lead 3** in turn.

Testing the second and third phases is identical to testing the first phase. If you want to capture a waveform that illustrates PD activity in each phase, a short process is added to the end of testing each phase.

The Baker DX reporting function stores the last waveform captured during testing. To capture a screen shot for each test phase that displays PD activity, ramp voltages back up to at least the PDIV level for each phase after acquiring the extinction voltages. After you reach the PDIV level, stop testing, save results, and move to the next phase. After you complete phase 3 testing, save your results.

Partial discharge display options and reporting

Options for displaying PD data during testing

The Baker DX is equipped with multiple viewing options for observing the partial discharge activity on the unit being tested. The data gathered for PD detection is separate from the data gathered for the surge waveform, allowing you to manipulate the PD waveform independently of the surge waveform if desired.

The default view shows the PD waveform fully zoomed in.

PD activity typically occurs on or immediately after the peak of the surge waveform, though it may also occur at the second peak if the pulse exceeds the PDIV value. Discerning exactly where the discharge activity is occurring and what it looks like usually requires viewing the PD data in an expanded view.

Essentially, the viewing options include:

Waveforms locked—With the **Locked/Unlocked** icon in the locked state, the PD and surge waveforms are synchronized. In this state, touching the surge or PD zoom in/out icons has the same effect: the display scale of *both* waveforms will increase or decrease with each touch of the icon.

Waveforms unlocked—With the **Locked/Unlocked** icon in the unlocked state, the PD and surge waveforms are not synchronized. In this state, use the surge zoom in/out icons to adjust the display scale of the surge waveform. Use the PD zoom in/out icons to adjust the display scale of the PD waveform.

Touching the **Locked** icon to set it in the locked state at any point during testing will automatically lock the PD and surge waveforms together.

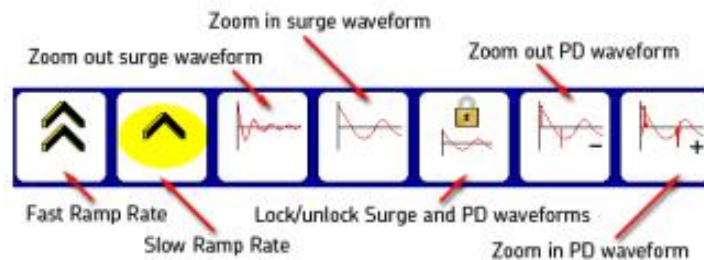


Figure 104. Waveform zoom and lock icons.

In the following example, the waveforms are locked and fully zoomed out.

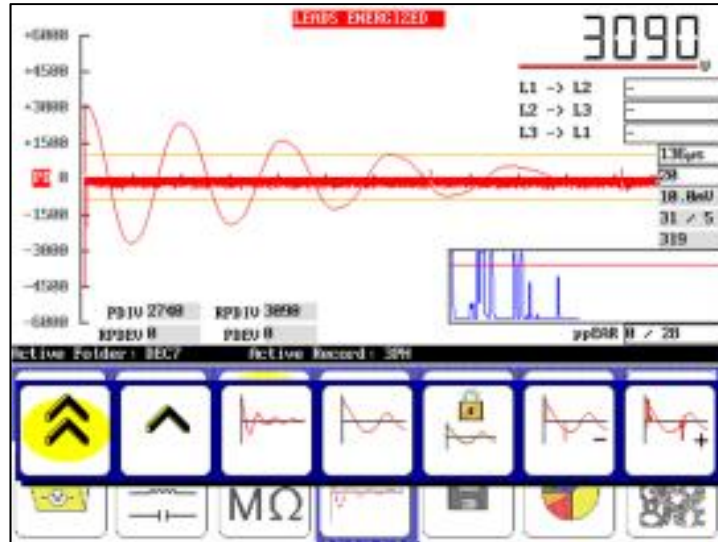


Figure 105. PDIV and RPDIV displayed in locked view.

In the following example, the waveforms are locked and the PD waveform signal expands with the surge waveform, down to $2\mu\text{s}$ per division—the maximum surge zoom level of the Baker DX tester.

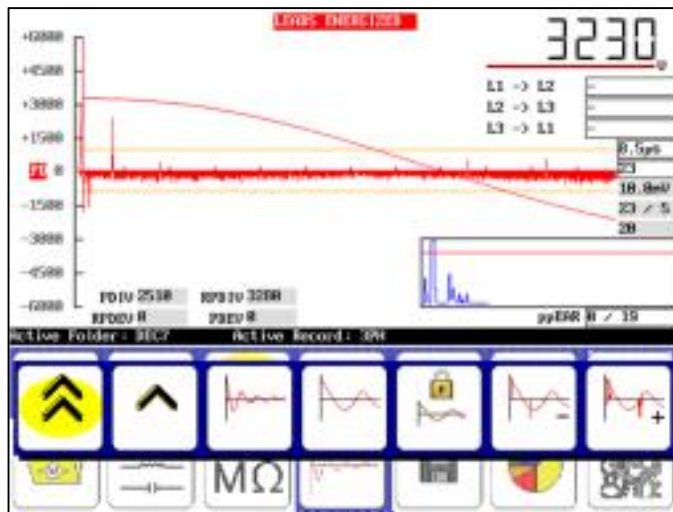


Figure 106. Inception voltages shown in expanded locked view.

In the following example, the PD and surge waveforms are unlocked, so the PD waveform display scale can be adjusted without affecting the surge waveform display scale.

When the two waveforms are not synchronized, the activity areas on the PD waveform will not correspond with their overlaid locations on the surge waveform. This view provides maximum resolution for the sampling frequency of the partial discharge detector.

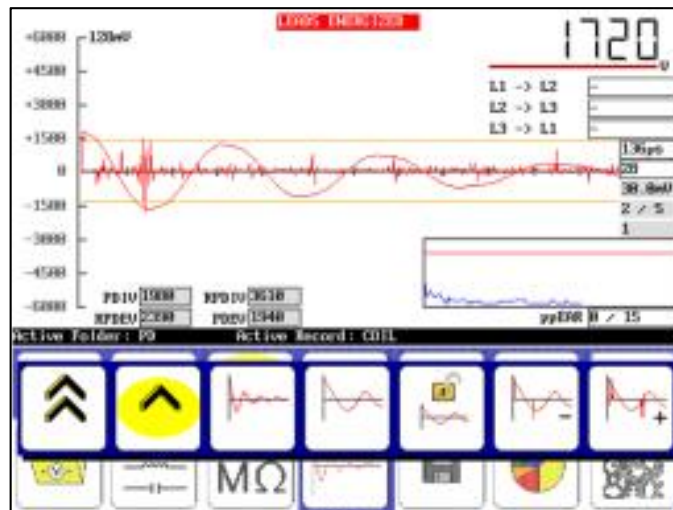


Figure 107. Voltages shown in expanded unlocked view.

PD data reporting—three-phase coil mode

Partial discharge tests are reported differently depending on whether the test was being conducted in single-coil mode or three-phase coil mode.

In three-phase coil mode, results are reported in two ways. The first report is the normal surge report with the PD data included. The waveform displayed is the last waveform captured during the testing process. The partial discharge signal is overlaid on the surge waveform and displayed with the resolution used during the preceding surge test.

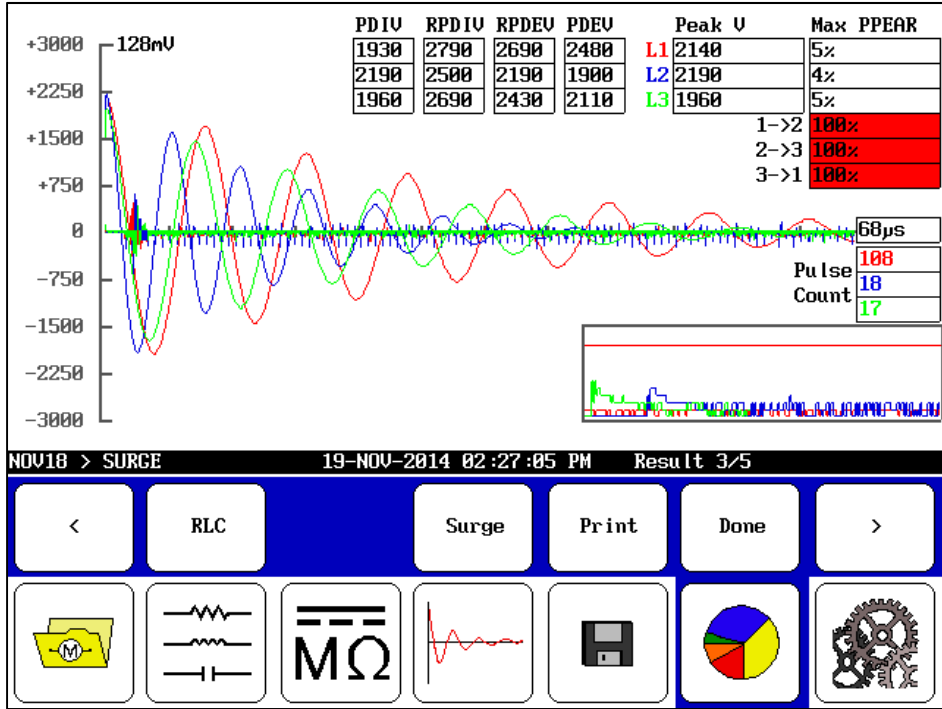


Figure 108. PD three-phase report. PD data overlaid on surge waveform.

The values for PDIV, RPDIV, RPDEV, and PDEV are indicated for each phase in the table at the top center portion of the display.

Tapping the display will switch to a house plot view where the three phases are displayed with their respective PD activity for each surge pulse that occurred during testing.

The x axis corresponds to the individual surge pulses, and its width is determined by the test phase with the most pulses. If the duration of tests for each phase is uneven, the shorter phases will not extend across the entire graph. For this reason, you should attempt to keep the duration of each test approximately the same length.

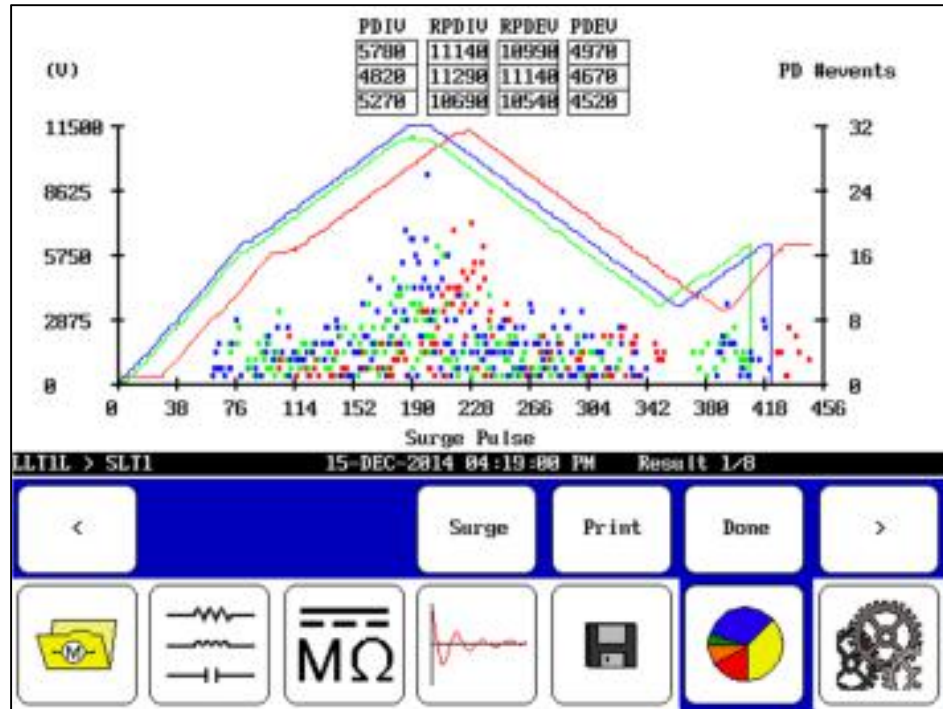


Figure 109. PD three-phase house plot report view.

The left axis shows the voltage of the surge pulse. The waveforms are indicated by solid colored lines for each phase.

The right axis shows the number of PD events recorded for each pulse. In this view, you can see how the PD activity rises and falls with the surge voltage.

Single-coil testing

The preceding section described three-phase coil testing. This section focuses on single coil testing.

A common application is quality control testing in which a succession of coils that are the same are tested. The process starts with a known good coil or reference from which to make comparisons.



NOTE

Refer to “Determining a known-good coil to use as a reference” found at the beginning of this chapter for information about known good coils and using the reference recall feature.

1. Connect test lead No. 1 to coil lead 1 and test lead No. 2 to coil lead 2.
2. Test lead No. 3, No. 2, and ground are all at ground.
3. Test lead No. 3 and the black ground lead can be hooked to a field pole, iron core, or frame if applicable, but it is not required.

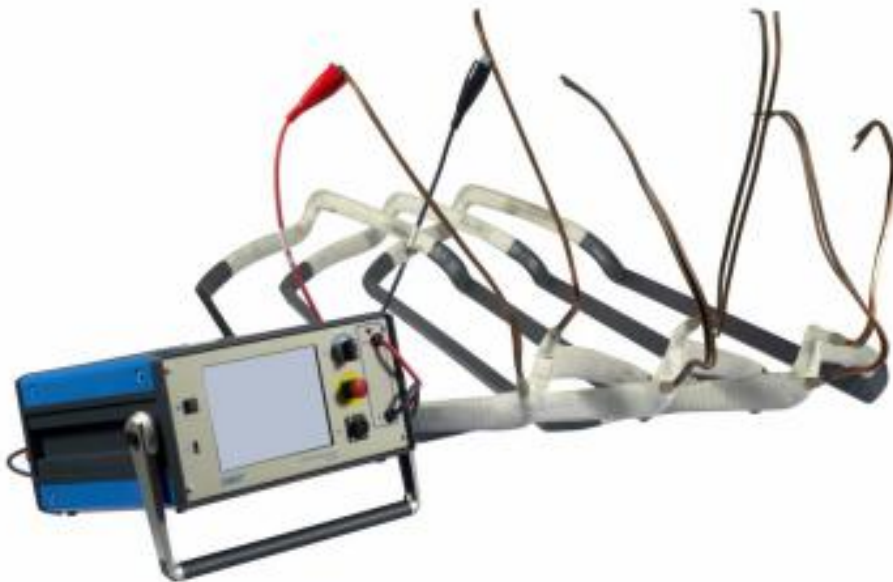


Figure 110. Testing single coils with the Baker DX.

- Select the folder and record you want to use and check the **Status Bar** to ensure that **Active Folder** and **Active Record** display the proper information for these tests.

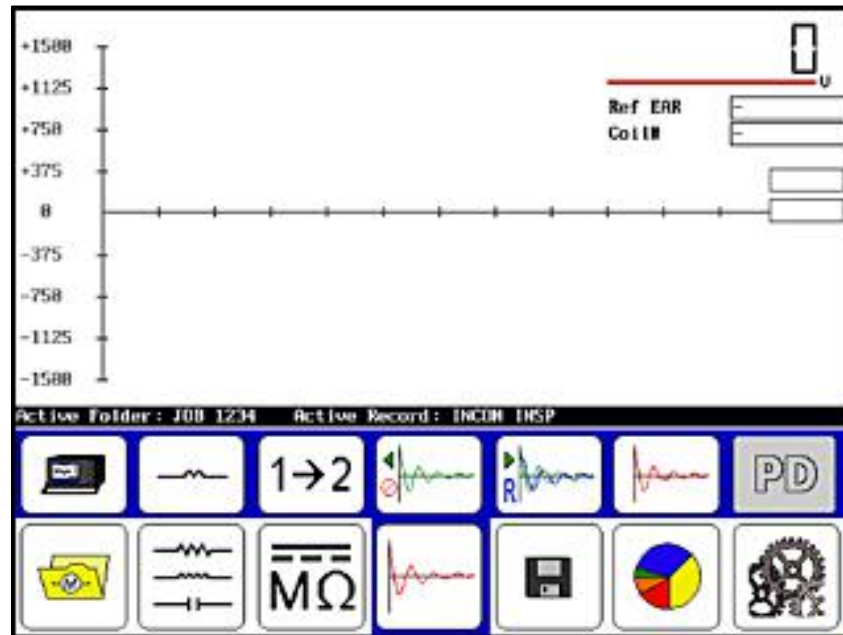


Figure 111. Single-coil test initial screen.

- Touch the **Configuration options** icon then the **Coil mode selection** icon to bring up the popup menu shown below.

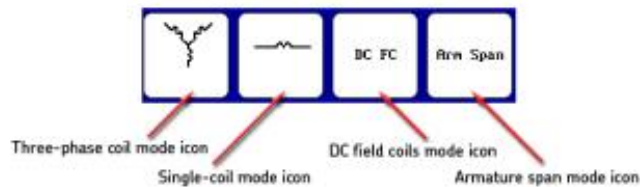


Figure 112. Coil mode selection popup menu.

- Select the **Single-coil mode** icon for this example.

The single-coil testing submenu is shown in the following graphic. This submenu appears during a surge test operation when a **Standalone Unit** is selected along with **Single-coil mode**.

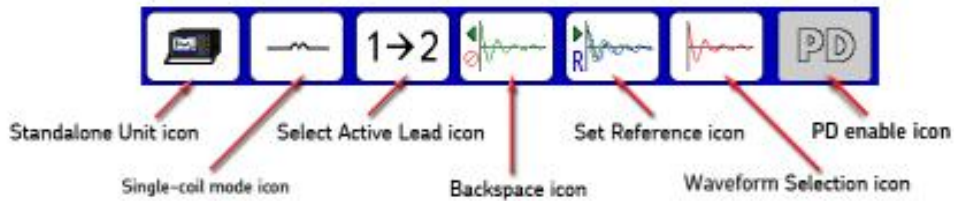


Figure 113. Single-coil testing submenu icons.

- L **Select Active Lead** icon—used to select the active lead and the direction to start the surge flow—hot side.
 - L **Backspace** icon—used to delete tests.
 - L **Set Reference** icon—used to set the selected test as the reference.
 - L **Waveform Selection** icon—used to select optional coil test displays.
 - L **PD**—touching this icon enables PD testing. Icon turns green and PD data fields appear in the display. Once the reference is set, the PD button is replaced by the ZS Override button. If PD is enabled, all coils are tested for PD; otherwise, no coils are tested for PD.
 - L **ZS Override** (Zero Start Override) icon—replaces PD button after reference is set. When pressed, it tells the tester to go immediately to the reference level (removing the need to ramp up), allowing the tester to reach the target voltage faster.
7. Touch the **Single-coil mode** icon and the following popup menu appears.



Figure 114. Single-coil mode popup menu.

8. Touch the **Single coil** icon.

9. On the DX host, press and hold the **Start (PTT)** button (or footswitch) and the **Ramp rate and waveform zoom** popup menu appears.

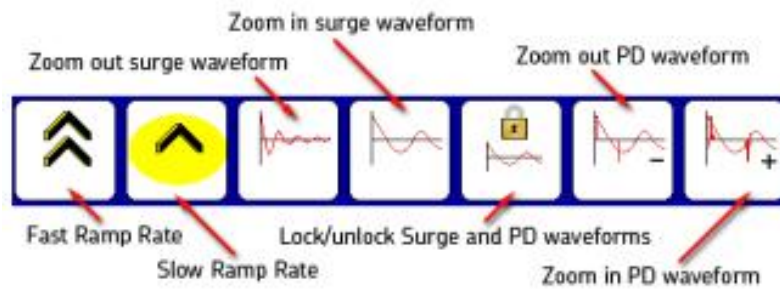


Figure 115. Ramp rate and waveform zoom popup menu.

10. Alternately use the **Fast/Slow Ramp Rate** icons to control the rate of voltage increase while rotating the **Voltage Output Control** knob to set the test voltage.
11. Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform. Ensure that the display scale used matches the reference waveform used.
12. Using a known good coil, when you obtain a satisfactory waveform, touch the **Set Reference** icon and then touch the **ZS Override** icon.



NOTE

Refer to “Determining a known-good coil to use as a reference” at the beginning of this chapter for more information on known good coil and using the reference recall feature.

13. Touch **Yes** to answer the override message, which will appear in a dialog box like the one shown below.



Figure 116. Override zero start message dialog.

14. Test each subsequent coil by connecting the clips to each coil and pressing and holding the **Start** button on the DX Host (or footswitch) for more than three seconds.

15. In the simple example below, you can see the test results collected when testing single coils.

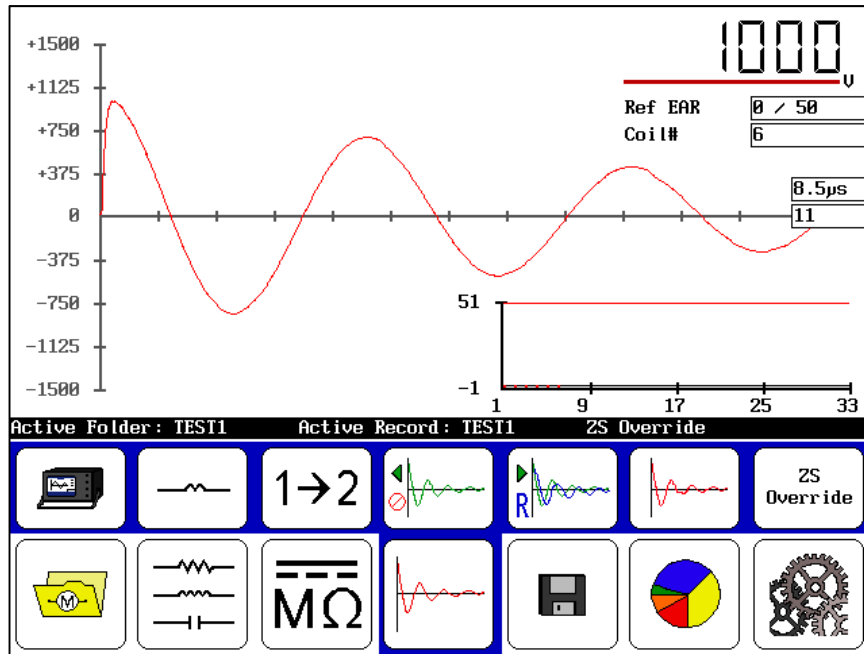


Figure 117. Coil test results screen.

16. If desired, **Save** the test results in the **Active Folder/Active Record**.

Switching active leads

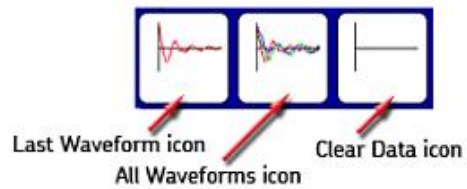
By default, the Baker DX tests coils with lead 1 set as the active lead (hot side). Surge flow starts from this direction. If you want to switch surge flow direction to test your coils, you should consider the following issues.

Typically you will have a different wave shape when you switch from **1→2** (lead 1 active) to **2→1** (lead 2 active) because various factors (such as the pole, direction of current flow through the circuit) can affect the waveform shape. For this reason, a different reference waveform will be needed for each direction.

If test lead reversal is required or desired, you should test all coils with lead 1 active and using an appropriate reference waveform first. After pressing the **Select active lead** icon to activate lead 2 (icons displays **2→1**), ramp up a known good coil as described in the process above to obtain a new reference waveform and set the new reference before testing all coils with lead 2 active. After setting the new reference, testing with the Zero Start Override process can be used for all remaining coils.

Viewing coil test results

1. As you work through the testing process, you can view the results of testing a series of coils by touching the **Waveform Selection** icon. A new set of options appears in popup menu as shown below.

**Figure 118. Waveform selection submenu.****NOTICE**

Selecting the Clear Data icon immediately deletes all data and the reference test.

Touch the **Waveform Selection** icon then the **Last Waveform** icon to display the results for the last test as shown below. The reference waveform is shown in red and the current test waveform is shown in black.

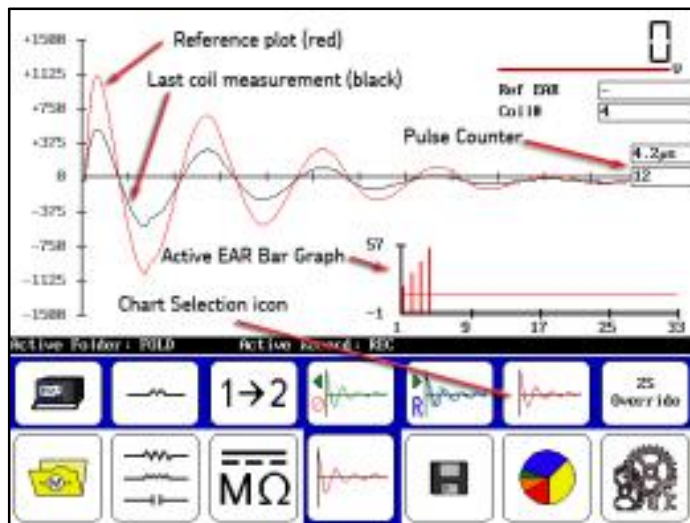


Figure 119. Single-coil test results screen—Last Waveform selected.

The **Ref EAR** box displays when and what criteria is exceeded by using red highlighting. This criterion is set to a default value in the user settings, but you can change it to different criterion as needed.

The **Coil#** (coil count) box displays the current coil results viewed in the **Display Area**.

In this chart type, you see only the results from the last coil tested. The reference plot is shown in red; the coil measurement plot is in black.

The **Pulse Counter** displays the number of pulses applied at a specific voltage.

The **Active EAR Bar Graph** shows you a “live view” bar graph of all the EAR values from reference to the current coil. This “live view” shows you where you are in real time in the coil test. The red horizontal line in the chart is the max limit set for your EAR measurements. In the following example, we exceed the limit, which is why the bar charts are so far above the reference line and the **Ref EAR** field is red.



NOTE

If the **EAR Fail Stop** option is enabled in the system settings, the test would stop automatically. For more details on this option and other test settings, refer to the “Using system settings” section in chapter 5 for more details.

You should also notice that the Y-axis on the **Active EAR Bar Graph** has a -1 value at its bottom. This is so the EAR zero line can be displayed in the graph.

- If you touch the **Waveform Selection** icon then the **All Waveforms** icon, your display would look more like the one below. The reference measurement and the last (current) coil measurement are displayed in red.; all other test measurements in the series are shown in black.

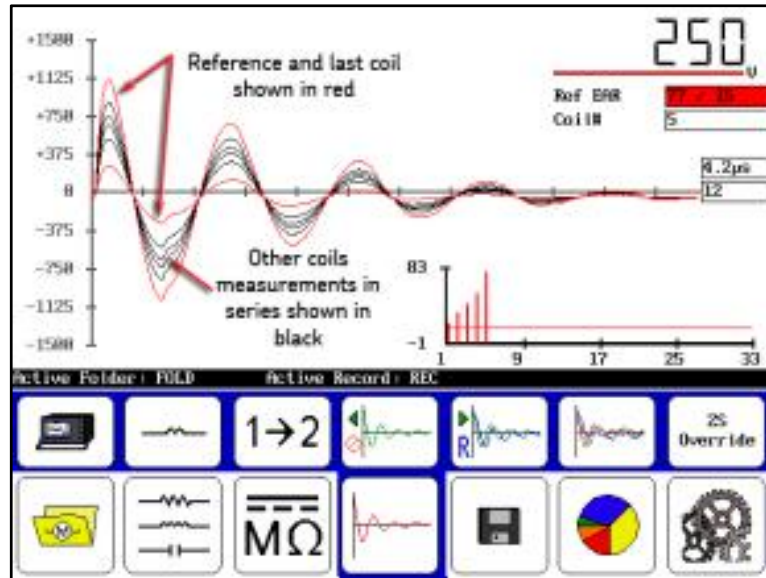


Figure 120. Single-coil test results screen—All Waveforms selected.

- When you have completed your tests and are ready to save your data, touch the **Save** icon then touch **Yes** in the *Confirmation Dialog* to confirm that you want to save the data.

Deleting data

When you delete data, you have a couple of options. You can delete individual coil data during testing by touching the **Backspace** icon then retesting the coil as needed.

You can delete multiple tests in this manner, simply by using the **Backspace** icon to delete the target test(s) then conducting new tests as needed.

If you want to remove all coil data, touch the **Waveform Selection** icon the **Clear Data** icon.

You will see a dialog asking: “Delete All Coil Data?” Touch **Yes** to delete all test data collected.

You will then see another dialog asking: “Also Clear Reference Waveform?”

Touch **No** to keep the reference. If you touch **Yes** to clear the reference, you will need to set a new reference to continue testing and/or for future testing.

Partial discharge testing—single-coil mode

Partial discharge (PD) testing involves detecting localized, partial bridging between conductors due to dielectric breakdown caused by high-voltage stress that does not fully short the two conductors. These discharges, when severe enough, can create a persistent visible glow known as corona, while less severe breakdowns can cause smaller invisible partial discharges.

NOTE

For detailed information on partial discharge detection theory including common terminology used, refer to “Partial discharge detection in chapter 14

For more information on partial discharge testing application on the Baker DX, refer to “Partial discharge detection” in chapter 15

Preparing for tests

Partial discharge testing relies on the accurate detection of four key metrics: partial discharge inception voltage (PDIV), repetitive partial discharge inception voltage (RPDIV), repetitive partial discharge extinction voltage (RPDEV), and partial discharge extinction voltage (PDEV).

The RPDIV and RPDEV voltages are determined by using data from several surge pulses and comparing them to the current pulse. To ensure that these values are accurately detected, voltage ramping should occur in controlled, and slowly-increasing and slowly-decreasing steps.

From the *User Settings* screen, we suggest using a fast ramp rate of no more than 50 volts and a slow ramp rate of no more than 10 volts.

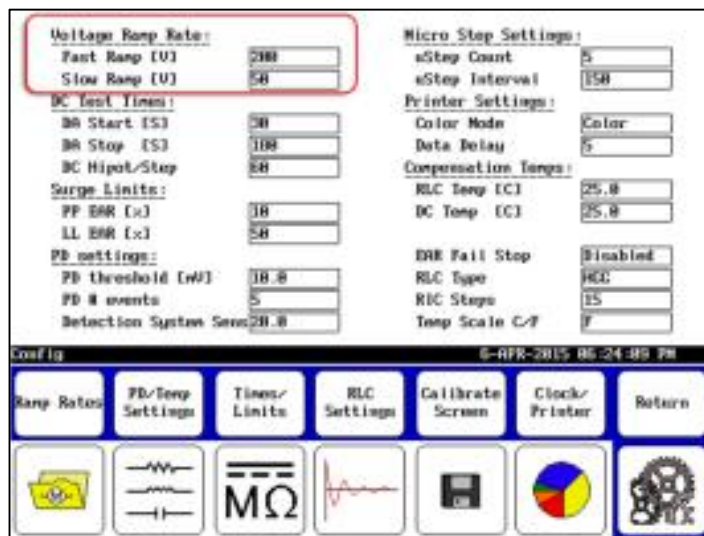


Figure 121. Setting ramp rates for PD testing.

As the voltage approaches the maximum test voltage, use the slow ramp to obtain greater accuracy. When possible, run a test with a known good coil of similar insulation and ratings to determine a baseline noise level of the partial discharge signal. This helps you select a threshold level that clearly indicates partial discharge activity and reduces the occurrence of false positive readings during testing.

Temperature and humidity

Measurements collected during PD testing can be affected by temperature and humidity. For example, PD activity often increases with higher humidity. For these reasons, you should record the temperature and humidity when conducting PD testing to ensure that you have consistent conditions for reliable and comparable results. Ideally, the testing environment should be controlled to provide consistent temperature and humidity. In any case, you should record the ambient temperature and humidity levels during PD testing in case they vary from test to test.

NOTE:

The temperature and humidity recording in this case is different from that described earlier for compensating temperature and recording humidity for DC testing. PD testing does not use the DX features for DC testing compensation and recording; so for PD testing, recording ambient temperature and humidity is a manual process.

Checking and recording system noise level

The DX Partial Discharge feature includes the ability to measure and record the level of system noise present for different test setups. Different coils and stators, along with the difference in overall noise in the earth ground, will present different noise signals that should be recorded to determine the sensitivity of the Partial Discharge detector. The threshold for PD event magnitude must be above this value to function correctly.

NOTE

To record the system level noise follow the procedure below, this procedure should be followed for every different load for the most accurate PD records.

4. Connect the test leads to the device under test as normal for a surge/PD test in either three-phase mode or coil mode.
5. Surge into the device under test with the initial surge voltage (do not ramp up). Keeping the voltage low ensures that no PD is present on the load.
6. Observe the magnitude of the PD signal in comparison to the threshold value and position on the display.
7. Enter into maintenance mode and adjust the user setting **PD threshold (mV)** so that the PD signal is just below or just exceeding the threshold indicator line. Press the **PD/Temp Settings** button then the **PD threshold** button in the popup menu to change the **PD threshold (mV)** value.

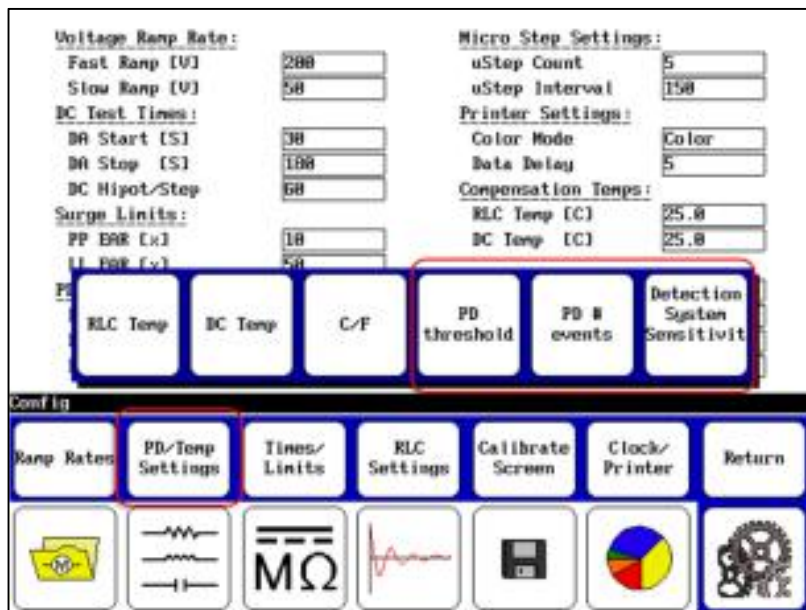


Figure 122. User Settings screen, PD value settings menus.

8. Return to the surge screen.
9. Surge into the device under test with the initial surge voltage (do not ramp up).
10. Observe the new relative positions of the PD signal and the threshold line. If the two are not at an equivalent level, enter into maintenance mode again and re-adjust the user setting **PD threshold (mV)**.

<u>Voltage Ramp Rate:</u>		<u>Micro Step Settings:</u>	
Fast Ramp [V]	200	uStep Count	5
Slow Ramp [V]	50	uStep Interval	150
<u>DC Test Times:</u>		<u>Printer Settings:</u>	
DA Start [S]	30	Color Mode	Color
DA Stop [S]	180	Data Delay	5
DC Hipot/Step	60	<u>Compensation Temps:</u>	
<u>Surge Limits:</u>		RLC Temp [C]	25.0
PP EAR [x]	10	DC Temp [C]	25.0
LL EAR [x]	50	EAR Fail Stop	
<u>PD settings:</u>		Disabled	
PD threshold [mV]	10.0	RLC Type	HCC
PD # events	5	RLC Steps	15
Detection System Sens	20.0	Temp Scale C/F	F

Config 6-APR-2015 06:24:09 PM

Ramp Rates	PD/Temp Settings	Times/Limits	RLC Settings	Calibrate Screen	Clock/Printer	Return

Figure 123. User Settings window, PD settings.

11. When the signal and threshold are at the same level, record the level of the threshold in the **Detection System Sens** user setting—this is the system level noise. This information will be reported with partial discharge tests that are saved along with the date the sensitivity was last recorded. Press the **PD/Temp Settings** button then the **Detection System Sensitivity** button in the popup menu to change this value.
12. Re-adjust the **PD threshold (mV)** so that it is above the detected noise floor so that only PD will trip the event indicator.

Performing PD tests—single-coil mode

PD testing for single-coils follows a similar procedure to regular surge testing in single-coil mode. If you are not already there, ensure that the tester is in surge testing single-coil mode.

1. For this example, touch the **Standalone Unit** icon then the **Coil Mode Selection** icon in the **Mode Submenu**.
2. From the popup menu, select the **Single-coil mode** icon.
3. Touch on the **Enable PD** icon on the right side of the screen. This activates the detector circuit and tells the tester to display a PD waveform along with the surge waveform.

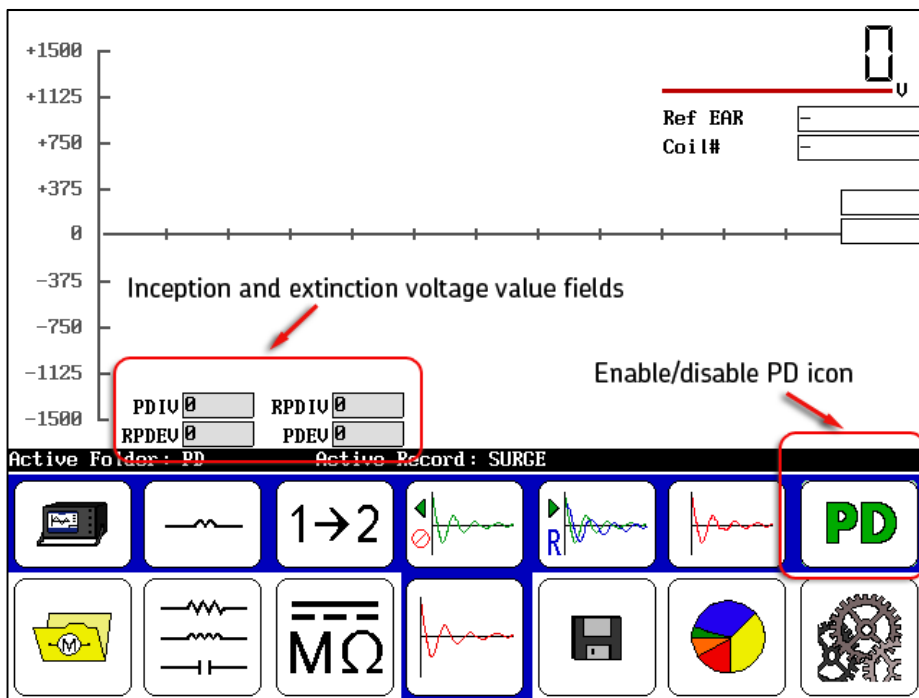


Figure 124. Enabling PD testing.

After the enable PD icon is touched, the inception and extinction voltage value fields will appear as shown above. Other PD display elements will appear after testing begins.

4. Touch the **1→2** icon to test the coil from lead 1 to lead 2. Testing will lead 1 active is required; testing with lead 2 active is not necessary for PD testing.
5. Hold down the **PTT** button and use the **Voltage Control** knob to ramp up the voltage slowly and evenly.
6. Ensure that ramping is slow enough to allow observation of PD events.

As the voltage increases, if there is partial discharge the PD waveform will display pulse activity (indicating that partial discharge is occurring) when the expanded view is selected as shown in the example below. The default view shows the PD waveform fully zoomed in.

NOTE:

Refer to the “PD data display options during testing” section below for more information on display options for the PD and surge waveforms.

If these pulses are occurring and not meeting the threshold criteria, you might need to adjust the PD threshold and PD # events values in the *User Settings* screen to appropriately indicate PD.

When PD activity exceeds the threshold value, a PD pulse occurs, the PDIV level is reached, and the surge voltage value is recorded as RPDIV.

A red **PD** indicator also begins to flash just left of the X-axis.

As you continue to increase the voltage, the activity will become more pronounced and more frequent. At the point where more than 50% of the surge pulses have a PD pulse, the software records the current surge voltage level as RPDIV.

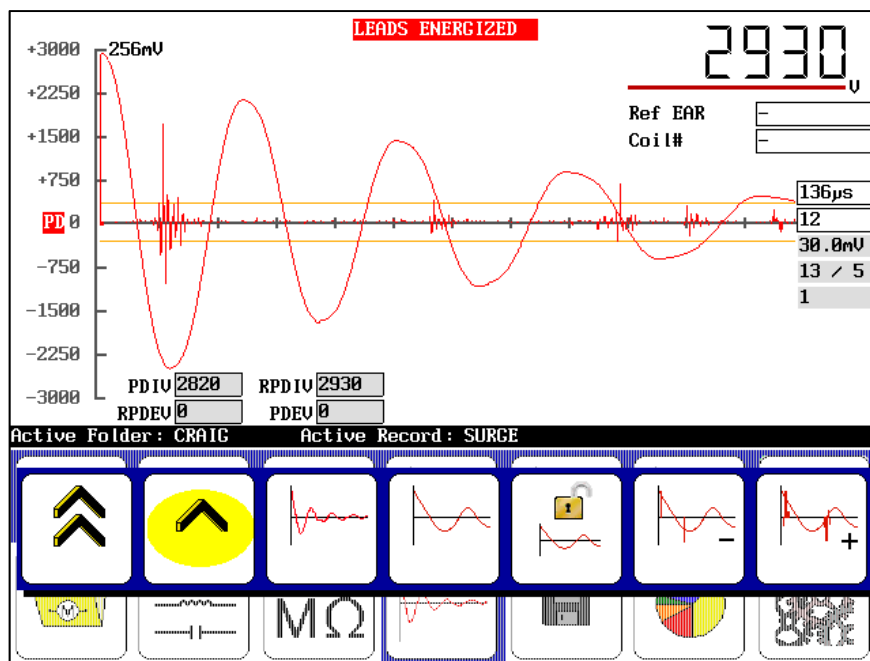


Figure 125. Acquired inception voltages (PDIV and RPDIV); single-coil mode testing. Results shown in expanded view.

7. To acquire the extinction voltages, hold down the **PTT** button and use the **Voltage Control** knob to ramp down the voltage slowly and evenly.
8. Touch the **Slow Ramp Rate** icon to ramp down at a slower rate if desired.

As the voltage decreases, the PD pulses decrease. At the point where less than 50% of the surge pulses have a PD pulse, the software records the current surge voltage level as RPDEV. As the voltage continues to ramp down, the software continually records the current surge voltage level at which a PD pulse is detected. The last recorded value is saved as the PDEV (the lowest voltage at which the detector sees a PD pulse).

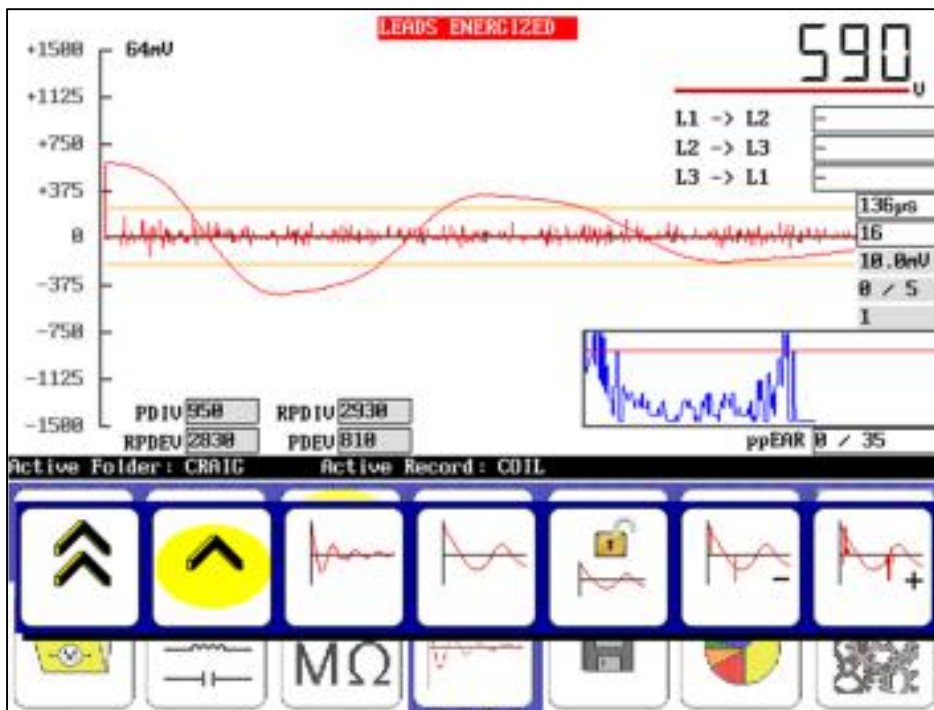


Figure 126. Example of acquired extinction voltages (PDEV and RPDEV); single coil mode testing. Results shown in expanded view.

9. When you acquire the extinction thresholds, discontinue the test and save the results.
10. Repeat the process for additional coils as needed.

Alternatively, you can use the Zero Start Override process for testing subsequent coils after setting a reference coil using the ramp-up process just described. This process is commonly used when testing for PD using a go/no go approach. If PD is recorded during the process, you can re-test the suspect coil using the ramp-up approach to get a closer view at PD activity.

1. Using a known good coil, when you obtain a satisfactory waveform, touch the **Set Reference** icon and then touch the **ZS Override** icon.



NOTE

Refer to “Determining a known-good coil to use as a reference” at the beginning of this chapter for more information on known good coil and using the reference recall feature.

2. Touch **Yes** to answer the override message, which will appear in a dialog box like the one shown below.



Figure 127. Override zero start message dialog.

3. Test each subsequent coil by connecting the clips to each coil and pressing and holding the **Start** button on the DX Host (or footswitch) for more than three seconds.

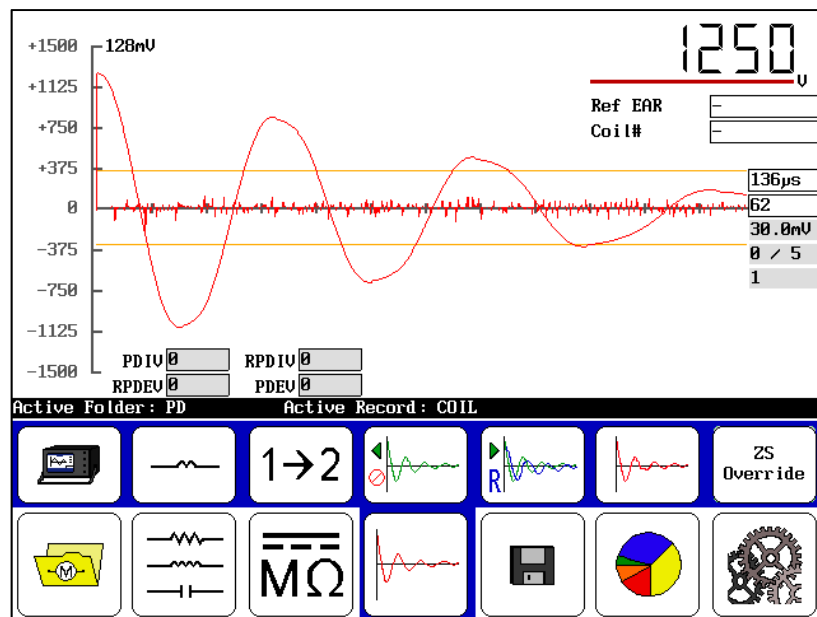


Figure 128. PD ZS0, no PD events indicated.

PD data reporting—Single-coil mode

Partial discharge tests are reported differently depending on whether the test was being conducted in Single-coil mode or three-phase coil mode.

In single-coil mode, the available reports include three elements. First, we have the EAR report for each coil with respect to the reference waveform, as shown in the example below.

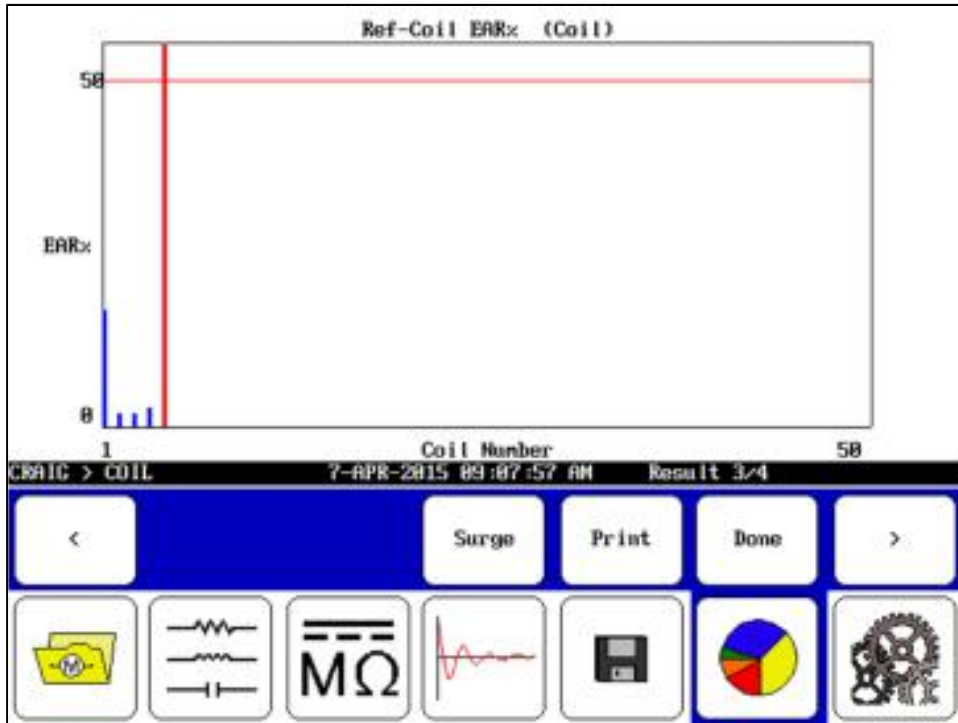


Figure 129. Coil EAR report example.

This report shows the bar graph for each coil, but not the EAR waveforms themselves. The waveforms are saved, but are only available when using the Surveyor DX software.

When you tap on the display area in the screen, you will see the average number of PD events that each coil exhibited over its testing in zero-stop override (ZSO) mode. An example report is shown below.

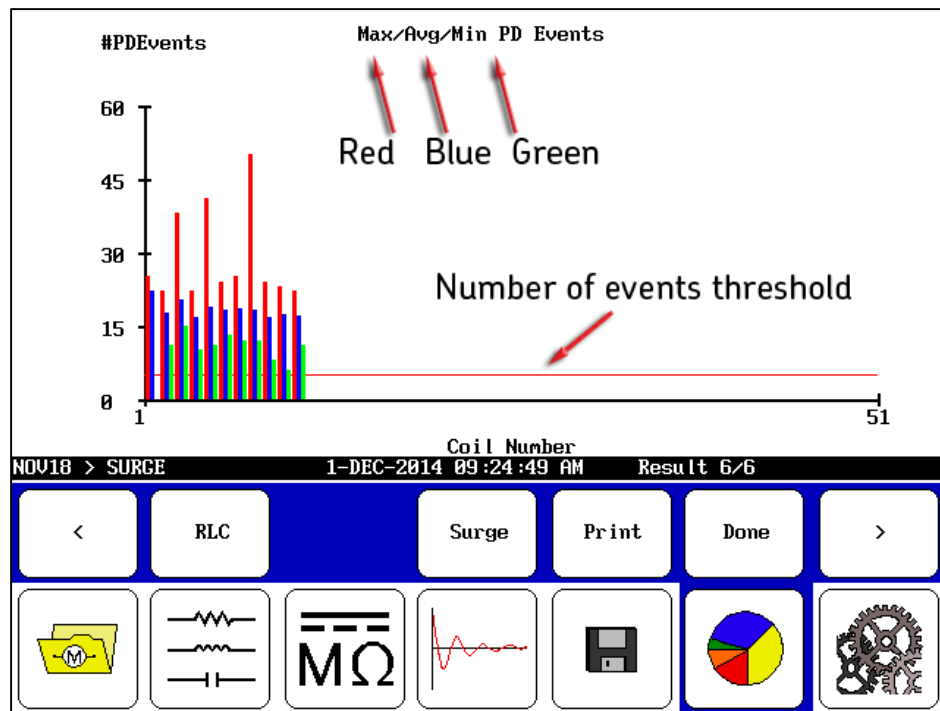


Figure 130. PD events statistics report; single-coil testing only.

This data can be used to determine “go/no-go” status for each coil based on its PD results; or it can be used to help determine coil placement if being placed into a stator. Coils with more PD should be located further away from end coils, thus reducing the stress they are exposed to.

During testing, the software generates multiple surge pulses over the course of a test cycle. Within each surge pulse, the tester collects the number of PD events detected. The report includes the minimum, average, and maximum number of PD events detected for each coil displaying PD activity.

Tap the display screen again to switch between viewing this report and PD Percentage Plot shown below.

During testing, the software generates multiple surge pulses over the course of a test cycle. Within each surge pulse, the tester collects the number of PD pulses detected. The PD Percentage Plot shows the percentage of the total number of surge pulses that had PD pulses detected within them.

This information can be used to rate coils. Essentially, you can rate coils from 0–100 percent, with the lower percentage indicating better coils (less PD activity). The ratings can help determine coil placement in a stator or even indicate bad coils. Higher percentage coils, for example, might be placed further away from end coils to reduce the stress they are exposed to.

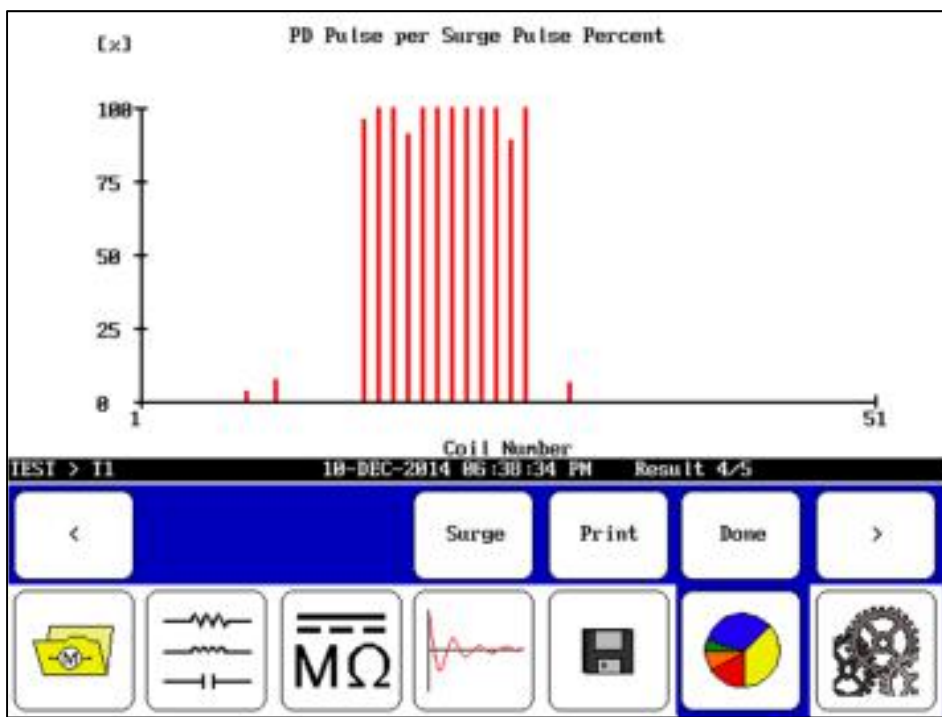


Figure 131. PD percentage plot view—single-coil testing only.

NOTE:

If you see a report that shows excessive PD activity and/or activity reaching very high pulse percentages, you might need to adjust your settings and retest. Such behavior typically indicates that your PD threshold is set too low or the PD # events level is set too low.

Armature span tests using the DX host

DC motor armature windings can be tested for turn insulation integrity. Armature windings are connected to the commutator in such a manner that all the windings are connected to each other. As a result, the bar-to-bar inductance measurements can be very low—in the micro-henry range. If the inductance is so low that the surge tester is unable to reach the required test voltage when testing between adjacent bars, a “span” of several bars can be tested instead. The inductance between every 5–10 bars is often high enough to allow for a “normal” surge test using the DX’s high-voltage leads.

Selecting a test voltage for the span test

Paschen’s minimum breakdown voltage for air is approximately 375V, which would suggest at least 375V per turn of the coil being tested. If, for example, three bars are spanned with three turns per coil then $3 \times 3 \times 375V = 3375V$ would be a test voltage. Unfortunately, such a high voltage may exceed the dielectric strength of the commutator-to-shaft insulation or the ground wall insulation of the coil. Therefore, a test voltage that adequately tests the coils without overstressing perfectly good insulation would be a better choice. Follow industry accepted test voltages, consult the motor’s original equipment manufacturer, or follow company guidelines when selecting the test voltage.



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the Baker DX setup procedure has been followed. Refer to chapter 6 “Setting up the Baker DX tester” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.

Span test procedures

1. Temporarily label the bars on the armature to be tested with the bar numbers. Labeling every 5th or 10th bar is all that is necessary.



Figure 132. Armature labeling for span testing.

2. Ensure the footswitch is attached to the DX.
3. Probes will be used to conduct the tests.

4. Touch the **Data Folders** icon in the **Mode Menu** to select the folder and record to use. Check the **Status Bar** to ensure the **Active Folder** and **Active Record** fields display the intended target destinations for your test.

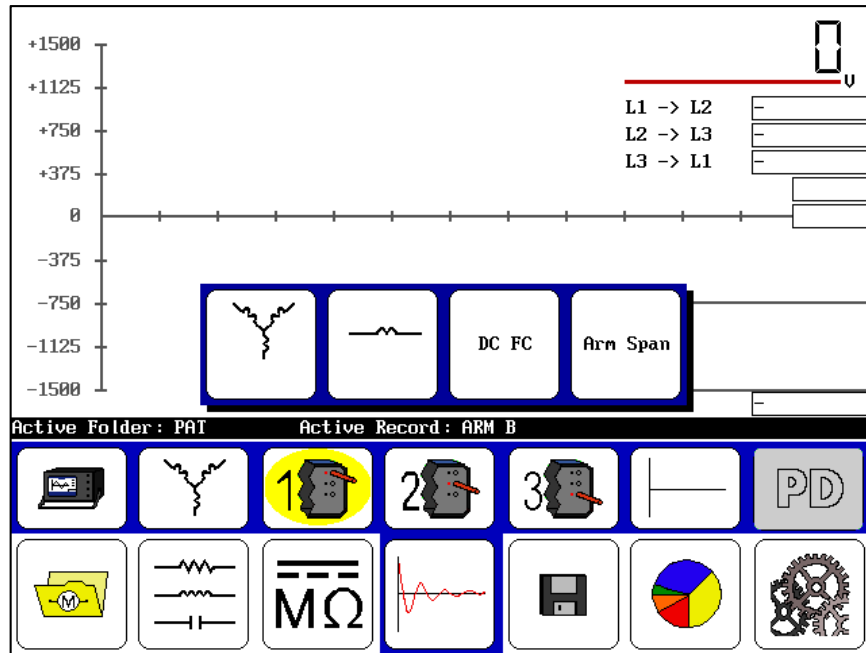


Figure 133. Armature span test start screen.

5. Ensure the configuration icon displays the **Standalone** icon.
6. Touch the **Surge** icon in the mode menu.
7. Touch the **Coil Selection** icon then the **Arm Span** icon.
8. Contact the first bar with one probe and with the other probe contact the bar that gives you the desired span. For example, bars 1 and 5.
9. Press the footswitch and ramp up the voltage to the required test level.
10. Use the **Surge waveform zoom** icons to adjust the waveform to fit the display.

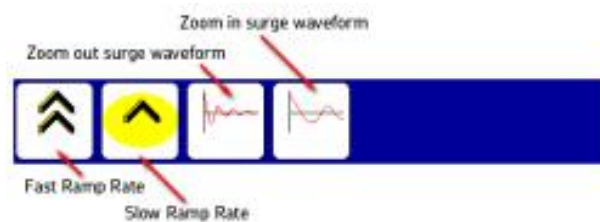


Figure 134. Ramp rate and waveform zoom popup menu.

11. When a good stable waveform is available at the required test voltage, release the footswitch.
12. Save the waveform by pressing the **Reference** Icon. (You can also use a previously saved reference if you have one.)



NOTE

Refer to “Using the recall reference feature” at the beginning of this chapter for more information on this topic.

13. Touch the **ZS Override** icon so that the test voltage will automatically go to the same voltage as used to acquire the reference waveform. No manipulation of the **Voltage Output Control** knob will be required with the zero start system overridden. Touch **Yes** in response to the override message.

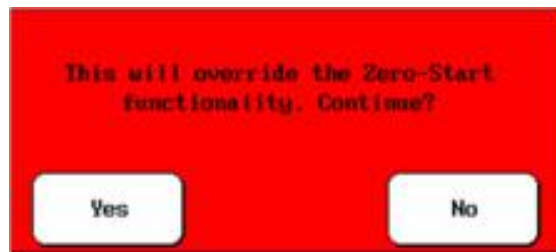


Figure 135. Override zero start message dialog.



WARNING

High-voltage testing.

Take all precautions to avoid injury or death from electrical shock. Accidentally pressing the Start button or footswitch will apply a high voltage to the test leads.

Make sure all personnel are away from the device under test and not in contact with either the load or the test leads.

14. Leave the probes over the same bars as the reference above. The preceding step only acquired the reference waveform.

15. Press and hold the footswitch again to acquire the waveform for the first pair of bars spanned. The waveforms should perfectly overlap, because the bars being tested are the same that were used to acquire the reference waveform (unless you used the recall reference feature).
16. Release the footswitch. The new waveform will be saved and the error area ration (EAR) of this waveform as compared to the reference waveform will be calculated and displayed in the bar chart in the **Display Area**. Because the same bars as the reference are being tested, the EAR value will be very low: 0–3 percent. The coil counter will increment in the upper right side of the display. The coil counter always corresponds to the waveform just acquired.

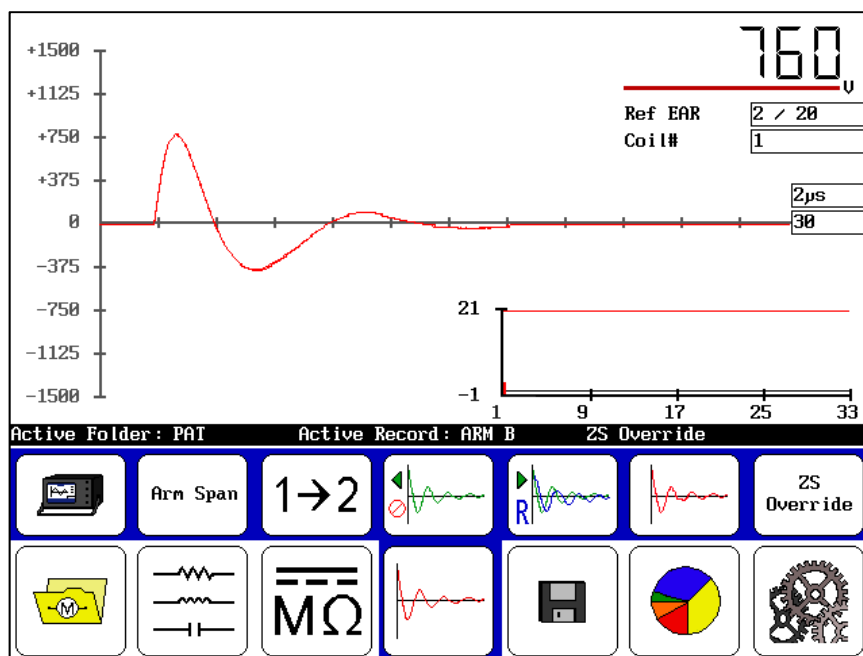


Figure 136. First waveform acquired after setting reference.

17. Move the test probes to the next pair of bars to be span tested. In this example; we used a span of five bars, so the next set would be bars 2–6.

18. Press and hold the footswitch and observe the waveform on the screen. If the armature winding insulation is good, the new waveform will almost perfectly overlay the reference waveform still displayed on the screen. If there is separation between the two waveforms, there is most like a hard short in the armature winding. If the new waveform is “fluttering,” there is arcing in the armature winding.

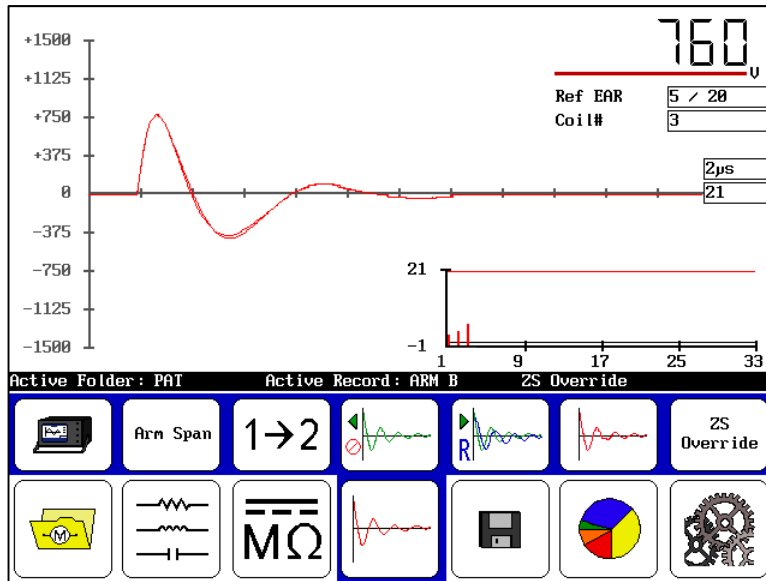


Figure 137. Good coil waveform.

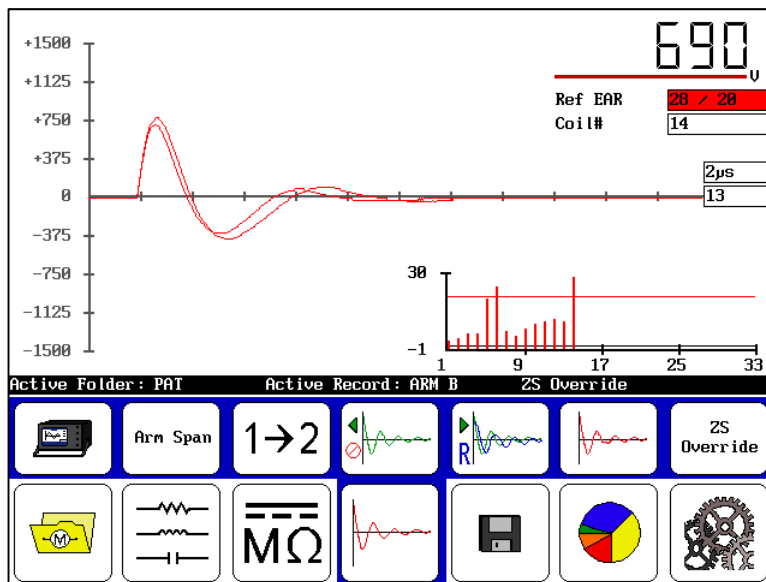


Figure 138. Bad coil waveform.

19. Release the footswitch. Again, the active waveform is saved, the EAR calculated and displayed, and the coil counter incremented.

20. Move the probes to the next pair of bars (3–7 in this example) and repeat the steps above. For every set of bars span tested, observe the waveform looking for fluttering, which is an indication of arcing within the armature winding. If the test area is quiet enough, a distinct arcing sound may even be heard if there is insulation damage.
21. Continue testing bar pairs all the way around the circumference of the commutator.
22. After all bars have been tested, save the data by pressing the **Save** icon. After saving, the data can be recalled for analysis, printed using a printer connected to the DX USB port, or saved to a USB drive for uploading to a computer using the Surveyor DX software.

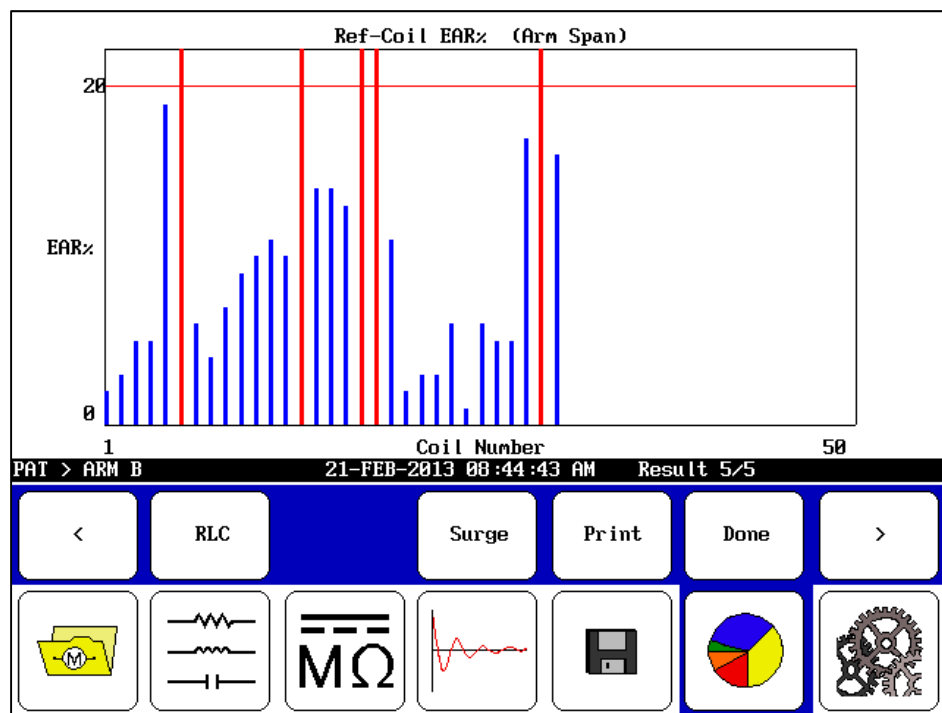


Figure 139. Arm span results screen ready for printing or export.

23. During the span test process, the display can be changed so that just the immediately acquired waveform and the reference waveform are shown on the screen.

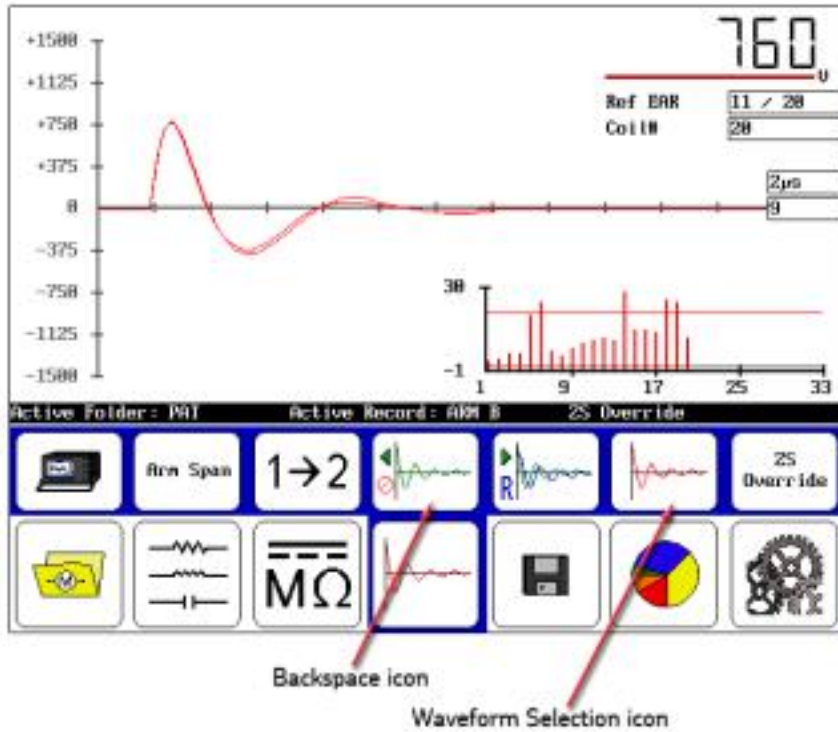


Figure 140. Single waveform displayed.

24. Touch the **Waveform Selection** icon and the popup menu shown below appears. Touch the **Last Waveform** icon to display the results for the last test as shown below. The reference waveform will be shown in red and the current test waveform will be shown in black.

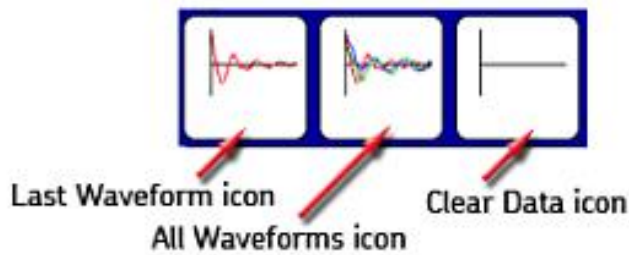


Figure 141. Waveform Selection popup menu.

25. Alternatively, if you touch the **Waveform Selection** icon then the **All Waveforms** icon, your display would look more like the one below. The reference measurement and the last (current) coil measurement are displayed in red.; all other test measurements in the series are shown in black
26. The multiple waveform display will look very busy when 10–20 waveforms are shown. To more easily see the winding faults, display just the single waveform by touching the **Last Waveform** icon.

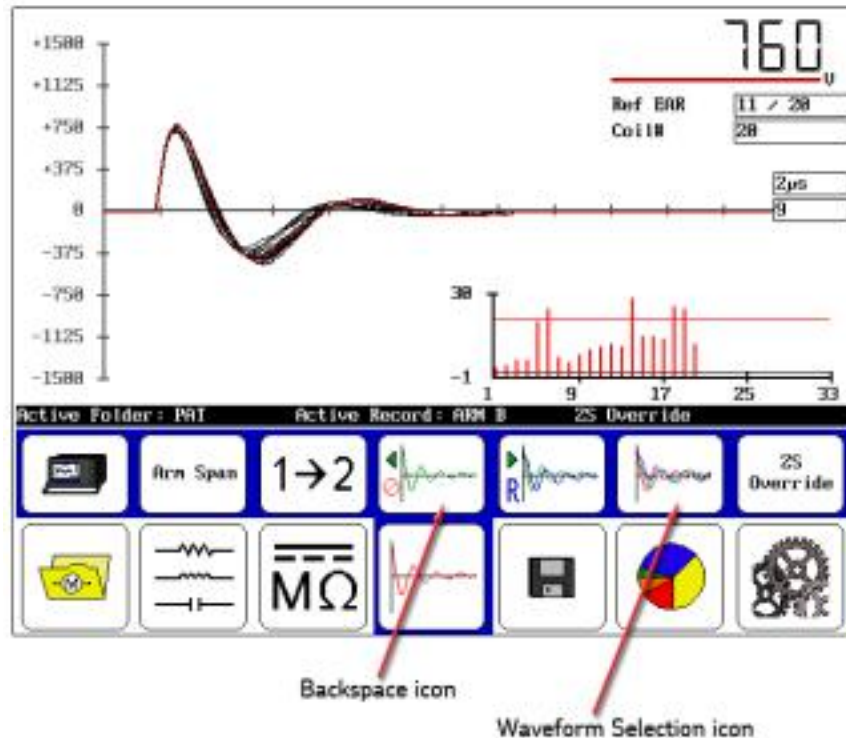


Figure 142. All waveforms displayed.

27. During a span test, the probes can slip on the commutator bars or the footswitch might be inadvertently pressed, resulting in an unwanted waveform being acquired. To erase this waveform, press the **Backspace** icon then repeat the test. A dialog box appears to confirm that you want to delete the coil selected. Pressing the **Backspace** icon several times, erases the last “several” waveforms.

Low-voltage armature or coil tests using the DX host

Low-voltage armature or coil mode is used to plot resistance, inductance, phase angle, and impedance measurements taken over different coils or over different armature bars. For example, in the case of testing a DC armature, you can take test measurements on each bar on the commutator. All measurements are made on each coil or armature bar. The results are plotted with respect to the different coils tested.

Buttons on the right and VCR controls are used to select the test data that you want to plot. The VCR controls move you through which coil or armature bar measurement you want to see. The buttons along the right edge are used to select the type of test measurement you want to plot.

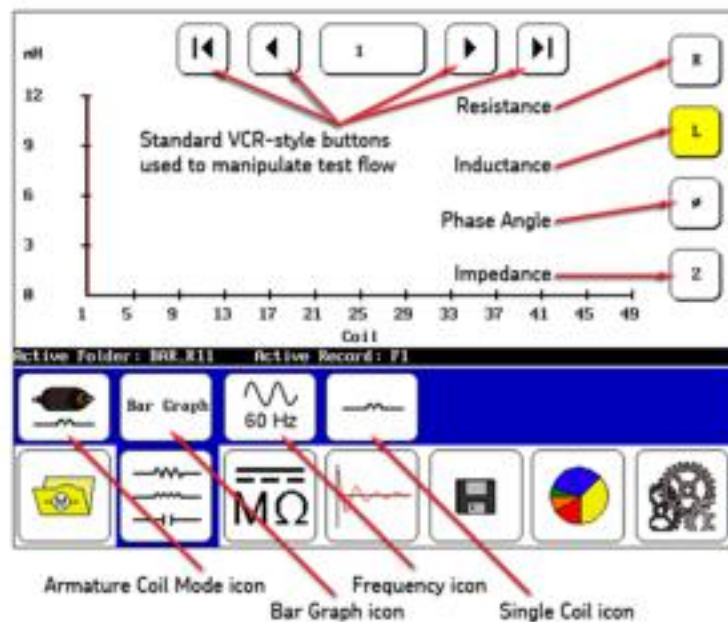


Figure 143. Low-voltage armature or coil mode screen elements.

In the submenu, the first icon from the left—the **Armature Coil Mode** icon—shows you that you are in low-voltage armature or coil mode. The **Bar Graph** icon identifies the display format selected. Touching the icon allows you to change the type. The frequency displayed is shown by the next icon, which again can be changed by touching the icon. The fourth icon—**Single Coil** in this case—shows the type of coil being tested. That selection can also be changed by touching the icon. This icon is a notation in the result that also appears in the report when printed.

Low-voltage armature or coil test procedures



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the Baker DX setup procedure has been followed. Refer to chapter 6 “Setting up the Baker DX tester” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



CAUTION

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.



NOTE

Refer to “Determining a known-good coil to use as a reference” found at the beginning of this chapter for information about known good coils and using the reference recall feature.

1. Touch the **Data Folders** icon in the **Mode Menu** to select the folder and record to use. Check the **Status Bar** to ensure the **Active Folder** and **Active Record** fields display the intended target destinations for your test.

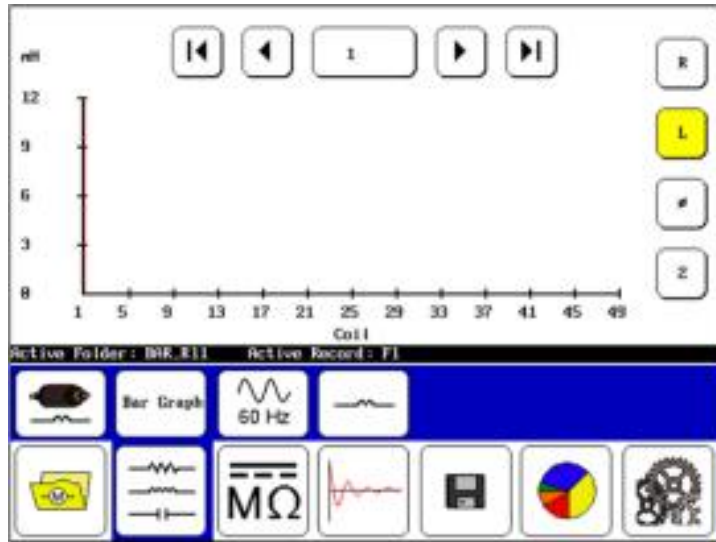


Figure 144. Low-voltage armature or coil test start screen.

2. Start the testing from the following screen by touching the **RLC mode** icon in the **Mode Menu** then touching the **Armature Coil Mode** icon in the **Mode Submenu**. The starting screen should then look like the one shown above.

3. Push and release the **Start (PTT)** button to run the test. The “Leads Energized” message will appear at the top of the display. When the test finishes, the measurement for each coil will display in the results as shown in the following example.

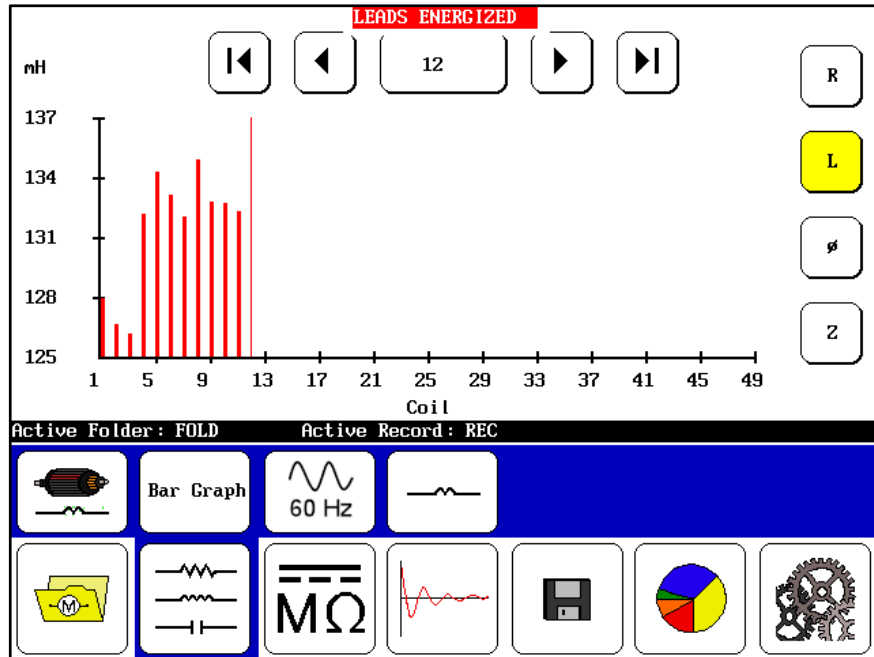


Figure 145. Low-voltage armature or coil test results screen.

4. Touch the **Save** icon to save your test results.

Rotor influence check (RIC) tests using the DX host

The rotor influence check (RIC) test checks the influence of the rotor on the test measurements taken with respect to moving the rotor to different positions.

The RIC test is a set of stator impedance measurements made at incremental rotor shaft positions; for example, every five degrees. A plot of inductance measurements is made with respect to shaft positions, and is then interpreted with the goal of identifying rotor problems

Buttons on the right and VCR controls are used to select the test data that you want to plot. The VCR controls move you through which rotor position measurement you want to see. The buttons along the right edge are used to select the type of test measurement you want to plot.

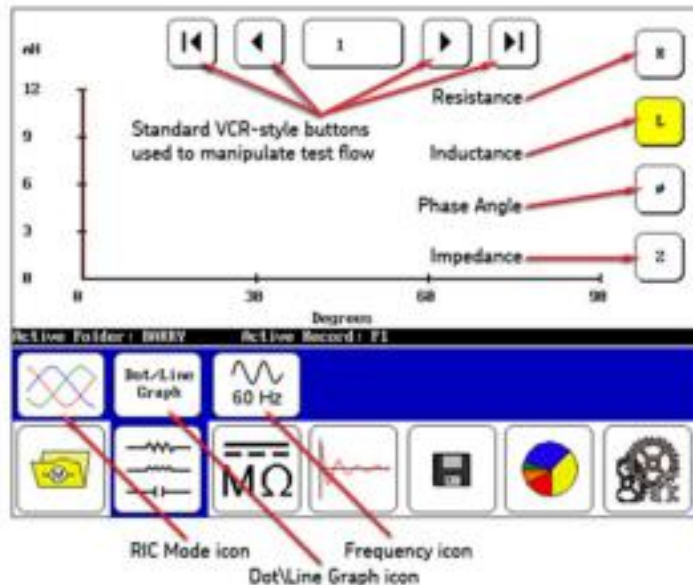


Figure 146. RIC test screen elements.

In the submenu, the first icon from the left—the **RIC Mode** icon—shows you that you are in RIC test mode. The **Dot/Line Graph** icon identifies the display format selected. Touching the icon allows you to change the type. The frequency displayed is shown by the next icon, which again can be changed by touching the icon.

Across the bottom of the display, the X-axis is shown in degrees. The X-axis starts with 0–90 degrees and auto-scales as needed to fit in all rotor shaft angles measured. As you conduct your test, you will move the rotor to the next position and do a measurement, move the rotor again and do another measurement, and so on through all test positions. The DX will plot the measurements over the rotation of the rotor, which helps identify rotor defects.

Rotor influence check test procedures



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the Baker DX setup procedure has been followed. Refer to chapter 6 “Setting up the Baker DX tester” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.

Do not to run the normal RLC resistance test prior to running a RIC test because the currents involved in the resistance test may impair the measurement results.



CAUTION

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.

1. Touch the **Data Folders** icon in the **Mode Menu** to select the folder and record to use. Check the **Status Bar** to ensure the **Active Folder** and **Active Record** fields display the intended target destinations for your test.

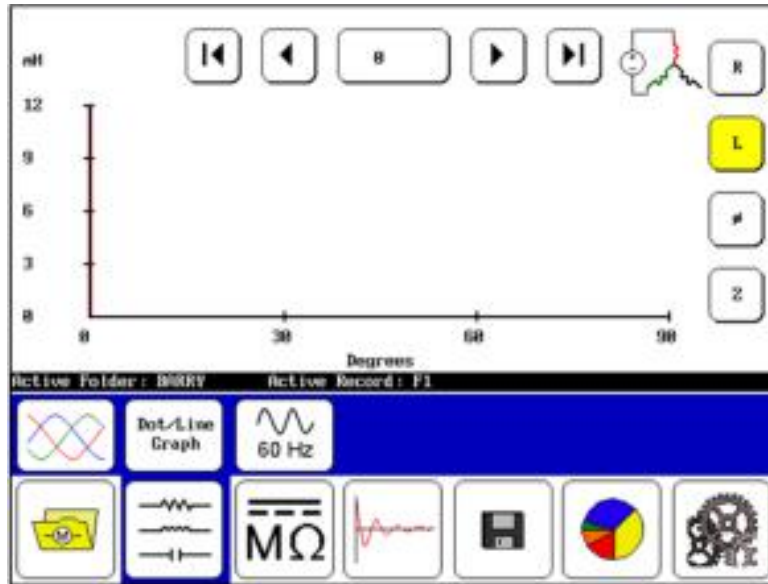


Figure 147. RIC test start screen.

2. Start the testing from the following screen by touching the **RLC mode** icon in the **Mode Menu** then touching the **RIC Mode** icon in the **Mode Submenu**. The starting screen should then look like the one shown above.
3. Starting at 0 degrees, push the **Start (PTT)** button to execute the first set of tests on that position of the rotor. The DX will automatically run three inductance tests—one for each lead. The results of these tests are presented in the **Display Area**.
4. Move the rotor to the next shaft angle (also shown in the display) and press the **PTT** button again. As above, three inductance tests will be performed and the results plotted on the screen.
5. Continue moving the shaft and running tests until the required number of angles have been tested. (4-pole motors require 180° of shaft rotation to get a usable X-Y plot. 6-pole motors require 120°. 8-pole motors require 90°, and so on.)

During the test, you will see the display grow as you move the rotor to a new position and execute another test (via **PPT** button). As the example graphic below shows, the *RIC Test* screen provides you with a number of features to help track and review your progress.

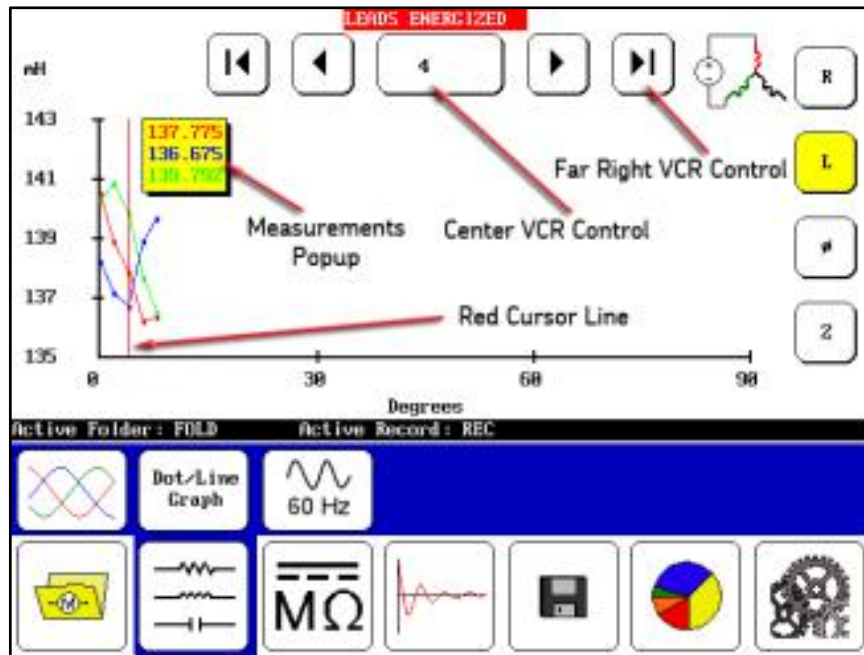


Figure 148. RIC test screen in progress as test data collected.

The **Center VCR Control** indicates the current test position viewed, which is indicated in the plot by the **Red Cursor Line**.

The cursor line indicates the position being updated during test, so normally it would be ahead of the recorded test data as you execute tests in sequence. If you touch the **Center VCR Control**, you can choose which test position to go to and the cursor will also move to that position (for example, if you want to view the results of an earlier test).

The **Far Right VCR Control** icon returns you to one point beyond the last test completed so you can continue with your testing in the original sequence.

The **Measurement Popup** provides you with greater resolution for the selected test than you can get from viewing the plots on the graph. The measurements are color-coded to correlate with the graph.

As you select different measurement sets using the control icons on the right edge of the screen (for AC resistance, inductance, phase angle, and impedance) the Y-axis changes accordingly to display the proper units for each measurement type and scale.

During your testing process, if you decide that you want to go back and view a previous test, you can use the **Next** and **Previous** VCR Control icon to step

incrementally through the tests, or you can touch the **Center VCR Control** to open a **Touchpad** as shown below.

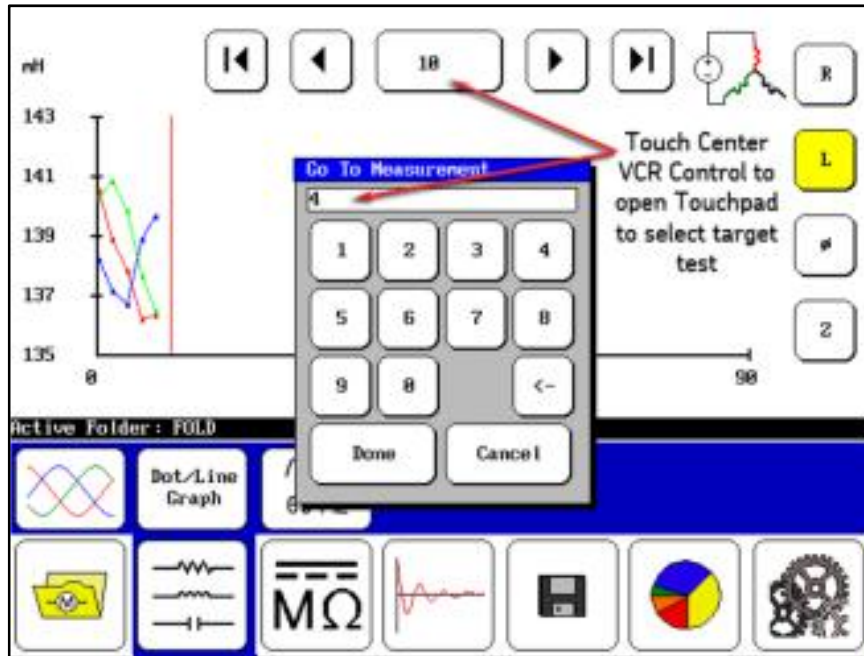


Figure 149. RIC test screen with Touchpad to select target test.

You can simply view the results if you like, or you can retest at that point by pushing the **Start (PTT)** button. The tests will be executed and the results will be written over the results currently stored for that test position.

You can then go to other tests as needed and replace their results in the same manner, or you can touch the **Far Right VCR Control** icon to return to the next test position and continue your testing.



NOTE

Angle step sizes and other parameters are defined in the system settings. Refer to the “Using system settings” section in chapter 5

- Continue testing by moving the rotor to a new position and executing another test (via the **PPT** button). The “Leads Energized” message will appear at the top of the display with each test execution. When you have completed all your tests on every rotor position, the test results will be plotted in the **Display Area**. In the following example, the test is still in progress, but the results are representative of what you will see during testing.

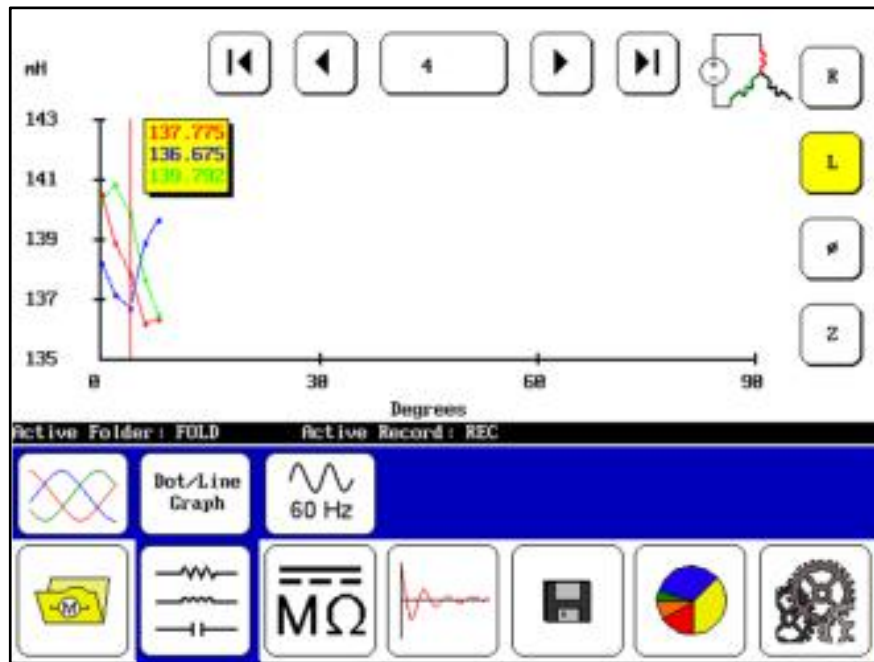


Figure 150. RIC test results screen.



NOTE

The X-axis starts with 0–90 degrees in the display, but if the measurements continue past 90 degrees the scale will bump up to 120, 180, and 360 as needed (depending on the number of poles in the motor.)

- When you have completed your tests, touch the **Save** icon to store your test results.

Combining a DX host and power pack for testing

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 packs and resistance testing

The resistance tests are run from the Baker DX host. Refer to the procedures for the resistance, inductance and capacitance tests found earlier in this chapter.



NOTICE

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.



CAUTION

Do not connect both sets of leads together at any time; damage to the tester will result.



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 to prevent injury or death from electrical shock.

DC tests using power packs



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the power pack setup procedure has been followed. Refer to chapter 7 “Setting up power packs” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



CAUTION

Do not connect both sets of leads together at any time; damage to the tester will result.



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 to prevent injury or death from electrical shock.

1. If a folder and record have not been created for the motor selected to test, do that now from the **Folders** icon and set up the intended folder/record as the **Active Folder** and **Active Record** in the **Status Bar**.

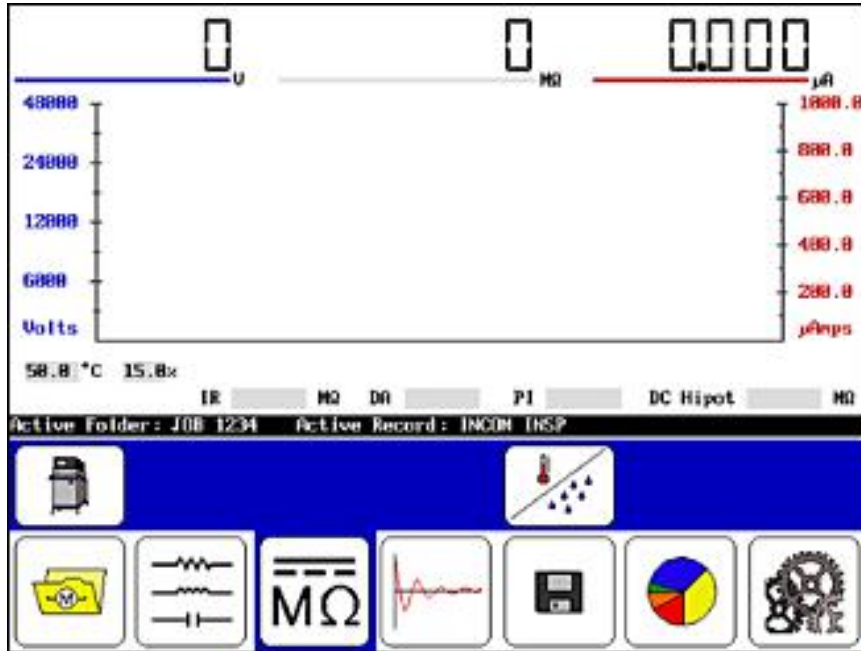


Figure 151. DC tests start screen.

2. Select the **DC/megohm** icon from the DX screen, which brings up the **Configuration Options** icon. When you touch the configuration icon, new icons appear that indicate installed options that allow operation either as a standalone unit or with a power pack.

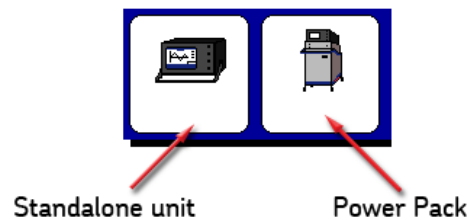


Figure 152. Configuration Options popup menu.

3. If an interface board *is not* installed a message dialog will appear.
4. For purposes of this instruction, touch the **Power Pack** icon.
5. To compensate temperature and/or record humidity, touch the **Temperature/humidity** icon; otherwise, skip to Step 14.

Compensating temperature and recording humidity

The following popup menu is used to enable/disable temperature and humidity compensation and to select the compensation needed for these test elements when compensation is enabled.

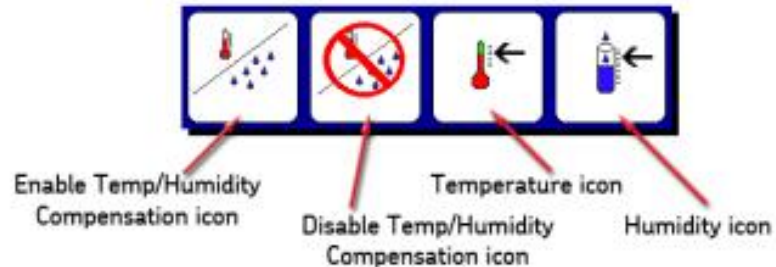


Figure 153. Temperature and humidity compensation popup menu.

- Touch the **Enable Compensation** icon then the **Temperature** icon.
- The default temperature is 40 °C; use the keypad to enter the actual temperature to calculate compensation then touch **Done**.
- For reference purposes, specify the humidity by touching the **Humidity** icon then use the keypad to enter the relative humidity percentage.
- Touch **Done** after making your entry.

Because this is a comprehensive test, you must predetermine the necessary values to input during the test before the test start (refer to the “Recommended test voltages” section in “Appendix C — DC and surge tests voltages.”)



NOTE

Step times, ramp rates, and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

- ❏ The value for the IR, DA, and PI tests would be operating or line voltage V_{LL} . For this example, we use 480 volts.
- ❏ The value for the DC-HiPot would be $2 \times (V_{LL}) + 1,000 = 1960$ volts for this example.
- ❏ The increments for the DC step voltage are derived from $1,960 - 480 = 1,480$. Using three increments for this example, $(1,500 / 3 = 500 \text{ v})$, each increment for the step DC-HiPot would be 500 volts (500 v, 1000 v, and 1500 v).
- ❏ To run a final DC-HiPot, set the voltage at 2000 v.

6. Push and hold the **Start (PTT)** button (or footswitch) and the following controls appear.

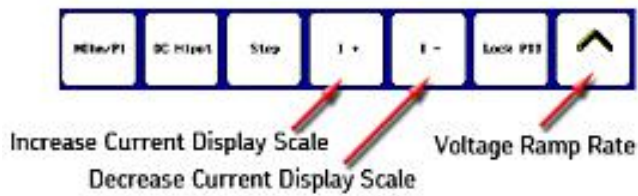


Figure 154. Test submenu items.



NOTE

As a matter of best practice, perform the following steps in quick succession. Also note that for DC HiPot tests using the Baker PP40, the **Surge range switch** must be in the “down” position. HiPot testing will not work correctly with the switch in the “up” position.

- a. Rotate the **Voltage Output Control** knob on the front panel to raise the voltage level to 2,300 volts.
- b. Touch the **MOhm/PI** icon to start the megohm insulation resistance (IR), dielectric analysis (DA), and polarization index (PI) tests.
- c. If hands-free testing is desired, touch the **Lock PTT** icon. When the icon changes to a yellow highlight as shown in the example below, release the **Start (PTT)** button (or footswitch).
- d. Yellow highlights identify locked controls. The submenu will look like the following while the tests are running:

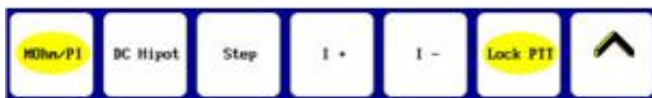


Figure 155. Test submenu items with yellow highlights.

7. Use the **Increase Current Display Scale (I+)** or **Decrease Current Display Scale (I-)** icons as needed to adjust the current’s scale.
- e. The **Status Bar** displays a countdown timer for each of the megohm, step-voltage, and standard DC-HiPot tests as shown in the following example.



Figure 156. Status Bar with Countdown Timer.

- f. 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.



NOTE

DA start/stop and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

Conduct step voltage or DC HiPot test

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

8. Use the **Voltage Output Control** knob to raise the voltage to the next step.
9. Touch the **Step** icon to program/set a 60-second test. Repeat the steps until you achieve the desired voltage variable.



NOTE

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.

Step and HiPot intervals and other test settings are specified in the System Settings mode. Refer to the “Using system settings” section in chapter 5 for more details.

Conduct standard DC HiPot test

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

10. Use the **Voltage Output Control** knob to set the voltage to the desired DC-HiPot voltage.
11. Touch the **DC-HiPot** icon to program/set a 60-second test.
12. When the test is complete, push the **Start (PTT)** button (or footswitch), and *allow the unit to discharge completely before disconnecting test leads.*



NOTE

The HiPot overcurrent trip indicator detects any arc-over in the insulation and puts an immediate stop to testing. The overcurrent 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 touch the **Test** button, it resets the trip circuitry, removes the HIPOT TRIP message, and readies the tester for a new test.

13. Touch the **Save** icon to save the test results to the active folder and active record.
14. For the Baker 30 or Baker x85, ensure that the **Test Select** switch is set to **HiPot** (**Test Select** switch not available on the Baker 40). The DC-HiPot test is now ready for test start from the following screen.

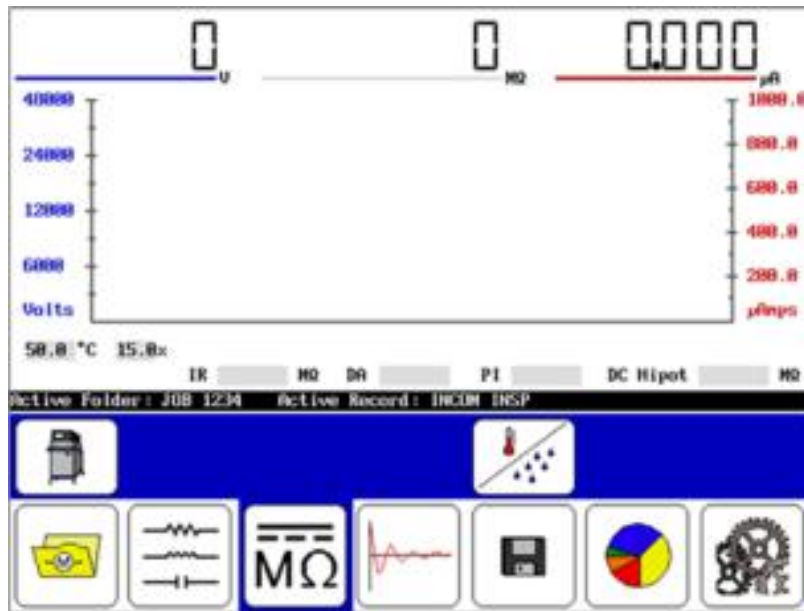


Figure 157. DC HiPot test start screen.

15. Start the test by pushing and holding the **Test** button on the power pack (or footswitch).
16. Adjust the **Voltage Output Control** knob so that HiPot voltage is at the required test voltage (at least 2,000 V).



NOTICE

Interrupt this test any time you observe a fast sharp rise in current by releasing the Test button.

To avoid damage to the unit under test, do not change either the Function selector switch out of HiPot or the Test Select switch during the performance of a HiPot test.

17. Adjust the **Function** selector switch to select a more sensitive $\mu\text{A}/\text{div}$ to better monitor the leakage current (for example, if the signal is $< 50 \mu\text{A}$, switch to $10 \mu\text{A}/\text{division}$; $< 5 \mu\text{A}$ switch to $1 \mu\text{A}/\text{division}$). 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.
18. After completing the test, release the **Test** button (or footswitch) then return the **Voltage Output Control** knob to **Min** (full counterclockwise rotation).
19. If desired, save the test results in the **Active Folder / Active Record**. Rerunning the test overwrites the last test results.

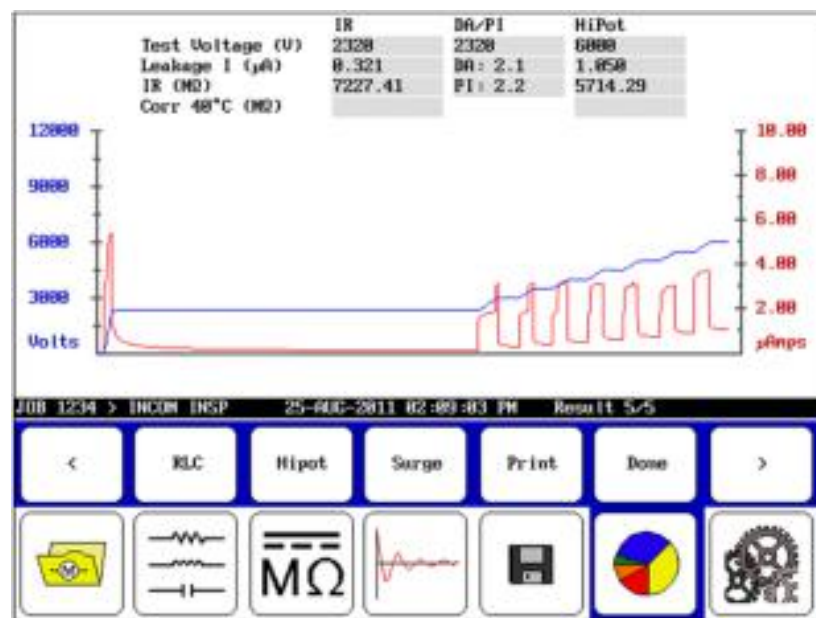


Figure 158. DC HiPot test results screen.



NOTICE

Shutting down the power pack prior to saving will cause the loss of all data.



WARNING

To prevent injury or death from electrical shock, always allow sufficient time for the test winding to completely discharge before disconnecting the test leads. Discharge the winding for at least four times the duration of the DC-HiPot test for high-voltage windings.

On the Baker 30, set the Test Select switch to the LEADS GROUND position before disconnecting test leads.

On the Baker 40, wait at least 40 seconds before disconnecting test leads.

DC HiPot testing notes

The overcurrent trip levels that activate the HiPot trip are 8.5 times the $\mu\text{A}/\text{division}$ setting on the tester. For example, on the $10 \mu\text{A}/\text{division}$ setting, HiPot trip will occur at $85 \mu\text{A}$. If a HiPot trip occurs, release the **Test** button to reset the overcurrent trip. A message dialog like the one shown below will also appear.



Figure 159. Overcurrent message dialog.

An error message dialog like the one shown below will appear on the Baker DX screen if you select the power pack option, but the **Start (PTT)** button on the DX host unit is pressed instead of the **Test** button on the power pack/or footswitch.

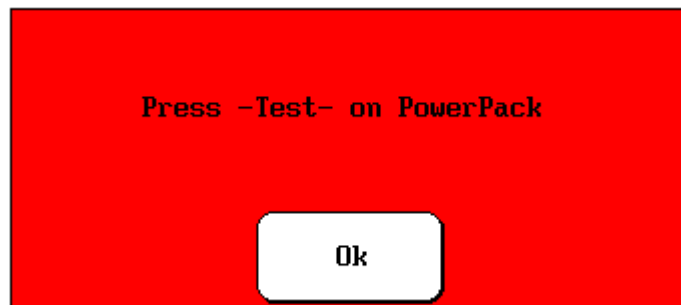


Figure 160. Start button message dialog.



NOTE

For DC HiPot tests using the Baker PP40, the **Surge range switch** must be in the "down" position to allow for test voltages greater than 18 kV.

Surge tests using power packs



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the power pack setup procedure has been followed. Refer to chapter 7 “Setting up power packs” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.

Power pack surge testing—Baker 30, Baker x85, and Baker 40 (three-phase lead test option Baker 30 and Baker x85 only)



NOTE

For the Baker 30/x85, you need only connecting the power pack's test leads to the motor leads once. The Baker 30/x85's Test Select switch tells the power pack how to handle the test leads for HiPot and Surge testing.

For the Baker 40, because it has only a single active lead, you will need to manually move the active lead between the different motor leads for each test operation.

Baker PP40 power pack manual surge range switch

This Baker PP40 Power Pack is equipped with a manual range switch for performing surge tests. This switch provides positive control of the surge test voltage and eliminates dependency upon automatic range switching during a test.

Flip the **Surge range switch** up for tests requiring voltages less than 18 kV.

If the **Surge range switch** is in the “up” position and the **Voltage adjust knob** is rotated to increase the voltage above 18 kV, *the analyzer will not generate any surge pulses.*

Flip the **Surge range switch** down for tests requiring voltages greater than 18 kV.

If the **Surge range switch** is in the “down” position and the **Voltage adjust knob** is rotated to decrease the surge voltage below 18 kV, *the analyzer will not generate any surge pulses.*

1. Place the DX into standalone mode.
2. Touch the **Surge** icon from the DX screen, which brings up the **Configuration Options** icon. When you touch the configuration icon, new icons appear that indicate installed options that allow operation either as a standalone unit or with a power pack.

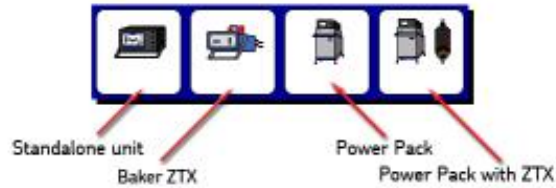


Figure 161. Configuration Options popup menu.

3. If an interface board *is not* installed, a message dialog box appears.
4. For this example, touch the **Power Pack** icon. The **Coil Mode Selection** popup menu appears in the **Display Area** showing you the options for this test.

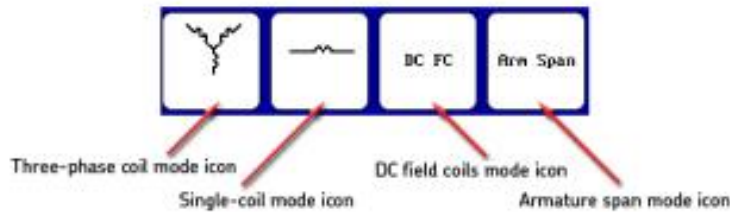


Figure 162. Coil Mode Selection popup menu.

5. Touch the **Three-phase coil mode** icon.
6. For the Baker 30 and Baker x85, ensure that the **Test Select** switch is also set to **Surge** (not available on the Baker 40).

- With the first **Lead Selection** icon selected by default (identified by the yellow highlight in the submenu), the surge test is now ready to start from the following screen.

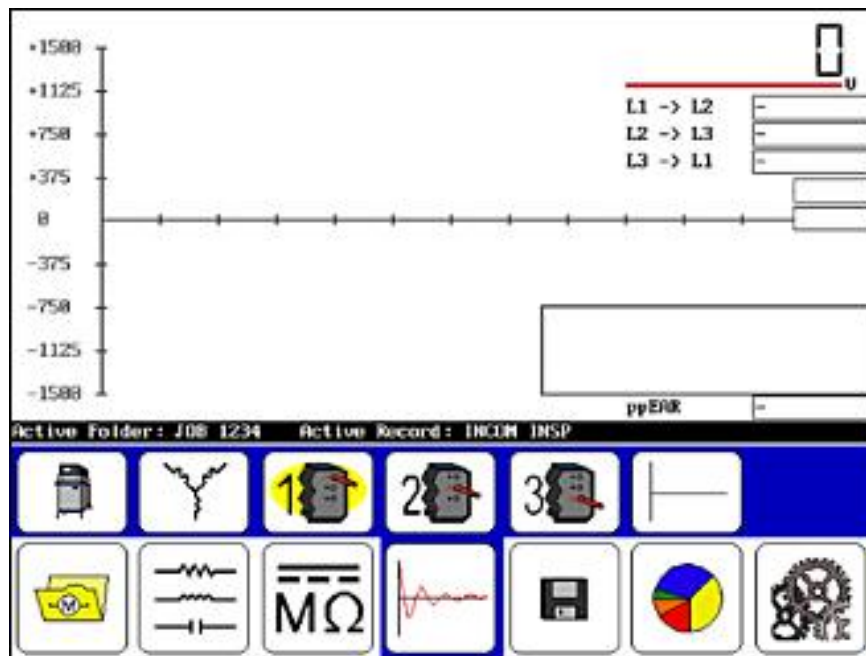


Figure 163. Surge test start screen.

- Start the test by pressing and holding the power pack **Test** button (or footswitch). Using the power pack's **Voltage Output Control** knob, slowly increase the voltage. A waveform should appear immediately.
- Use the Baker DX unit's **Fast/slow ramp rate** icons to raise the target voltage faster or slower. Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform.
- Upon completion of the test, release the **Test** button (or footswitch) then return the **Voltage Output Control** knob to **Min** (full counterclockwise rotation).

11. 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.*

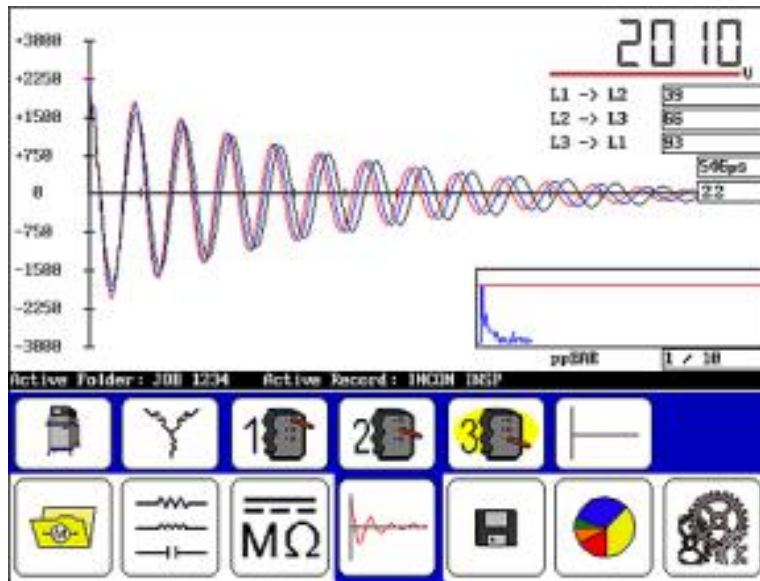


Figure 164. Surge test results screen.



NOTICE

Shutting down the power pack prior to saving will cause the loss of all data.



WARNING

To prevent injury or death from electrical shock, always allow sufficient time for the test winding to completely discharge before disconnecting the test leads.

On the Baker 30, set the Test Select switch to the leads ground position before disconnecting test leads.

On the Baker 40, wait at least 10 seconds before disconnecting test leads after a surge test. After a HiPot test, wait at least 40 seconds.

Armature tests using the x85 power packs



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the power pack setup procedure has been followed. Refer to chapter 7 “Setting up power packs” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



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 to prevent injury or death from electrical shock.

1. If they are not yet running, power up the Baker DX and the power pack.
2. If a folder and record have not been created for the motor to be tested, do that now from the **Folders** icon and set up the intended folder/record, which should appear in the **Active Folder** and **Active Record** in the **Status Bar**.

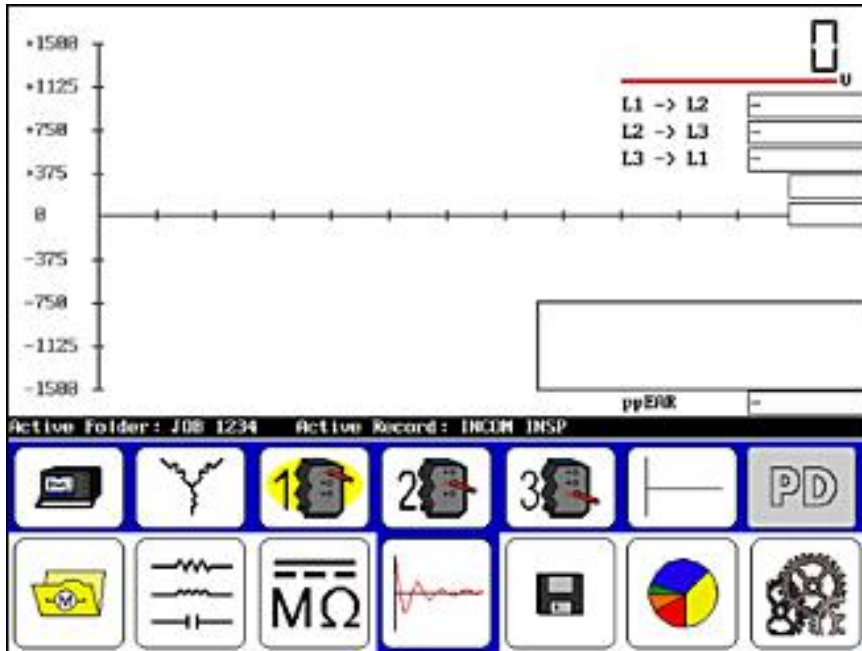


Figure 165. Armature test start screen.

3. Touch the **Surge** icon then the **Configuration Options** icon in the **Mode Submenu**. A new popup menu appears to show any installed options. The options can include standalone unit, Baker ZTX, power pack, or power pack with ZTX built in.

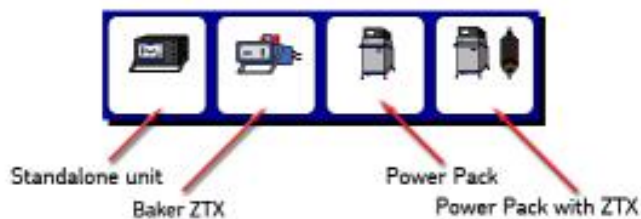


Figure 166. Configuration Options popup menu.

4. If an interface board *is not* installed, you will see a message dialog notifying you of that fact.
5. Touch the **Power Pack with ZTX** icon for this example.
6. The submenu will change to show that you are in single-coil mode.

- Touch the **Single-coil mode** icon and the following popup menu appears.



Figure 167. Single-coil mode popup menu.

- Touch the **Arm Bar** icon.
- Ensure that the **Test Select** switch is set to **Ground** and the **Function** switch is set to **ARM**.
- Press and hold the footswitch and the **Ramp rate and waveform zoom** popup menu appears.

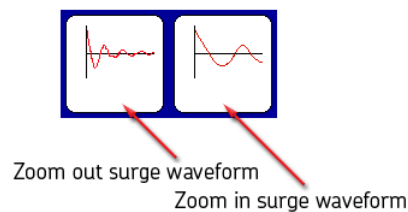


Figure 168. Surge waveform zoom icons.

- Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform.



CAUTION

To avoid damaging the unit under test or substantially reducing the switching element's useful life, do not change the Function selector switch out of Arm during the performance of any armature test.

- Press and hold the footswitch to test each commutator sample, selecting one for a starting point and as a reference.



NOTE

Refer to "Using the recall reference feature" at the beginning of this chapter for more information on this topic.

- From a sample, select one to be the reference by selecting the **Reference icon**.
- Starting at position one, press and hold the footswitch until you obtain a stable good waveform.

15. When the footswitch is released, the waveform will be captured and stored. The coil index box will increment and the unit will be ready for the next commutator bar test.
16. Move the test fixture (or probes) to the next bar taking care to center the bushes on the next two adjacent bars.
17. Press and hold the footswitch to test the next bars. Release the footswitch when a stable waveform is obtained.
18. Repeat the process until all bars have been tested.
19. Example deviant armature scan results are shown below.

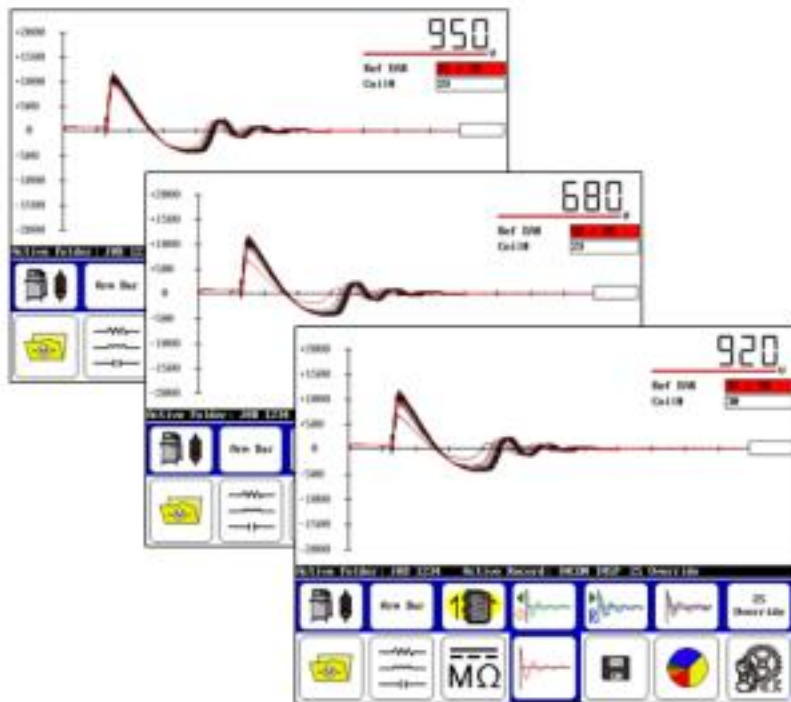


Figure 169. Example waveforms collected and compared.

20. After testing all bars, return the **Voltage Output Control** knob to **Min** (full counterclockwise rotation).



NOTICE

Shutting down the DX host prior to saving will result in the loss of all data from the previous unsaved test.

21. If desired, touch **Save** to store the test results in the **Active Folder/Active Record**. It will save as Arm data and it will appear on the results as such. Running the test continues adding armature coils up to 400 (DX can store only 400), after which you must create a new record for armature with more commutator bars.
22. Touch the **Report** icon then the **Display** icon to view the commutator bar results as shown in the example below.

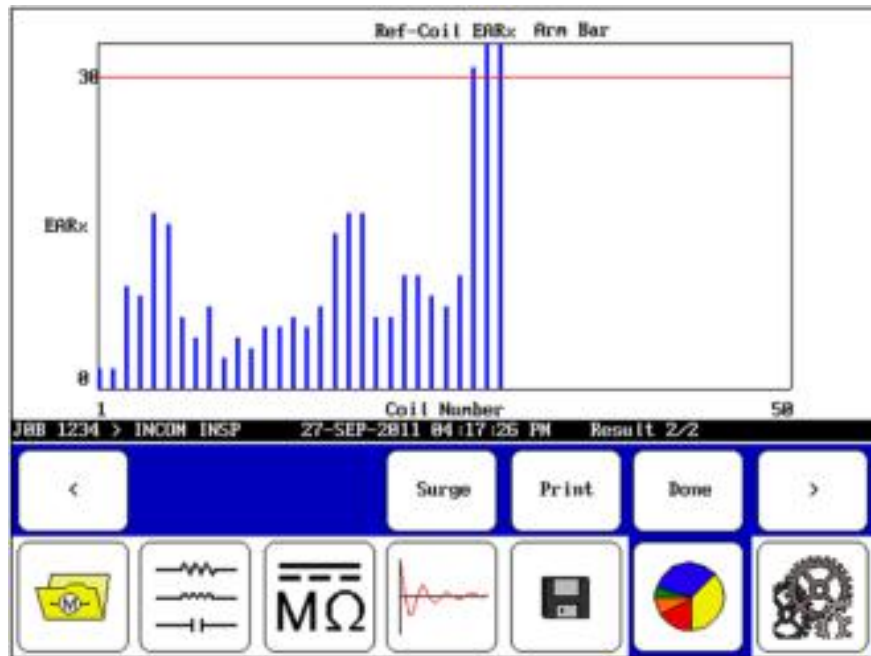


Figure 170. Armature test results screen.

In the simple example above, armature coils 28, 29, and 30 are out of limits.

Generic coil and DC IP tests using x85 power packs

When combined with a Baker x85 power pack, the Baker DX accommodates testing of DC IP (interpole) and generic coils.



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the power pack setup procedure has been followed. Refer to chapter 7 “Setting up power packs” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.

1. If a folder and record have not been created for the coils under test, do that now from the **Folders** icon and set up the target folder/record to display in **Active Folder** and **Active Record** in the **Status Bar**.

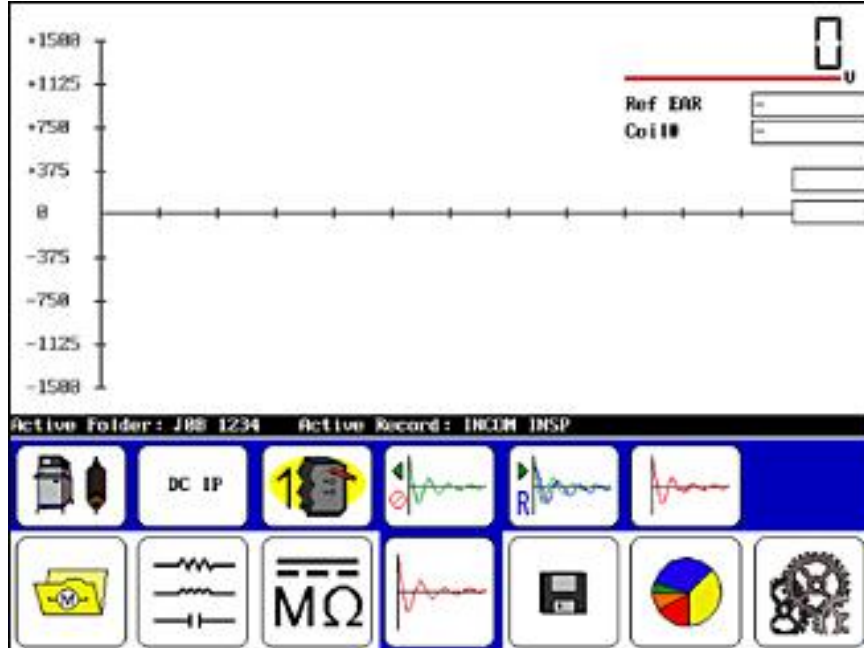


Figure 171. Coil test start screen.

2. Touch the **Surge** icon to bring up the submenu shown above.
3. Touch the **Configuration Options** icon, which then opens a popup menu showing if any options have been installed. Icons that appear

will allow operation as a standalone unit, with power packs, ZTX, or power pack with ZTX built in.

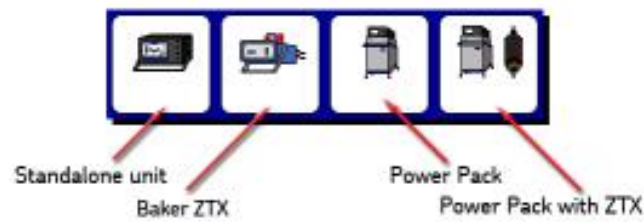


Figure 172. Configuration options popup menu.

4. If an interface board *is not* installed, a message dialog appears
5. Touch the **Power Pack with ZTX** icon to continue with this example.
6. The submenu will change to show that you are in single-coil mode.
7. Touch the **Single-coil mode** icon and the following popup menu appears.



Figure 173. Single-coil mode popup menu.

8. Touch the **DC IP** icon.
9. Touch the **Test Lead** icon in the surge submenu.
10. For the Baker 30 and Baker x85, ensure that the **Test Select** switch (upper right front panel) is set to **Ground**.
11. *On the power pack*, press and hold the footswitch and the **Waveform zoom popup menu** appears.

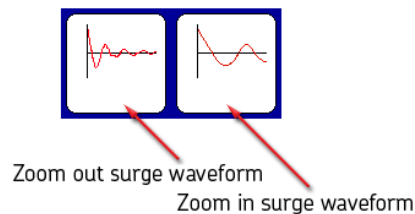


Figure 174. Waveform zoom popup menu.

12. Rotate the **Voltage Output Control** knob to set the test voltage. For this example, set the voltage to 870 volts (typically add 300 volts for each turn).

13. Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform.



CAUTION

To avoid damaging the unit under test or substantially reducing the switching element's useful life, do not change the Function selector switch out of Arm during the performance of any armature test.

14. Using a known good interpole, press the footswitch, to conduct a test on the first interpole, which will be used as a reference. You can also use the reference recall feature if you have a stored reference.



NOTE

Refer to “Determining a known-good coil to use as a reference” at the beginning of this chapter for more information on known good coil and using the reference recall feature.

15. When a stable waveform is obtained, set it as the reference by touching the **Reference** icon.
16. Connect the next interpole to the tester.
17. Press and briefly hold the power pack's footswitch to initiate the test.
18. When you release the footswitch, the new coil's waveform is compared to the reference waveform. A coil-to-coil error area ratio (EAR) will be calculated and displayed in the **EAR box** in the **Display Area**. The coil number will increment and displayed as well.
19. Connect a new coil and repeat the steps above. Continue the process until you have tested all coils.

20. Examples of coil waveforms collected during testing are shown below:

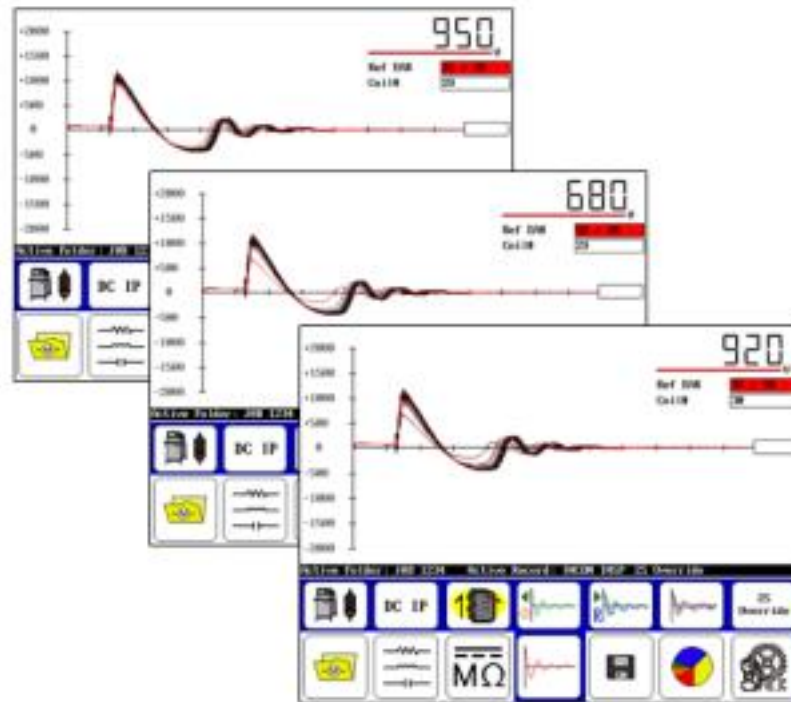


Figure 175. Example coil test waveforms collected and compared.

21. After completing the test, return the **Voltage Output Control** knob to **Min** (full counterclockwise rotation).



NOTICE

Shutting down the power pack prior to saving test data will result in the loss of all data.



WARNING

To prevent injury or death from electrical shock, always allow sufficient time for the test winding to completely discharge before disconnecting the test leads.

22. 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.

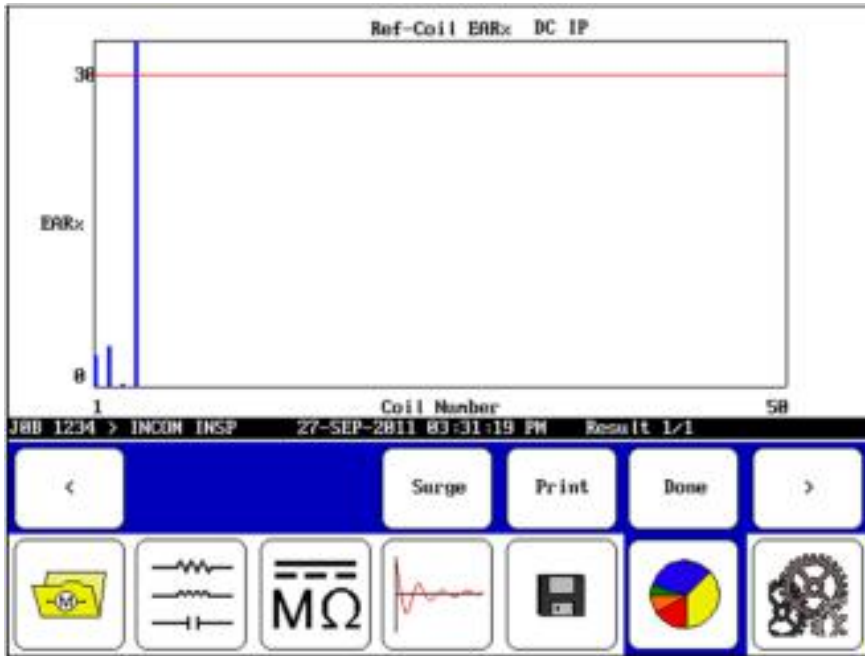


Figure 176. Simple example of a coil test results screen.

Armature tests using the Baker ZTX accessory

The Baker ZTX unit extends the capabilities of the DX host unit to enable low-impedance coil testing, such as found in DC armature and other coils.



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the setup procedure for the Baker ZTX accessory has been followed. Refer to chapter 8 “Setting up the Baker ZTX” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.



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 to prevent injury or death from electrical shock.

23. If it is not yet running, power up the Baker DX; the DX host powers the Baker ZTX accessory.
24. If a folder and record have not been created for the motor to be tested, do that now from the **Folders** icon and set up the intended folder/record, which should appear in the **Active Folder** and **Active Record** in the **Status Bar**.

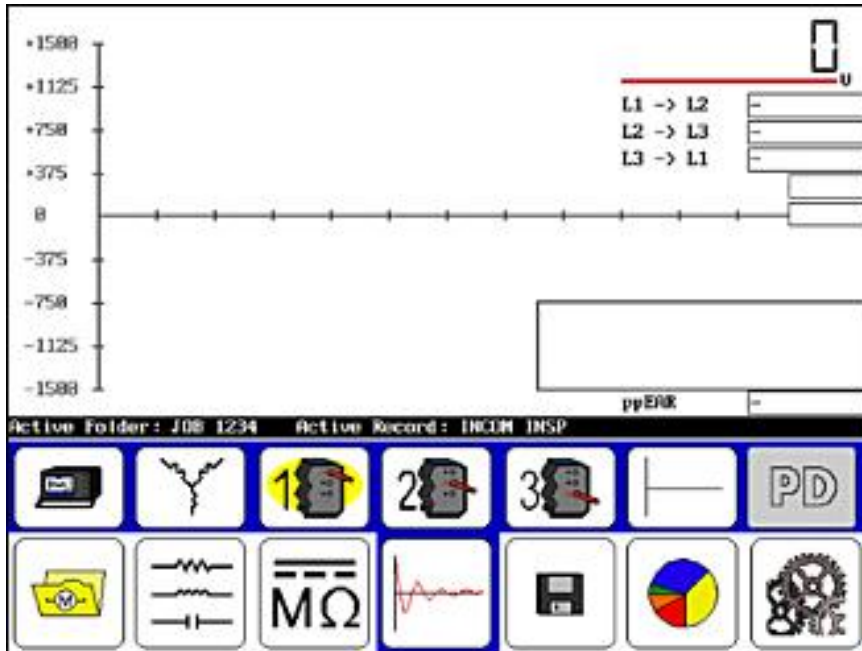


Figure 177. Armature test start screen.

25. Touch the **Surge** icon then the **Configuration Options** icon in the **Mode Submenu**. A new popup menu appears to show any installed options. The options can include standalone unit, Baker ZTX, power pack, or power pack with ZTX built in.

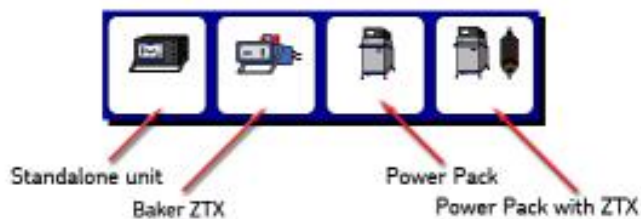


Figure 178. Configuration Options popup menu.

26. If an interface board *is not* installed, you will see a message dialog notifying you of that fact.
27. Touch the **Baker ZTX** icon for this example.
28. The submenu will change to show that you are in single-coil mode.

Touch the **Single-coil Mode** icon and the following popup menu appears.



Figure 179. Single-coil Mode Popup Menu.

29. Touch the **Arm Bar** icon.
30. Press and hold the footswitch and the **Ramp rate and waveform zoom** popup menu appears.

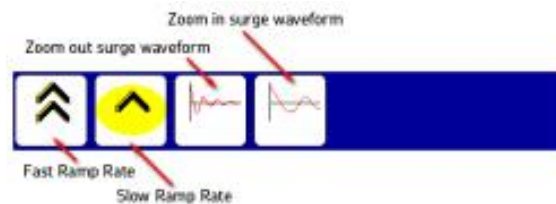


Figure 180. Ramp rate and waveform zoom popup menu.

31. Alternately use the **Fast/Slow Ramp Rate** icons to control the rate of voltage increase while rotating the **Voltage Output Control** knob to set the test voltage. For this example, set the voltage to 870 volts (typically add 300 volts for each turn).
32. Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform.
33. Press and hold the footswitch to test each commutator sample, selecting one for a starting point and as a reference.



NOTE

Refer to “Using the recall reference feature” at the beginning of this chapter for more information on this topic.

34. From a sample, select one to be the reference by selecting the **Reference icon** and then touch the **ZS Override** icon and touch **Yes** in response to the override message.



Figure 181. Override zero start message dialog.

35. Move the fixture to the next pair of bars, then press and hold the footswitch until you obtain a stable waveform.
36. Continue moving the fixture (or probes) for each pair of bars, then press and hold the footswitch to obtain stable waveforms.
37. Repeat the process until all bars have been tested.
38. Examples of armature bar span waveforms collected during testing are shown below:

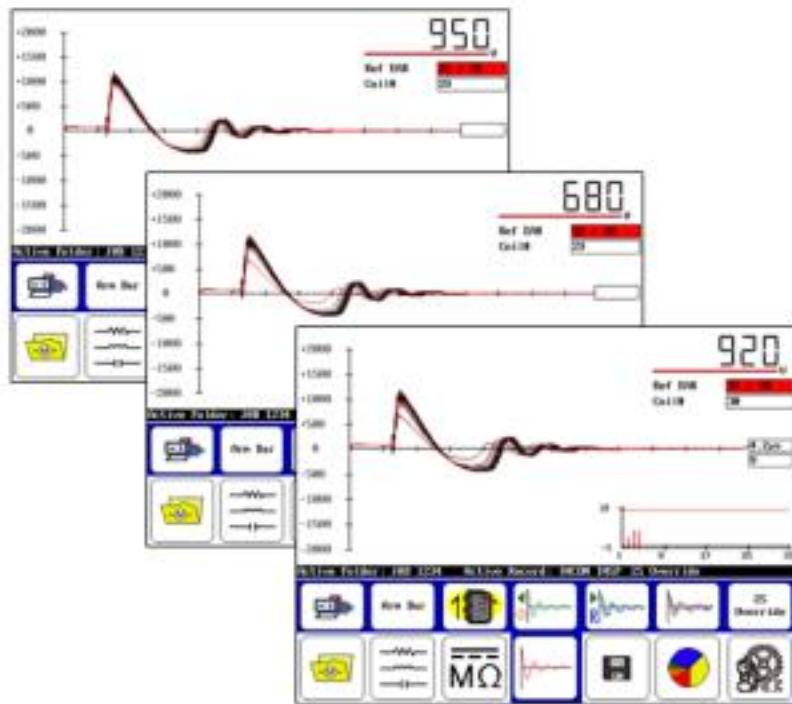


Figure 182. Example span waveforms collected and compared.



NOTICE

Shutting down the DX host prior to saving will result in the loss of all data from the previous unsaved test.

39. If desired, touch **Save** to store the test results in the **Active Folder/Active Record**. It will save as Arm data and it will appear on the results as such. Running the test continues adding armature coils up to 400, after which you must create a new record for armature with more commutator bars.
40. Touch the **Report** icon then the **Display** icon to view the commutator bar results as shown in the example below.

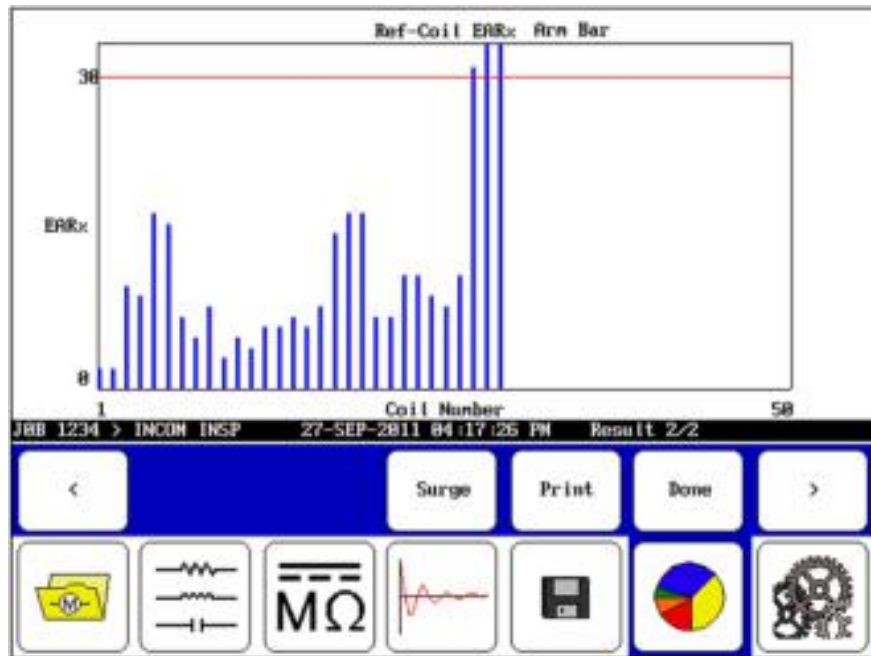


Figure 183. Armature test results screen.

In the simple example above, armature coils 28, 29, and 30 are out of limits.

Generic coil and DC IP tests using the Baker ZTX accessory

The Baker ZTX unit extends the capabilities of the Baker DX to enable low-impedance coil testing of the type found in DC armatures and other coils. The Baker DX as a standalone unit can perform DC FC (field coil) and span (armature coil, or arm span) testing. The arm span test is typically used as a substitute for not having the low-impedance capability of the Baker ZTX arm span test accessory.

The DX—in combination with the Baker ZTX unit—expands capabilities to test low-impedance generic, DC armature (arm span), and DC interpole (DC IP) coils.

The following procedure focuses on low-impedance DC IP and generic coil testing.



NOTICE

Review all safety information provided with the equipment and presented in chapter 2 “Safety and general operating information” before setting up or operating.

Confirm that the setup procedure for the Baker ZTX accessory has been followed. Refer to chapter 8 “Setting up the Baker ZTX” as needed.

Refer to chapter 9 “Setting up fixtures and test accessories” for information needed on this topic.

The open ground system on the Baker DX renders the unit inoperative if it detects an open ground.

1. If it is not already running, power up the DX host; the Baker ZTX is powered by the DX host
2. If a folder and record have not been created for the motor under test, do that now from the **Folders** icon and set up the target folder/record as the **Active Folder** and **Active Record** displayed in the **Status Bar**.

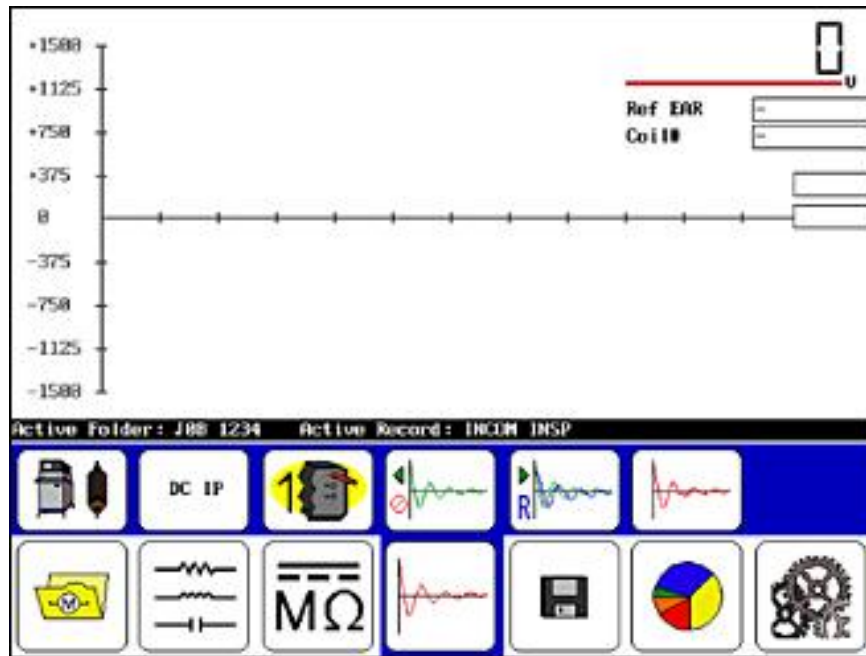


Figure 184. Coil test start screen.

3. Touch the **Surge** icon then the **Configuration Options** icon. A new Popup Menu appears to show any installed options. These options can be standalone unit, Baker ZTX, power pack, or power pack with ZTX built in.

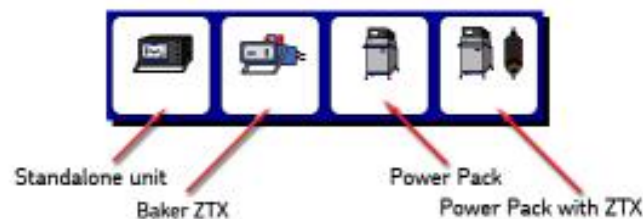


Figure 185. Configuration Options popup menu.

4. If an interface board *is not* installed, you will see a message dialog notifying you of that fact.
5. Touch the **Baker ZTX** icon to continue with this example.
6. The submenu will change to show that you are in single-coil mode.

7. Touch the **Single-coil Mode** icon and the following popup menu appears.



Figure 186. Single-coil Mode popup menu.

8. Touch the **DC IP** icon.
9. On the DX host, press and hold the **Start (PTT)** button (or footswitch) and the **Ramp rate and waveform zoom** popup menu appears.

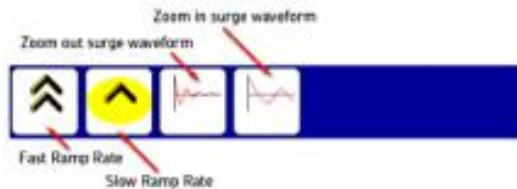


Figure 187. Ramp rate and waveform zoom popup menu.

10. Alternately use the **Fast/Slow Ramp Rate** icons to control the rate of voltage increase while rotating the **Voltage Output Control** knob to set the test voltage. For this example, set the voltage to 870 volts (typically add 300 volts for each turn).
11. Use the **Surge waveform zoom** icons to adjust the display scale of the surge waveform.
12. Using a known good coil, when you obtain a satisfactory waveform, touch the **Set Reference** icon and then touch the **ZS Override** icon.



NOTE

Refer to “Determining a known-good coil to use as a reference” at the beginning of this chapter for more information on known good coil and using the reference recall feature.

13. Touch **Yes** to the override message, which will appear in a dialog box like the one shown below.



Figure 188. Override zero start message dialog.

14. Test each subsequent interpole coil by connecting the clips to each coil and pressing and holding the **Start** button on the DX Host (or footswitch) for more than three seconds.
15. In the simple example below, you can see the test results for DC interpole coil #4.

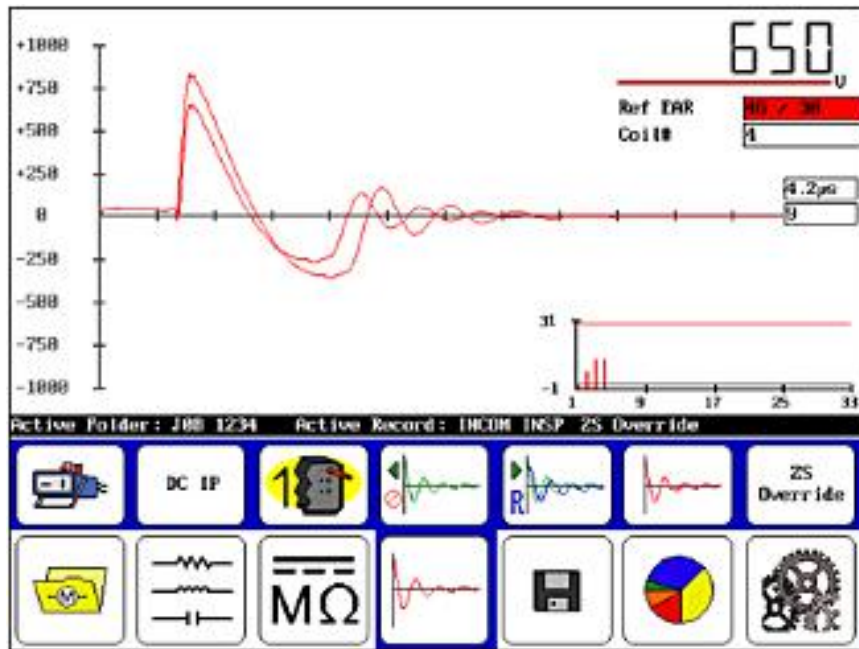


Figure 189. Coil test results screen.

NOTICE

If the DX host powers down prior to saving test data, it will result in the loss of all data.

16. If desired, **Save** the test results in the **Active Folder/Active Record**. It will save as **DC IP** test data and will appear on the results as such.

17. Touch the **Report** then **Display** icons to view coil results, which would be similar to the simple example shown below.

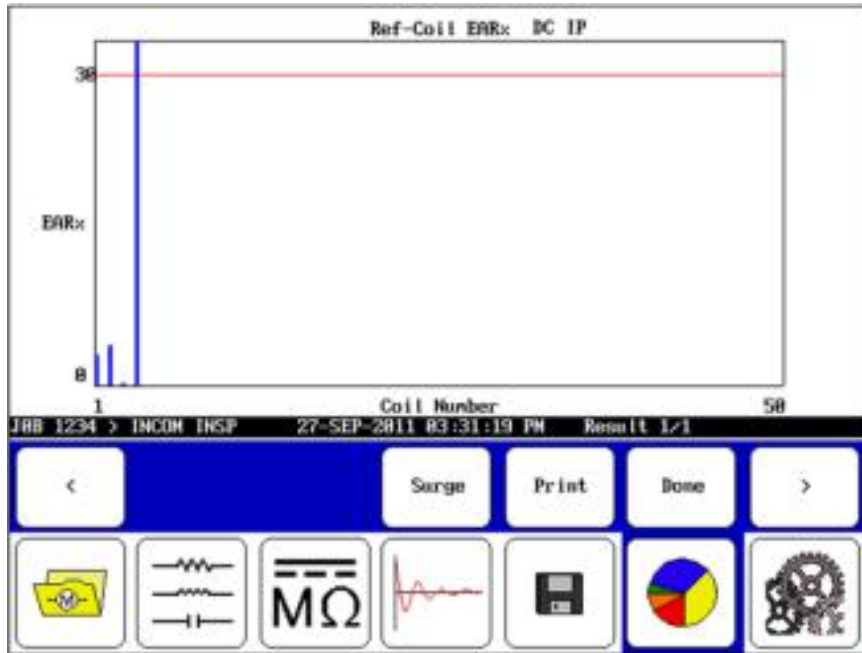


Figure 190. Coil test report screen.

As indicated by the results in this simple example, the DC interpole coil #4 is out of limits.

11

Coil resistance testing principles and theory

The coil resistance test is simple 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 wire conductivity associated with the winding'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).

Windings can be made with both copper and aluminum. The variation of resistivity to temperature is different for each material. Therefore, the wire material must be known before compensating resistance to 25°C/77°F.

Because 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 measuring 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 DX testers use this technique.

Resistance test display

A completed *RLC Test* screen is shown below for reference.



Figure 191. Completed RLC test screen.

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 other 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

12 Inductance, impedance, and phase angle measurement principles and theory

The windings in a motor form magnetic poles, which allow the motor to generate torque. For AC induction motors, the magnetic field from the stator windings interacts with the magnetic field of the squirrel cage rotor to generate a shaft torque. For DC motors, the interaction of the magnetic field from the stator field winding and the rotating armature winding also generates a shaft torque. Likewise, the interactions of the fields generated by the windings of a synchronous motor create shaft torque. The common agents in the different designs of these motors are windings—loops of wire that, along with a current, create a magnetic field.

Windings—loops of wire—have physical properties of inductance and resistance. Each specific coil or winding will have a characteristic inductance as well as resistance. Reason would suggest that a problem in a winding should show up as a change in inductance and resistance. Therefore, measurements of inductance and resistance are made to evaluate the winding's overall health; more specifically, to evaluate the winding's ability to create a magnetic field.

A short review of inductance and impedance in general is appropriate. In general, if a coil with N windings is excited with a voltage source V , there will be a current I drawn from the source.

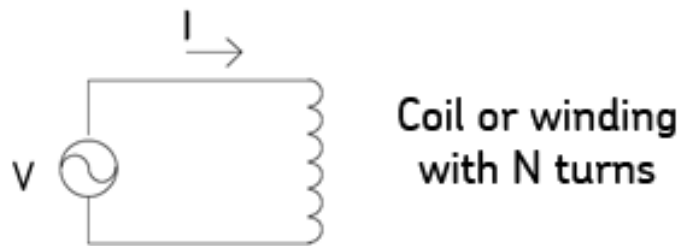


Figure 192. Basic coil winding schematic.

Just how much current flows through the coil, and the phase relationship between the voltage and the current depends on the resistance of the coil's wire, geometry of the coil, the number of coil turns, as well as the magnetic permeability of the material in the coil's vicinity.

A graphical representation of the voltage and current is shown below:

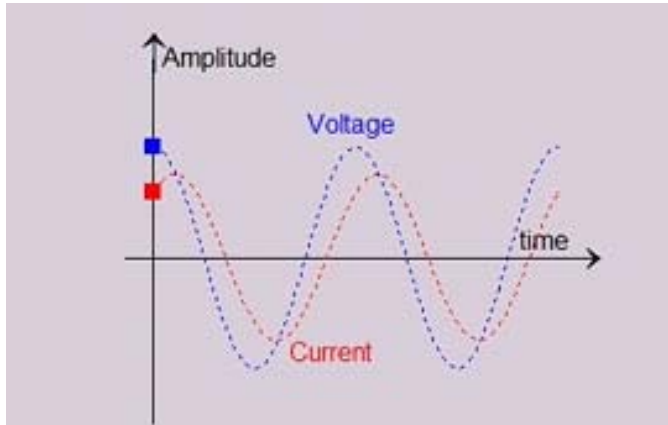


Figure 193. Representation of voltage and current over time.

Note the phase shift between the voltage and current. The ratio of the voltage and current amplitudes along with this phase shift are used to determine the coil's impedance.

The voltage and current are related by a “complex” impedance Z defined as:

$$Z = \frac{V}{I}$$

The impedance Z will have a component in phase with the voltage (called the real part) and a component (called the reactive part).

$$Z = R_{real} + jX_{reactive}$$

The real part of the impedance not only represents the component of current in-phase with the applied voltage, it represents the part of the coil's impedance that absorbs power. The reactive part of the impedance represents the ability of a coil to make a magnetic field. So, finally, the motivation for measuring a coil's impedance is clear: the ability of a coil to make a magnetic field, which is so important to the operation of a motor, is represented by the reactive component of the impedance of a coil.

Specifically, the measurement of inductance, which is proportional to the reactive impedance, is most often used when measuring a coil's inductive or magnetic properties. The reactive impedance (X) and inductance of a coil (L) are related as follows:

$$L = \frac{X_{reactive}}{2\pi f}$$

where f is the frequency of the source. By measuring the changes in the inductance L , changes in the coil's ability to make a magnetic field are determined. From a physical standpoint, the number of turns in a coil, the material properties surrounding the coil (that is, the motor core), and the shape of the coil all combine to determine the coil's inductance. The following equation shows how these parameters combine to determine a coil's inductance:

$$L = A_{\text{physical_geometry}} B_{\text{material_properties}} N^2$$

where the constant A describes the physical shape of the coil, the constant B describes the material properties of the coil's core, and N describes the number of turns in the coil. For example, a solenoid's inductance is found to be:

$$L = \mu_r \mu_0 N^2 \frac{A}{l}$$

where μ_0 is the magnetic permeability of air, μ_r is the relative permeability of the coil's core (approximately 1000 for electrical steels), N is the number of turns, A is the solenoid area, and l is the solenoid length.

There are other formulas for a coil's inductance, but the key thing to take away from these formulas is the contribution to the inductance value from the physical shape of the coil, the contribution to the inductance from materials properties, and the contribution to inductance by the number of turns (squared).

A motor's designer carefully chooses the shape and turn count of the coil along with the core material to generate the magnetic field required to produce the desired motor shaft torque. From a maintenance point of view, changes in inductance represent changes in turn count or changes in properties of the motor's core.

To summarize, a motor's inductance can be used to "measure" the ability of a motor to operate. In a perfect world, an inductance measurement would be a great way to precisely perform motor diagnostics. However, the world of a real motor is not as simple as our description might lead you to believe; we'll discuss more about the realities of inductance testing later.

Measuring a coil's inductance

To make a coil's inductance measurement, the voltage across the coil and the current through the coil are measured. However, just the amplitudes of the voltage and current are not sufficient to get coil inductance; the phase difference between the voltage and current is also required. Practically, a voltage amplitude measurement and the voltage phase with respect to some fixed phase reference are measured. Describing the voltage cosine of a certain amplitude and phase is shown in the following formula:

$$V(t) = V_0 \cos(\omega t + \alpha)$$

where V_0 is the nominal voltage, ω is the angular frequency, t is time, and α is the phase angle of the voltage with respect to a reference. For notational convenience, the voltage is often written in a vector notation as:

$$V = V_0 \angle \alpha$$

The current through the coil is described as:

$$I(t) = I_0 \cos(\omega t + \beta)$$

where I_0 is the nominal current, ω and t are as before for voltage, and β is the phase angle of the current with respect to the same reference as voltage. Again, for notational convenience, the current is written in vector notation as:

$$I = I_0 \angle \beta$$

This kind of vector notation is expressed as “voltage at an angle alpha” or “current at an angle beta.”

The impedance of a coil is completely described by the ratio of voltage and current along with the phase relationship between the two. The impedance is written as:

$$Z = \frac{V_0}{I_0} \angle (\alpha - \beta)$$

Using the notation above, a proper impedance or inductance measurement will require measuring the following four items:

$$V_0, \alpha, I_0, \beta$$

From these four parameters, the true AC impedance of a circuit is measured precisely as described in the equations above, which yields an accurate terminal inductance.

The effect of temperature on inductance measurements

Unlike DC coil resistance tests where the change of resistivity of the wire is well known, the change in inductance as temperature varies is not well known. The core material properties, which have such a strong effect on inductance measurements, are not well established in terms of how those properties change with temperature. To make the inductance measurement even more imprecise, the magnetic permeability of electrical steel also varies from one part of the lamination sheet to another part just due to the way the lamination sheet is fabricated. Therefore, there is no option to “temperature correct” inductance measurements.

Uses of the inductance measurements

Finding a hard turn-turn fault

The simplest application of inductance measurements is to determine if a winding has hard shorts. The idea is fairly simple: a serviceable winding will have a normal—or nominal— inductance related to the number of turns in the winding:

$$L \propto N^2$$

A winding with a short between two adjacent turns would have a decreased inductance of:

$$L \propto (N - 1)^2$$

For example, a stator made of form wound coils (eight turns per coil, five coils per group, and four groups per phase) has $8 \times 5 \times 4 = 160$ turns in a phase leg. With just one turn shorted, the phase leg would have 159 turns. The percentage change in inductance would be:

$$\Delta L = \frac{160^2 - 159^2}{160^2} 100 = 1.25\%$$

To identify a hard short, compare inductance readings that should be the same. For example, measure the phase to phase inductances of the three phases of an AC induction machine’s stator (without the rotor installed). If the stator is form wound, all three inductance readings will be very close to the same. If not, there is the possibility of a hard short in one of the windings.

From the example above, it is clear that the inductance measurement has to be very accurate. In practice, the inductance measurement is influenced by material properties of the core, the saturation state of the core, temperature effects, and so on. It's tough to declare a winding bad when inductance measurements are within a few percentage points of each other. If the stator is random wound, but of the lap winding type, the inductances should be close if the winding is short free. With a short present in the random wound winding, there can be a very large change in the inductances observed because of the possibility of the first and last turns being shorted. If the stator made of concentric coils, there will be a known inductance variation because the concentric windings are not all exactly the same shape. Unfortunately, the spread in inductance readings due to the slightly different coil lengths make it very difficult to declare a winding to have a short or not.

To summarize, inductance values can be used to determine hard shorts in some motor windings, but not all. Knowledge of the windings is important before passing judgment on a winding's integrity.

Example: the inductance of a GE 350HP 1750RPM 7kV stator with a short was measured at 60Hz and 1000Hz. The data is shown below:

Table 11. D3 #2 at 60Hz inductance.

	L	L (%)	D	Z	Phase
L1-L2	168.38	1.30063	0.994	63.79	84.32
L2-L3	170.57	0.184675	0.075	64.48	85.7
L3-L1	170.255	1.101289	0.0839	64.41	85.206

Table 12. D3 #2 at 1000Hz inductance.

	L	L (%)	D	Z	Phase
L1-L2	167.75	1.675112	0.0206	985.117	88.8
L2-L3	170.56	2.884615	0.009	1071.73	89.5
L3-L1	165.64	1.273847	0.0128	1040.86	89.26

The bar chart below shows the percentage “change” in inductance between phases of this wye-connected motor. Along with the inductance percentage values, the line-to-line error area ratio (EAR) surge test values for the same motor are also shown.

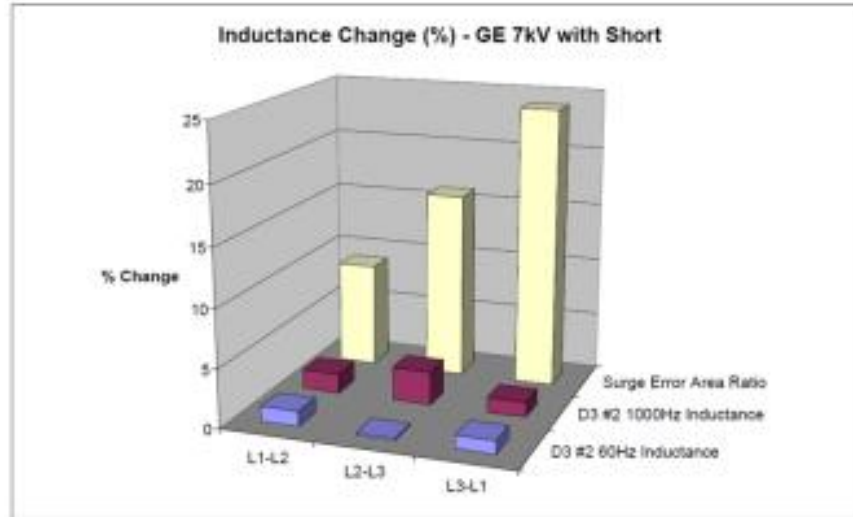


Figure 194. Percentage “change” in inductance between wye-connected motor phases.

Clearly, there is a change in inductance that is measurable for the stator with a short. The change shows up in inductance measurements at both 60Hz and 1000Hz. It is also clear from this chart that there is a much greater change in L-L EAR values of the stator with the surge test, making the surge test a much more sensitive method for finding turn shorts in windings.

Rotor Influence Check (RIC) testing theory

The theory of the RIC test is based in the fundamentals of an AC induction motor. AC induction motors are constructed with a stationary winding wound on the stator with a rotor containing a “squirrel cage.” The squirrel cage winding acts like a transformer secondary where a current will flow; but in this case, the secondary is allowed to rotate. The interaction of the magnetic fields caused by the squirrel cage current and the stator current creates a torque on the rotor that makes the rotor spin. The genius of this design is that the stator currents are the agent that—through the transformer effect—induces the currents in the squirrel cage.

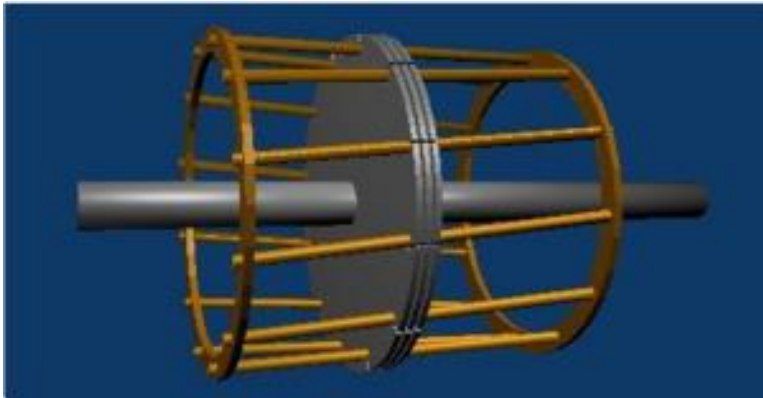


Figure 195. Squirrel Cage Illustration (from Wikipedia).

An AC induction motor is similar to a transformer, so a quick reminder of how a transformer works is in order. A normal transformer will behave such that the impedance of the secondary circuit will appear as impedance in the primary circuit. For example, if the secondary of a transformer is shorted, the primary will also appear to have a short. Likewise, if the secondary of the transformer is left open, the primary will also appear to be open. In general, if some resistance is placed in the secondary, a resistance will appear in the primary; but the value will be different than the actual secondary resistance value. (The primary resistance value is the ratio of the primary and secondary turns squared times the actual secondary resistance.)

$$R_{primary} = \left(\frac{N_1}{N_2}\right)^2 R_{secondary}$$

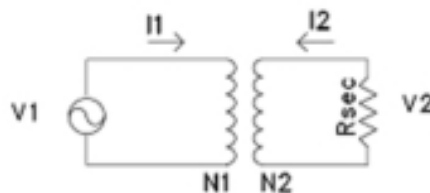


Figure 196. Basic transformer schematic.

Because the squirrel cage is a transformer secondary, it stands to reason that the impedance of the squirrel cage should “transfer” to the primary (stator) of the motor. Clearly, the squirrel cage looks like a short, so a short should also “appear” in the stator circuit. But if the secondary winding (rotor) is broken, no short will appear in the primary circuit. There are several “bars” in the squirrel cage, so if just one bar is broken, the stator impedance should look like “a little less of a short.”

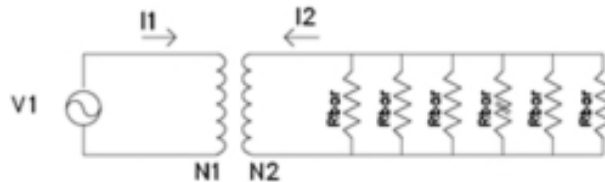


Figure 197. Transformer model of a rotor in an ACIM.

This small change in stator impedance is the concept behind using stator measurements to find problems in the rotor.

In addition to broken rotor bars, RIC testing advocates claim that other issues with the rotor promoted can be identified. If the rotor is placed in the stator bore so that the rotor is not centered, there will be a difference in “transformed” impedance observed at the stator leads for each of the three phases. Also, if the rotor “wobbles” inside the stator bore, then a difference in stator impedance will also be observed.

In summary, the RIC test is reportedly able to find three rotor problems:

- ↳ Static air gap eccentricity
- ↳ Broken rotor bars
- ↳ Dynamic air gap eccentricity

To actually perform a RIC test, inductance measurements at the stator terminals are made in shaft angle increments of 5 or 10 degrees. The resulting inductance measurements are then plotted: inductance on the Y axis and shaft angle on the X axis. A typical plot is shown below:

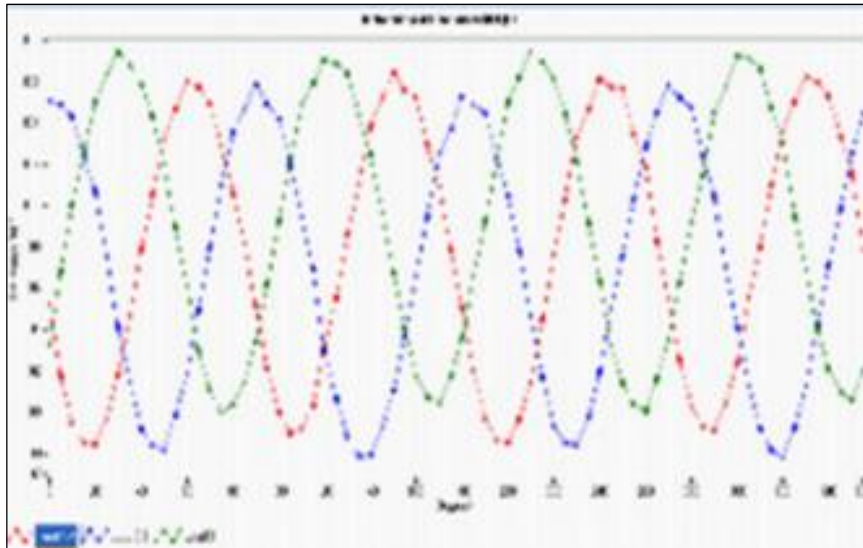


Figure 198. Typical RIC test curves.

A plot of a motor with a broken bar is shown below. Note how the plot of inductance vs. rotor position is erratic and not as uniform as the plot above.

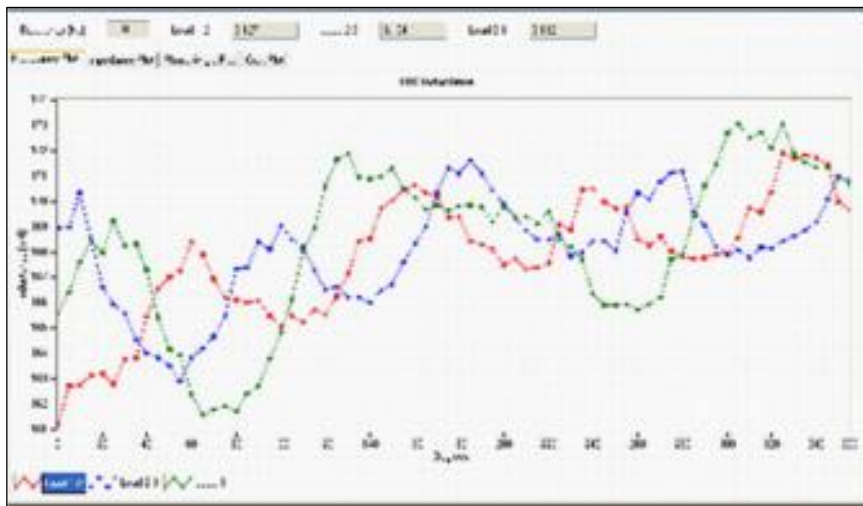


Figure 199. Dayton 5hp (B2) with drilled bar: inductance measurements.

There are problems with RIC testing. Namely, the test is quite unreliable and either misses rotor issues or declares there is a problem where there really isn't one. For example, the RIC test curves shown below are from a motor with a bar drilled in several places as shown in the photo that follows the graph.

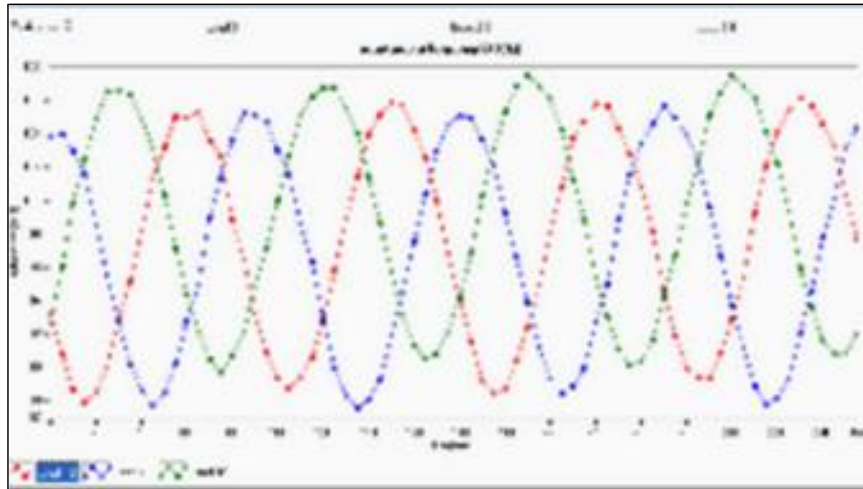


Figure 200. Delco 3hp after running under full load. Curves do not suggest a broken rotor bar.



Figure 201. Delco 3hp showing rotor bars drilled completely through

Great care must be taken before using the RIC test to condemn a motor. The load of the motor at last shutdown, eccentricity, and steel material properties all influence the RIC test, so much so that reliable rotor bar detection is difficult.

DC motor armature bar-to-bar resistance and impedance test

The DC resistance and the AC impedance of adjacent bars of a DC motor's armature can identify shorted turns within the armature winding. However, armatures are very unique windings in the sense that every bar on the commutator is in parallel with all the other bars. Because the bars are all in parallel, the DC bar-to-bar resistance will be very low, milliohms or even smaller. Likewise, the bar-to-bar inductance will be very low: microhenries or smaller.

Due to the low DC resistance and low inductance observed, a four-wire measurement is required when making bar-to-bar measurements. If a simple two-wire measurement is made, there will be great errors in the data—with the errors of many 100s of percent possible.

The indications of a shorted coil in the armature are a drop in the DC resistance between the adjacent bars, and a drop in the inductance between the bars. An example of just such a short is provided below. Two bar charts are shown of the bar-to-bar resistance and inductance. Note how the bar-to-bar resistance goes to zero when testing the bars with the shorted coil. Also, the inductance value drops to zero. In general, the resistance/inductance vs. bar number plots will have some variation, as shown below. However, bars with shorted coils will be obvious.

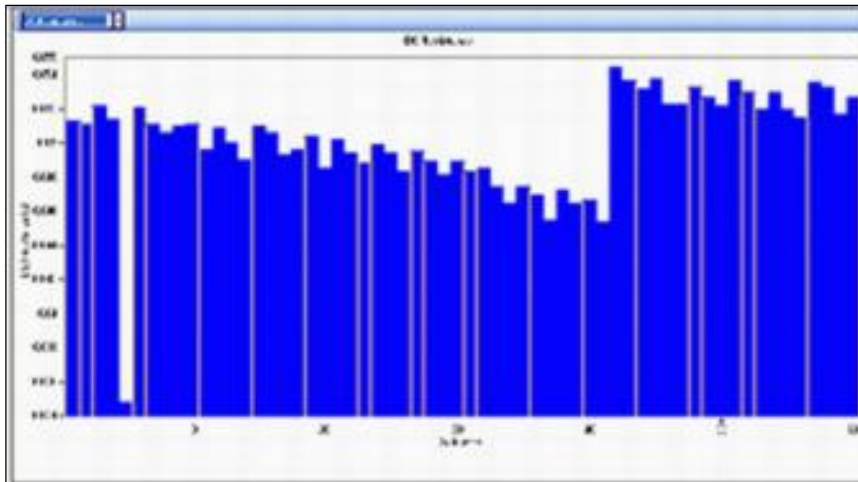


Figure 202. Graph of resistance and inductance done on a PC.

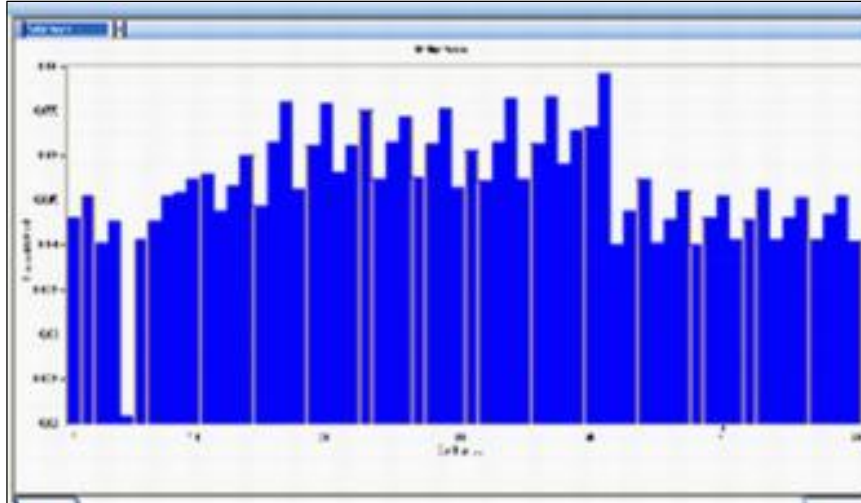


Figure 203. Graph of resistance and inductance done on a PC.

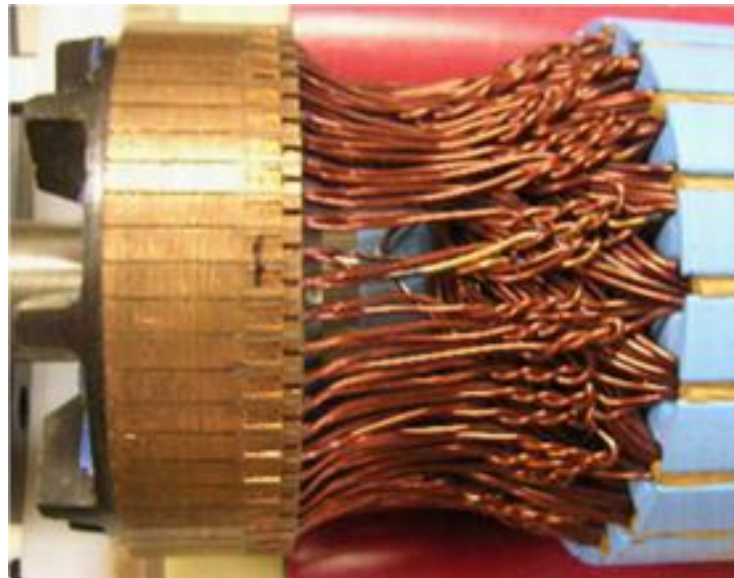


Figure 204. Example of a burned coil.

DC motor interpole coil testing

Like any other winding, the resistance and inductance of interpoles (from DC motors) can be used to look for the presence of shorts in the coils. Normally, there are two, four, or six interpoles in a DC motor. The general idea is that all interpole coils should have nearly the same resistance and inductance values.

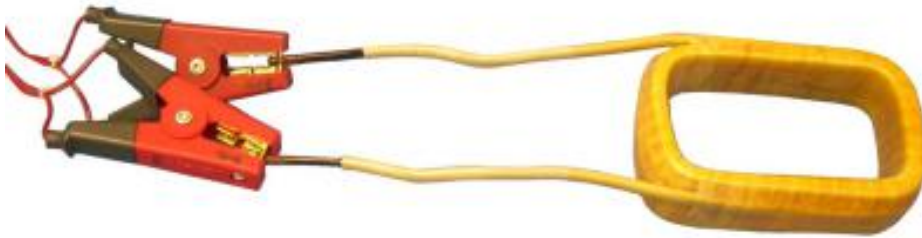


Figure 205. Interpole coil.



NOTICE

Often, the interpoles are removed from the stator during a DC motor refurbishment. The interpoles are placed on a cart or work surface where they are also refurbished. When making the inductance measurement, the environment of the coil has a significant effect on the inductance value. All of the coils should be placed in the same place on a work surface that has no steel in the area. Even a brad or nail in a wooden shop bench top can change the inductance value of a coil.

The test results below show resistance and inductance data from four identical interpoles.

Table 13. Test results from four identical interpoles.

Interpole	DC Resistance (milliohms)	Inductance (microhenries)
1	8.214	69.2
2	8.214	88
3	8.218	77.4
4	8.218	69.3

The resistance measurements show that all four coils are basically the same. However, the inductance values show some variability, which suggests a problem with the coils. In this case, the variability was caused by tools located near the coils and steel support legs supporting the wooden workbench top. If proper measurements are made, a change in inductance will follow a change in the DC resistance; confirming a real short in a coil.



NOTICE

If the interpoles are left mounted in the stator and inductance measurements are made of each individual coil, L value differences caused by variations in the stator steel can be observed. Before condemning a particular coil, ensure that you are confident in the integrity of the measurements.

13 DC testing principles and theory

High-voltage DC testing of electric motors determines the integrity of the ground wall insulation system of a motor's winding. The ground wall insulation system consists of the wire's insulation, slot liner insulation, wedges, and varnish.

The Baker DX performs three types of DC tests: insulation resistance (megohm) tests, high potential (HiPot) tests, and polarization index (PI) tests. Each test type answers a specific question regarding the properties or integrity of the ground wall insulation system. The tester can also perform a stepped HiPot test. A brief discussion of each test follows.

Before going further, we need to discuss the meaning of a "HiPot test." The label "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 high-voltage DC tests 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 voltage on the red test leads raises to a predetermined test voltage. 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.

DC tests display

A completed DC tests results screen is presented below for reference.

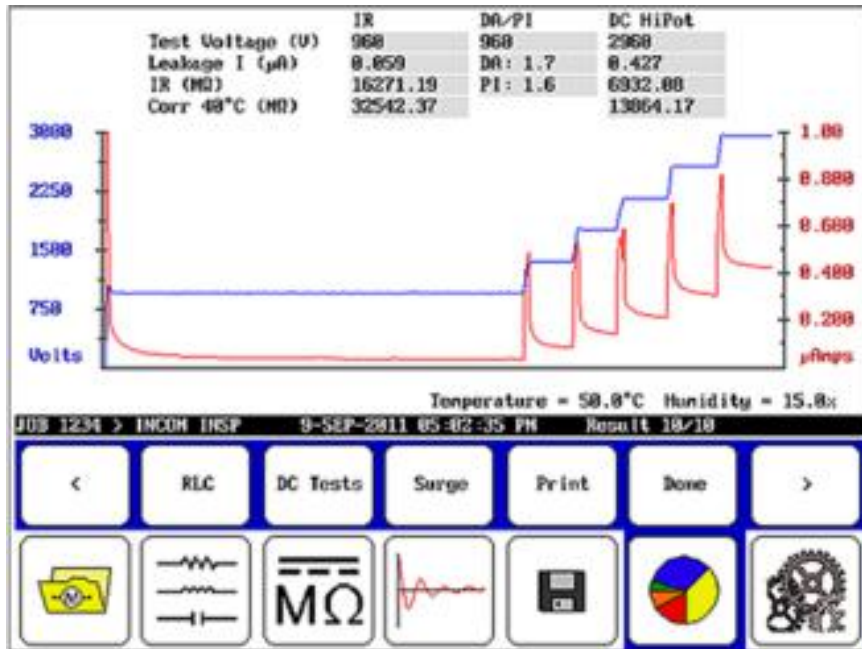


Figure 206. Completed DC test results screen.

Megohm test

The *megohm test* applies a DC voltage to the windings of a motor after first isolating the winding from ground. The relay matrix in the DX tester makes all test lead connections. Usually, you choose the test voltage to be at or near the motor's operating voltage (see IEEE 43). You can find recommended test voltages in "Appendix D—DC and surge tests voltages."

The purpose of the megohm test is to accurately measure the insulation resistance of the ground wall insulation. The insulation resistance (IR) is a function of many variables: the physical properties of the insulating material, temperature, humidity, contaminants, and so on.

We calculate the IR value using Ohm's law, dividing the applied voltage by the measured leakage current:

$$IR = \frac{\text{Applied voltage}}{\text{Measured leakage current}}$$

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 that 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 winding might need to be cleaned or heated to evaporate any moisture on its surface.

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, and so on. 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, and so on.

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 $480 \text{ V} \times 1.7 = 816 \text{ V DC}$. You can also find recommended test voltages in IEEE 43-2000, NEMA MG-1-1993, and EASA technical manuals "Appendix D—DC and surge tests voltages." Test voltages near the line-to-line operating voltages are often used. For example, 480 V class motors would use 500 V; 2300 V class motors would use 2300–2500 V; 4160 V class motors would use 4000–5000 V.

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."

Polarization index (PI) test quantitatively

The *polarization index* (PI) test quantitatively measures the ability of the ground wall insulation to polarize. The PI test is the most confusing DC test due to the subtleties involved in interpreting its 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," (or "absorption current") develops, adding 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. It takes 10 minutes to complete.

We calculate the PI value by dividing the IR at 10 minutes by the resistance at one minute, as shown below:

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

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:

Table 14. IEEE 43 Minimum acceptable values for thermal classes.

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



NOTE

Always consult any standard’s most recent edition (IEEE 43 in this case) for the latest minimum values and accepted practices.

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 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:

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

For example, if 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, you 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.

Dielectric absorption (DA) test

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 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, and the DA value often appears to be subject to trends.



NOTE

Other times are used for DA testing, so you should always consult any standard's most recent edition (IEEE 43 in this case) for the latest values and accepted practices.

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.

High potential (HiPot) 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

applies a DC voltage to the machine's windings as in a megohm test, but at a higher voltage—usually more than twice the voltage of the motor'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 much interest with the HiPot test. What is of interest is the value of the leakage current and, more specifically, whether 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—DC and surge tests voltages”).

The HiPot test usually lasts one minute with the leakage current recorded at the end. 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, you 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.

14 Surge testing principles and theory

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 applies a high-current impulse to a winding using a fast rise time, which 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 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.

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 be presented on a test display screen as shown below.

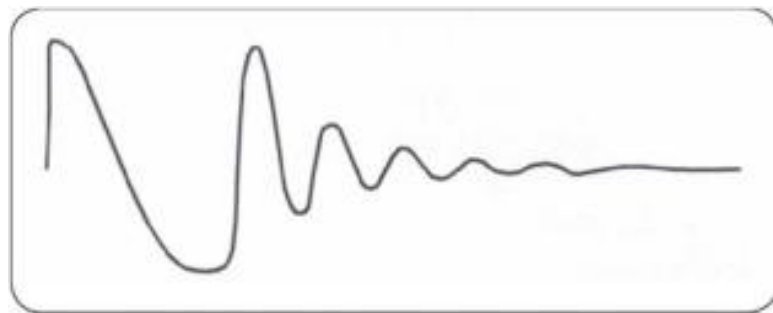


Figure 207. Ringing wave pattern resulting from surge testing.

The wave pattern observed during a surge test directly relates to the coil's inductance. (Other factors can influence the wave pattern, but inductance is the primary.) The coil becomes one of two elements in what is known as a "tank circuit," which is an 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:

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

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

A surge test can detect a fault between turns 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.

Surge test display

A complete surge test screen is provided below for reference.

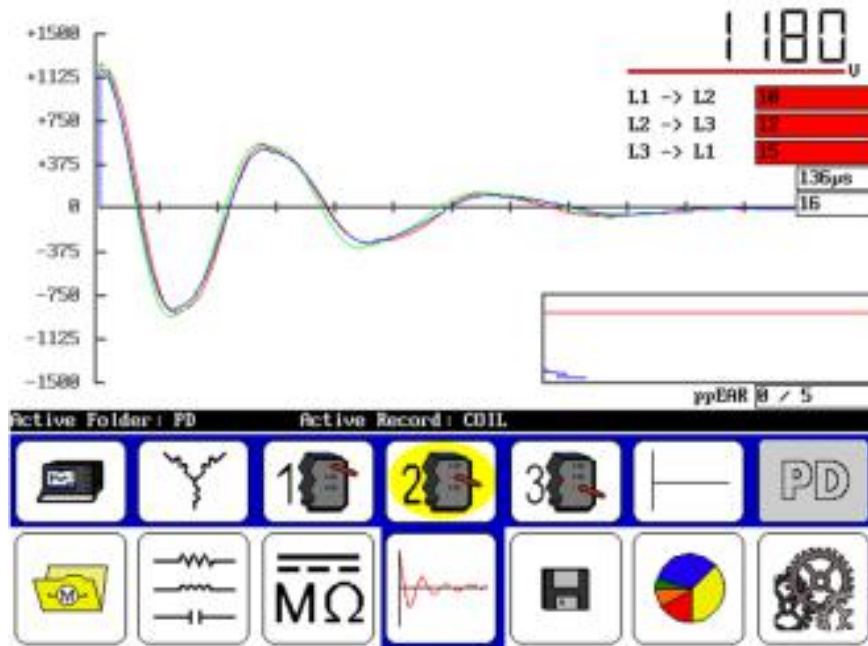


Figure 208. Completed surge test screen.



NOTE

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 “Determining a fault” section below for explanations of wave patterns indicating good or faulty windings. For determination of wave patterns for a variety of devices, refer to chapter 15 “Surge testing 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.

Determining 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.

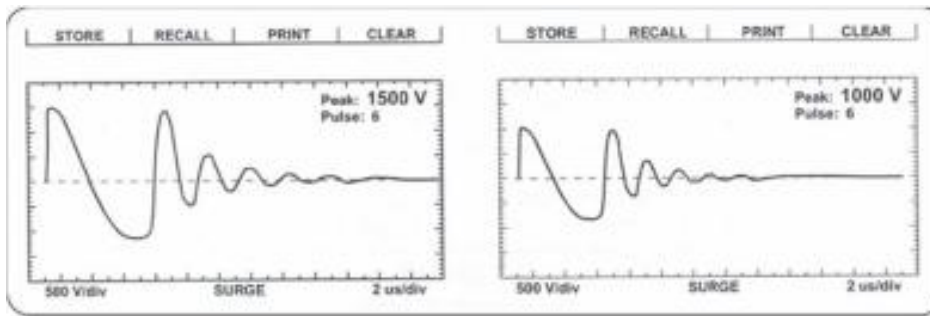


Figure 209. Good coil waveform (left) vs. bad (right).

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 by this arcing for reference if you can release the test or freeze the wave pattern at the moment when the wave pattern appears most affected by the fault (for example, reduced amplitude and increased frequency or shift to the left).



NOTE

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.

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.

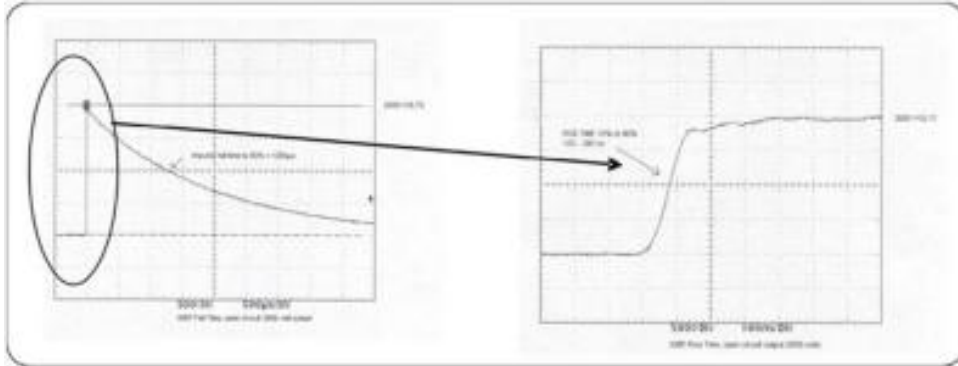


Figure 210. IGBT fall and rise times.

Partial discharge detection

Partial Discharge (PD) is a well-known phenomenon in the operation of motors as a predictive feature of insulation condition monitoring. PD is a localized, partial bridging between conductors due to dielectric breakdown caused by high-voltage stress that does not fully short the two conductors. These discharges, when severe enough, can create a persistent visible glow known as corona, while less severe breakdowns can cause smaller invisible partial discharges. These smaller discharges are of concern in high-voltage motors and low-voltage motors being driven by variable frequency inverters due to start-up transients and the tendency of these inverters to create large over voltages during switching that stress the insulation between coil windings.

PD causes

PD can occur in multiple locations such as gas-filled voids within the insulation, on the surface of the insulation due to contamination or tracking, and between the ground wall and the coil windings. Voids can be caused by improper impregnation of the coil insulation, surface contamination, or can occur over time as persistent high-voltage stresses break down the insulating material.

Due to the high-voltage differentials occurring across these areas, the gas/material can ionize and arc, further stressing the insulation and causing greater damage; the ultimate result is complete coil bridging, leading to motor failure. Discharges between the ground wall and the coil windings can occur due to poor coil lamination or an external cause such as contamination that weakens the dielectric properties between the coil and ground wall.

PD detection

When PD occurs in a coil, the discharged electric potential radiates high-frequency EM waves both into the atmosphere and on the reflected voltage waveform in the surge detector. These waves can then be received and extracted from the primary voltage waveform to deduce the presence of discharges along the windings. Many methods for receiving this information exist, including RF, acoustic, high-frequency current transformers (HFCTs), and voltage division and filtering.

In the Baker DX, a resistive divider attenuates the high-voltage signal to a low level for digitization; then the high-frequency components are filtered out to isolate the PD activity on the device under test.

A PD event is a detected voltage level that exceeds a specified voltage level (PD event threshold, defined in mV). When PD events detected exceed a specified number of events, a PD pulse is said to occur.

PD detection schemes rely on IEC-61934 to provide standards for the detection and communication of partial discharge severity. The schemes use four key measurements:

- ↳ **Partial Discharge Inception Voltage (PDIV)**
- ↳ **Repetitive Partial Discharge Inception Voltage (RPDIV)**
- ↳ **Repetitive Partial Discharge Extinction Voltage (RPDEV)**
- ↳ **Partial Discharge Extinction Voltage (PDEV)**

Other metrics that provide useful information on the intensity and severity of the discharges include the number of events or discharges per surge pulse, and the amplitude of the discharges occurring.

PD terminology

PD signal—a signal rising out of the high frequency information extracted from the surge waveform.

PD event—when a PD signal crosses the voltage threshold (PD threshold set in *User Settings* screen; defined in mV).

PD pulse—when PD events detected exceeds number of events value (PD # events set in *User Settings* screen).

Summarized PD detection process

The software counts the number of PD events within each surge pulse. When PD events detected exceeds the number of events value, a PD pulse is said to occur.

The first time the software detects a PD pulse is when the software records the current surge voltage level as PDIV.

At the point where more than 50% of the surge pulses have a PD pulse, the software records the current surge voltage level as RPDIV.

At the point where less than 50% of the surge pulses have a PD pulse, the software records the current surge voltage level as RPDEV.

As the voltage continues to ramp down, the software continually records the current surge voltage level at which a PD pulse is detected. The last recorded value is “saved” as the PDEV (the lowest voltage at which the detector sees a PD pulse).

PD is typically seen within the first peak of the surge pulse, but may also be seen within the second peak if the PD events exceed the PDIV value.

15 Surge testing applications

Maintenance testing

You will rarely find solid turn-to-turn (hard-short) winding faults in motors during maintenance testing. This condition is usually only found after the motor has failed.

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 that occurs within the windings, which induces very high current in the shorted coils.

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 time to failure is seconds to minutes. When the ground wall insulation is damaged to the point that line current flows to ground, the ground current circuit breaker will trip and stop the motor.

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 found later in this chapter). In this case, a consistent double wave pattern displays at all voltage levels.

The key to maintenance testing 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 460VAC motor. The peak voltage with respect to ground is:

$$V_{Peak} = V_{rms} + \sqrt{2}/\sqrt{3}$$

This 391volts is the highest voltage any turn in the winding can see with respect to ground. During normal operation, the motor will be in an environment where transients as high as $4 \times 391V = 1564V$ exist. These transients are due to contactors opening and closing, other components on the bus being energized/de-energized, lightning strikes, and so on. Now suppose that 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

normal electrical environment the motor experiences will continuously stress the fault.

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 standards references (IEEE, IEC, EASA, and so on) that explain the reasons for these recommendations.

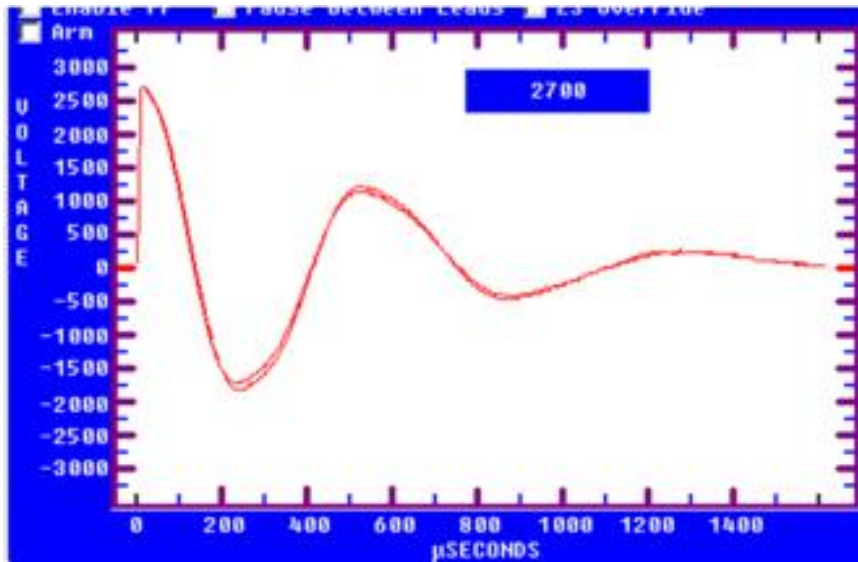


Figure 211. Comparing waveform separation acquired during test.

An arcing turn-turn is present in the stator by noting the separation in the two waveforms. Although there is very little difference between the waveforms, the real time data analysis performed by modern surge testing equipment can automatically catch such small shifts.

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.



NOTE

The DX will not allow an open lead test to continue. A message similar to the one shown below will appear.

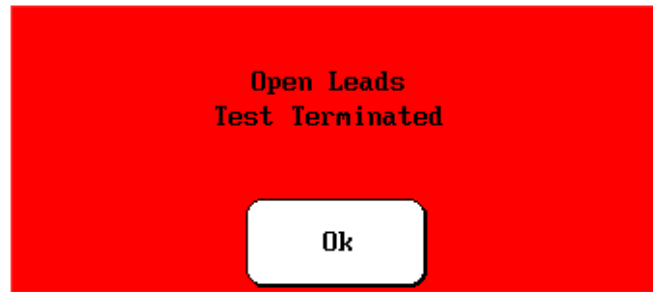


Figure 212. Open leads message dialog.

Single-phase motors and two-terminal devices

1. Connect test lead No. 1 to one side of the device.
2. Connect test lead 2 to the opposite side of the two-terminal device.
3. Connect the ground lead and test lead G of the tester to the frame or metal core material.
4. Run a surge test on lead 1 and watch for the left shift.
5. Run a test on leads two and again watch for the left shift.

Determining 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:

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

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 you 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.

Determining 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.
- ❏ 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 test voltage of:

$$\text{Test voltage} = \text{Number of turns} \times 500 \text{ V}$$

Refer to the “Recommended test voltages” section in Appendix C — for recommended surge test voltages.

Three-phase motors

Wave patterns for three-phase windings are all compared to each other. The DX storage capabilities allow the comparison of all three phases. We recommend the following procedure:

1. Connect test lead No. 1 to phase A terminal.
2. Connect test lead No. 2 to phase B terminal.
3. Connect test lead No. 3 to phase C terminal.
4. Connect the BLK G lead to the frame or core of the winding.
5. Begin with test lead No. 1. This indicates the test lead will be hot while leads No. 2 and No. 3 provide a ground path for the surge impulse.
6. Perform the test as described in the “Surge tests using the DX host” section in chapter 10 “Test procedures.”

For each test, check the display for a wave pattern. 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.

Determining 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 you 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).

The DX testers have the ability to detect changes in shape of the waveforms using the Pulse to Pulse EAR feature. The ppEAR will compare successive pulses to each other as the test proceeds. If there is a change in amplitude or shift in frequency, the ppEAR number will jump up.

In the repair shop: Separation of compared wave patterns on form-wound (without rotor installed) stators indicates a hard fault, such as a solid turn-to-turn or group-to-group short, an incorrect turns count, or misconnections.

Separation of waveforms for random-wound or concentric-wound windings is to be expected—even for good windings. Random wound motors with concentric windings will always show a shift that is due to the slightly different coil sizes for each of the winding’s phases. Excessive separation indicates a winding failure in these types of windings.

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 found 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 the ground test lead G to the other side.
2. Surge test the first coil and store the results in memory.
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.

For procedural details, refer to the “Single-coil testing” section in chapter 10 “Test procedures.”

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 field 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 375 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 375 V per turn. Because of the sometimes non-linear distribution of the surge pulse, it is recommended to use a minimum surge potential of 500 V per turn 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.

- ↳ 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 follow:

1. Remove the brushes touching the slip rings.
2. Short together the slip rings with jumpers. The jumpers limit the induced voltage on the rotor windings caused by the currents induced when testing the stator.
3. Perform a surge test on the stator as would be done on a three-phase induction motor. Refer to the "Surge tests using the DX host" section in chapter 10 "Test procedures" for more information.



NOTE

Because 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. Again, the stator is shorted to limit the induced voltage on the stator windings caused by currents induced when testing the rotor.
6. Perform a surge test on the rotor as if it were a stator. Choose the test voltage for the rotor carefully.



NOTE

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

Determining 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 you 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, remove the DC leads to the brush boxes or lift all of the brushes off of the slip rings.
2. Short the slip rings for the rotating fields together.
3. Perform a surge test on the stator following the procedure for three-phase motors.
4. Individual poles are surge tested as outlined in the procedures for testing single-phase motors and two-terminal devices. An example test voltage is 600 V per pole, but for your purposes you should check with the manufacturer for the proper test voltage or carefully evaluate the insulation system's dielectric strength and choose an appropriate test voltage. It is not necessary to disconnect the pole piece leads before testing.

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



NOTE

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 similar to that of two or more single coils.

Determining faults

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.



NOTE

The turn insulation on pole windings can be very thin. Take care not to overstress the insulation with too high of a test voltage. Also, the windings might compress as the rotor spins during operation, which can short adjacent turns. Unfortunately, simulating centrifugal forces is not possible when surge testing.

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. Separation of waveforms indicates either hard shorts or unequal rotor coupling for the different stator phase windings.

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 for DC motors

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. However, an evaluation of the dielectric strength of the turn insulation is required choose an appropriate test voltage.

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. On a disassembled motor, the armature can be tested with appropriately insulated HV probes. 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”).

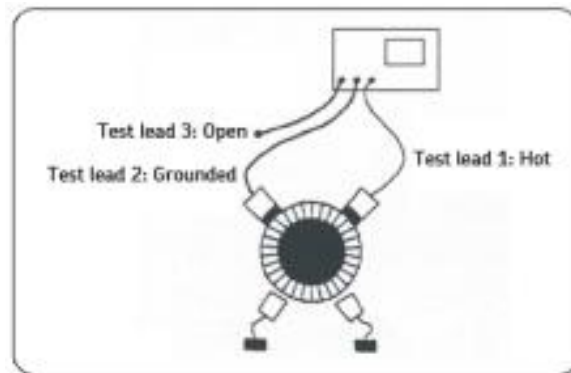


Figure 213. Span test setup.

Determining faults

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. On the left, we see the results of a good surge result, while on the right we see the results for a fault grounded under the brush or outside of surge test span.

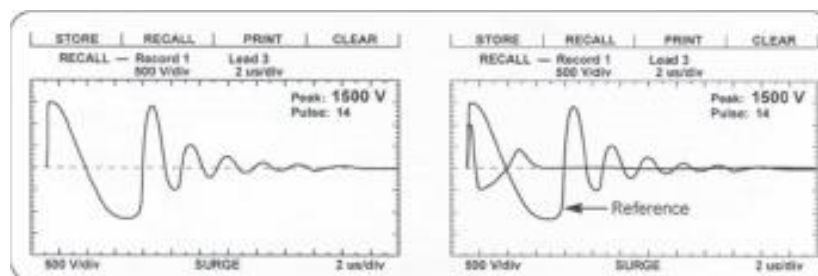


Figure 214. Comparing good (left) and short results (right).

Usually, as soon as the bad bar is placed under the hot brush or probe, the wave pattern will show the shift as noted above. Given the very parallel nature of armatures, the waveforms will start changing (with respect to the reference) as soon as testing gets close to the shorted bar. Over the short, the waveform shift will be the greatest. When the ground brush or probe is over the short, there will still be a shift, but not as great as when the hot brush/probe is over the short.

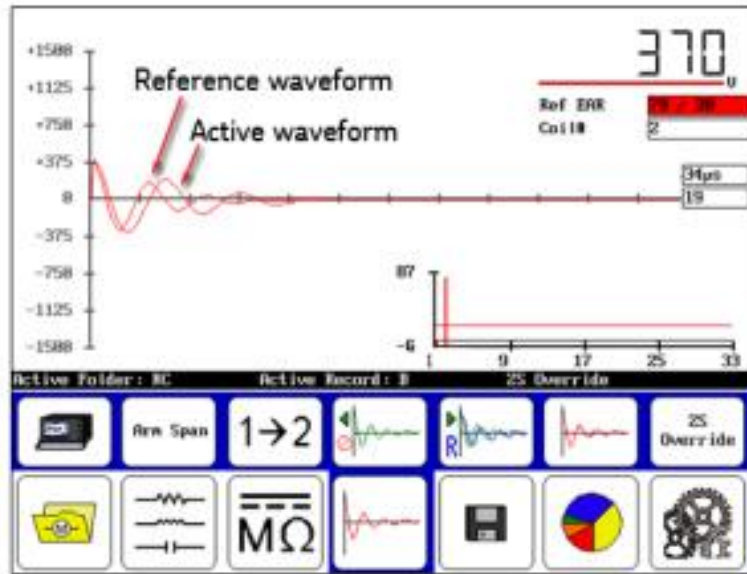


Figure 215. Test results showing a short.

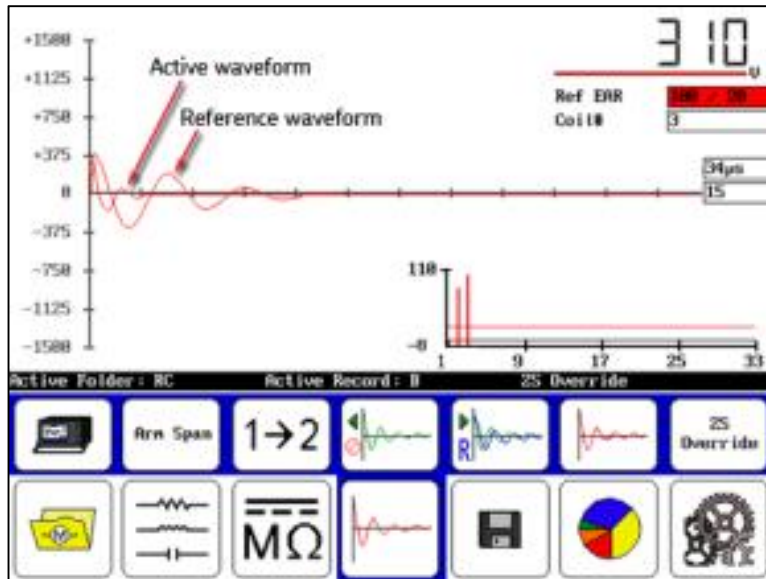


Figure 216. Span Test: Hot probe over bar with short.

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, 375 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 five bars, 1,000 V applied to the span will result in 200 V between bars.
- ↳ Consider, however, that a ten-bar span at 375 V between bars would require a span test voltage of 3750 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.

Testing large AC stators/motors

Large AC motors are tested the same way as small AC motors. The connections and grounding are the same and the waveforms look like good ringing patterns. However, there are a few items to be aware of. First, some large AC motors have a very high inductance, which means they ring with a very low frequency. For manually controlled instruments, be sure to zoom out to see the full ringing pattern.

Second, some large motors will exhibit extra features at the beginning of the waveform. These features can be caused by reflections of the surge pulse inside the motor, corona or partial discharge in the windings, or reflections on feeder cables (if testing from the switch gear). The screen capture below shows an example:

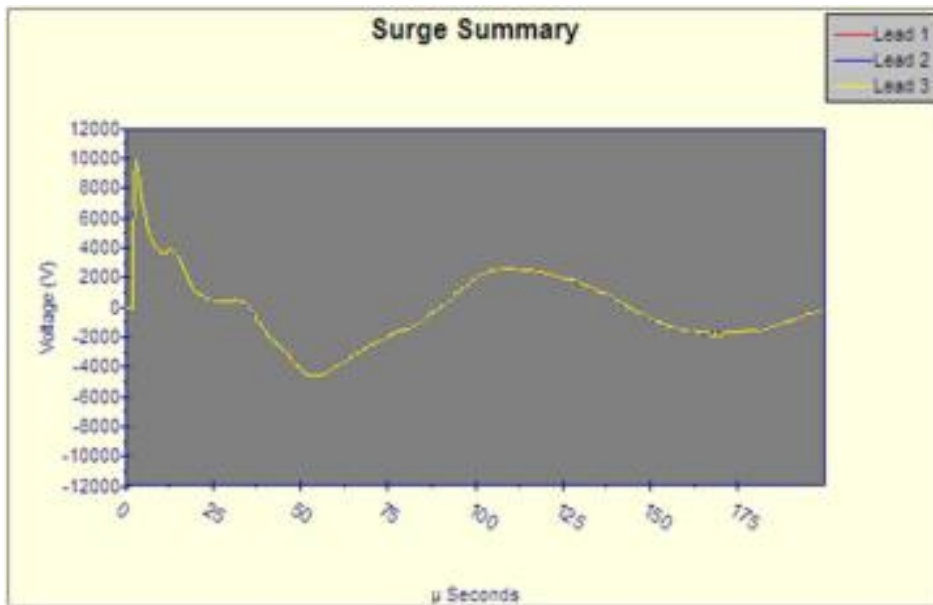


Figure 217. Surge waveforms for a 6600V, 8500HP, 8 pole motor.

Note, the small features in the first positive cycle, which in this case are caused by the surge waveform bouncing off the grounded end of the motor and returning to the tester (example source: 6600V, 8500HP, 8-pole motor).

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 turns are present. The inductance change caused by these faults is often not detectable. Instances have been noted where an end-turn of a winding is blown, 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.

- ↳ Perform the surge test on each of the parallel windings individually for the highest degree of fault sensitivity.
- ↳ For the highest surge test sensitivity, separate the winding into smaller groups, such as individual phases and perform the surge test on these smaller groups.

Rotor loading (coupling) when testing assembled motors

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

- ↳ **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.

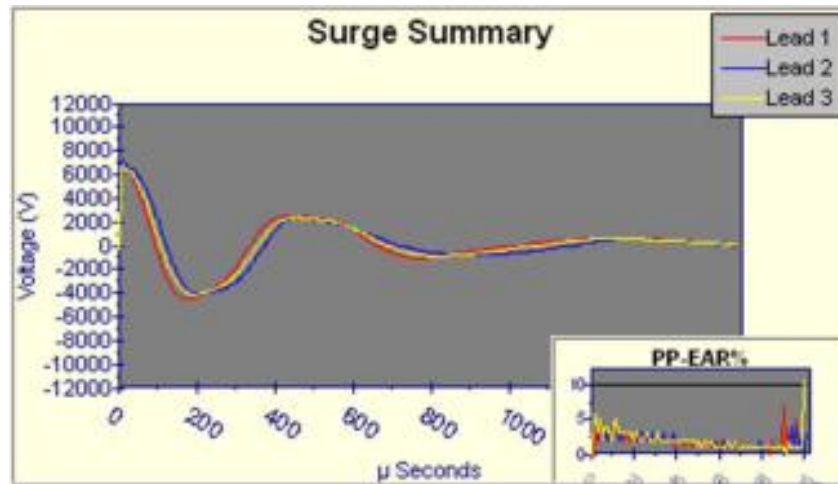


Figure 218. Example of rotor loading on surge test.

- 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.



Figure 219. Surge waveform showing rotor coupling.

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).

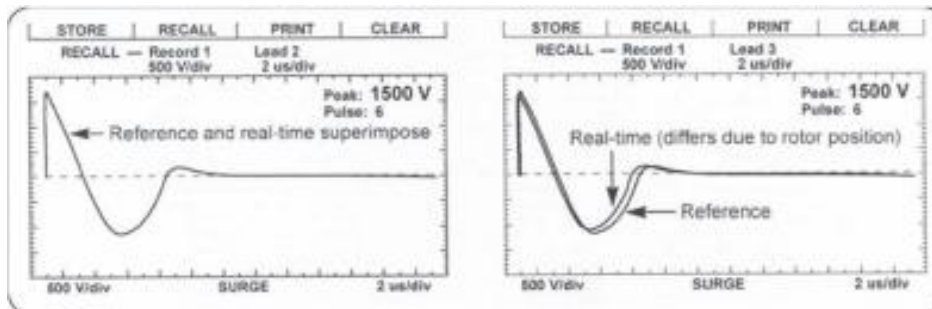


Figure 220. Wave pattern comparison for motor with rotor in place.

We recommend the following procedure for testing assembled motors where rotor coupling may occur.

1. Surge test phase No. 1 of the motor.
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.
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 an arcing 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.

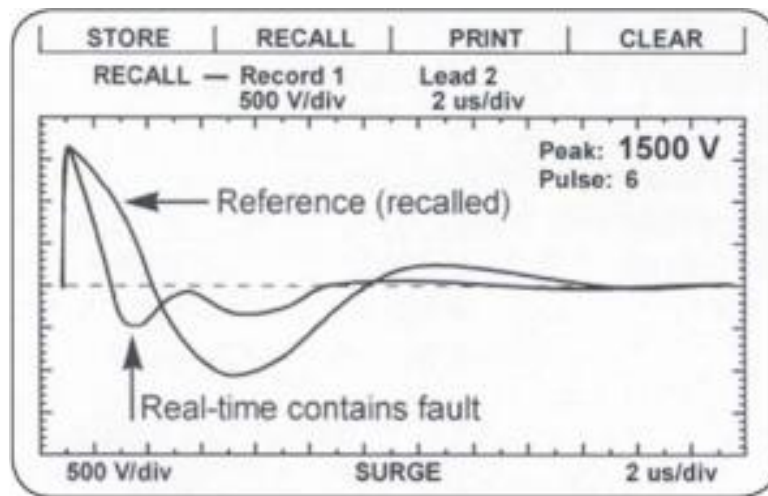


Figure 221. Motor with rotor in place and fault windings showing one trace shift significantly to the left.

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 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

To avoid injury or death from severe electrical shock, you must de-energize the motor before testing. Connect the test leads to only the load side of the open disconnect.

After megohm/PI/HiPot testing, ground the winding for four times the amount of time the winding was energized.

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.
- ↳ Disconnect surge arrestors.
- ↳ The feeder cable's capacitance, as well as the motor's ground wall capacitance, will load the surge test circuit. As a result, the will need a significantly higher internal charge voltage 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.

Single-phase transformers

1. Jumper (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.

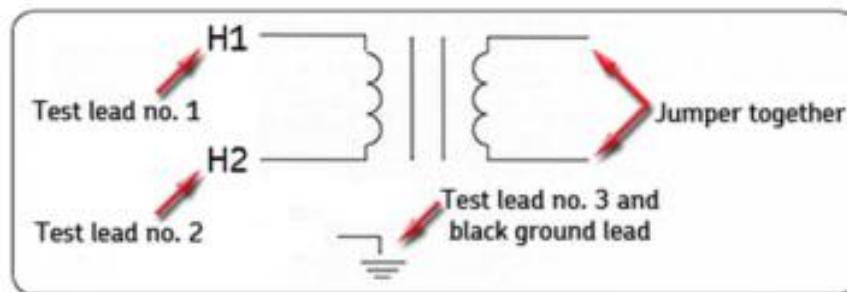


Figure 222. Single-phase transformer connections.

3. Connect the black GRD lead and test lead No. 3 to the frame.
4. 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.



NOTE

Secondary winding insulation problems reflect into the primary winding and will show on the display.

5. 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.”
6. Repeat this test process for each TAP position.

Three-phase transformers

It is beyond the scope of this manual to cover all possible transformer connections. It is important to remember that 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).



NOTE

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).

Table 15. 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

Table 16. 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

Determining 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).

Partial discharge detection

The Baker DX PD detection feature is enabled or disabled using the **Enable PD** button appearing on the surge test screen. PD testing occurs during surge testing and can be used in both three-phase and single-coil testing modes.

Partial discharge measurements and test results

The Baker DX measures the partial discharge inception voltage (PDIV), repetitive partial discharge inception voltage (RPDIV), partial discharge extinction voltage (PDEV), and repetitive partial discharge extinction voltage (RPDEV). These measurements are determined by calculating the number of events occurring over a user-defined magnitude level measured in millivolts. This data is overlaid on the waveform graph and is stored in the data log when the feature is enabled.

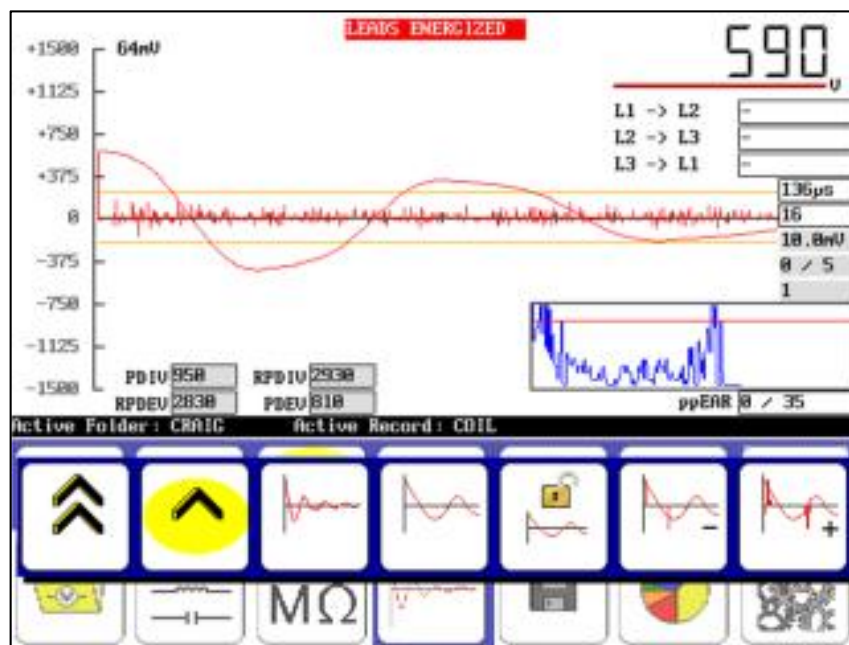


Figure 223. PD three-phase test results screen.

The measurements are made via a resistive voltage divider that attenuates both the surge pulse and the partial discharge events to a usable level by the digital hardware. The signal is filtered to isolate the high-frequency PD information.

Inception voltages

When the unit under test exceeds a minimum threshold, the tester alerts the user to the presence of significant PD and records the voltage as the PDIV.

The minimum threshold is based on the coil being measured and entered into the user settings. When the tester detects persistent discharges over multiple surge pulses, it records the RPDIV.

Extinction voltages

As the voltage is decreased from the RPDIV level, the PDEV and RPDEV are recorded as the discharge activity diminishes and finally disappears entirely.

Testing recommendations and indications

The primary value of partial discharge testing is data trending over time. As the unit is stressed and contaminated, PD activity intensifies and the inception and extinction voltages occur at progressively lower levels. Due to the nature of partial discharge, these values can vary significantly from one test to another, and are affected by environmental factors such as humidity and temperature. Therefore, PD testing should occur in similar conditions each time to ensure comparable results. Temperature and humidity should also be documented during preceding resistance, inductance, and capacitance testing.

The trend for partial discharge is an increase in severity over time, before suddenly decreasing dramatically. When this decrease occurs, the unit under test is nearing failure; sometime after this drop in activity, the coil will again exhibit high levels of PD and will likely fail. Following this characteristic curve over time is one way to determine when a unit is in need of service.

The results of the PD testing are stored and exported in the same manner as the surge waveform and EAR data for storage and analysis in Surveyor DX.

Appendix A — Troubleshooting



NOTICE

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

Self-help and diagnostics

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

By performing these procedures and having the requested information available will help SKF Service or Applications departments analyze the situation to provide you with an appropriate response.

You can reach either department at (970) 282-1200 or toll-free at 1 (800) 752-8272 for assistance.

Step 1: Basic information

Write down all basic instrument information including the following:

- └ Product
- └ Model number
- └ Serial number



NOTE

This information is located on the rear panel label. If the tester has special options installed, please note the options used. Any information concerning the instrument is helpful. A great tool would be a print or sketch of the waveforms displayed on the tester.

Step 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).

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

Start by reviewing the “Common application problems” section below. In some cases, you will be able to resolve the issue on your own.

If none of the descriptions fits your situation or they do not help you with your problem, ensure that you have basic information about the tester and specific information about the motor being tested available when calling or faxing SKF. Example test and specific information 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

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, attention: Applications.

Common application problems

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

❑ **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. *Contact the SKF Applications department for suggestions.*

❑ **Separation of compared wave patterns is seen when surge testing on coils 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; for example, both coils are wound clockwise beginning to end.

On very large equipment, slight differences in capacitance to ground may be the cause. Test again with the black ground lead removed from the motor frame. If the separation is now gone, capacitance to ground was

effecting the test. Be sure to reconnect the black ground lead afterwards.

- ❑ **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 you can break them down to smaller units of lower impedance.

A broken test lead or poor connection might be the cause. Recheck connections, or try using a different test lead selection (for example, 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.

- ❑ **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.

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

Baker surge testers can be powered by generators, but some proper grounding must be done beforehand.

Start by following all accepted electrical and safety practices when working with a generator's output. The output is often floating; that is, no ground is made at the generator. An appropriate ground—such as a service entrance ground—should be made at the generator output panel. This ground is then available as a personnel safety ground to ground all objects that the generator drives—including the Baker DX tester.

Alternatively, an isolation transformer (of appropriate VA rating) may be used between the generator and the Baker DX. An earth ground is made on the isolated secondary side of the isolation transformer, which is then available to properly ground work surfaces and test equipment—including the Baker DX.

❏ **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.

❏ **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 25–50 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. The upside is you can use a smaller, lighter, less expensive tester to perform tests on a larger selection of equipment.

❏ **Cleaning a dirty display.**

Use a water-dampened, soft, clean cloth (cotton) to gently wipe the LCD touch screen.



CAUTION

Do not use abrasive cleaners or chemicals to clean the screen. Steel wool or sandpaper will destroy the monitor screen.

❏ **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 30 and 40 kV power packs. Quite high levels of RFI/EMI may generate when the power pack is doing a surge test. Print the results after you complete your testing; 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

Sometimes, issues arise that have simple solutions that you can resolve on your own, negating the need to return a unit may. Please perform the following checks to determine whether you have such an issue before returning the unit to SKF.

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.



NOTE

It is not necessary to run the output control at a high level to determine if the DX 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 overcurrent trip. If the DC overcurrent 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.

Copy this form to send to SKF and make a copy for your records before sending.



NOTE

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 Number:

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, and so on), even if you already talked to someone at SKF by phone. Use the back of this form and additional pages if necessary. ***Note total number of pages used when sending.***

Person Contacted at SKF:

Ship the tester to:

SKF Condition Monitoring Center, Fort Collins (SKF USA)
 4812 McMurry Avenue
 Fort Collins, CO 80525
 Attn: Service Manager

Appendix B — Technical specifications, calibration, and applicable standards

Table 17. 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 μ sec to 6.5 msec	24 μ sec to 6.5 msec	24 μ sec 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 measurement and accuracy	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$
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 μ A division	0.1/1/10/100 μ A division	0.1/1/10/100 μ A division
Over-current trip settings	1.4 mA	1.4 mA	1.4 mA
Full scale voltage and current measurement and accuracy	$\pm 3\%$ voltage $\pm 5\%$ current	$\pm 3\%$ voltage $\pm 5\%$ current	$\pm 3\%$ voltage $\pm 5\%$ current
Megohm accuracy	$\pm 8\%$	$\pm 8\%$	$\pm 8\%$
Max megohm reading	100,000 M Ω	100,000 M Ω	100,000 M Ω
Memory and storage characteristics			
Data memory	Data memory	Data memory	Data memory

Table 18. Technical specifications—physical characteristics.

	Model DX4	Model DX6/6H0	Model DX12/12H0
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

Table 19. Accuracy of measurements—coil resistance test.

Approximate range resistance	Full scale accuracy
100 to 10,000 Ω	±3%
0.2 to 100 Ω	±2%
0.002 to 0.2 Ω	±4%

Calibration information

Please contact SKF Condition Monitoring Center, Fort Collins (SKF USA) for current calibration information. Contact the Service department at (970) 282-1200 or (800) 752-8272.

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 (for PD)
- ▣ IEC 61934 for PD and IEEE 927 (for PD)

Referenced EMC Standards

EMC Directive 2004/108/EC
IEC 61000-6-2, Second Edition: 2005
IEC 61000-6-4, Second Edition: 2006
CISPR 11:2004
EN 61000-3-2:2006
EN 61000-3-3:2005

Referenced Safety Standards

EN 61010-1:2001 Second Edition

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

Appendix C — DC and surge tests voltages

Recommended test voltages

SKF has a recommended standard (see table) for test voltages for DC tests and surge tests conducted on a motor, generator, or transformer. That standard is 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.



NOTE

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.

Table 20. Motor representations and formulas for calculating voltages.

V Line	Per Unit	Min Test, $V \text{ Line} \times 1.25 \times 1.7$	Max Test, $V \text{ Line} \times 1.5 \times 1.7$
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

IEEE 95-1977

Table 21. EASA DC-HiPot.

V Line	Per Unit	New, $3.4 \times V$ 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

Table 22. IEEE 522 surge testing.

V Line	Per Unit	New, $3.5 \times$ 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

Table 23. IEC 34-15.

V Line	Per Unit	V Line $\times 4E + 5,000$	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

Table 24. SKF recommended standards

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

**NOTE**

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

Appendix D — Printer compatibility list

Printers successfully tested on a DX

The following printers have been tested and are known to work with the Baker DX:

- ↳ HP Officejet 6000
- ↳ HP Deskjet 6940
- ↳ HP Laserjet 2430n
- ↳ HP Officejet 6100
- ↳ OKI B411d—available from Condition Monitoring Center, Fort Collins
- ↳ OKI C300/C500—available from CMC FC
- ↳ HP Officejet Pro 8000
- ↳ HP Deskjet 5650

Printers unsuccessfully tested on a DX

The following printers have been tested and are known *not to work* with the Baker DX:

- ↳ Samsung ML-2571N
- ↳ Canon ImageClass D340
- ↳ Brother HL-2230
- ↳ HP Officejet J4580
- ↳ HP LaserJet 1200 series
- ↳ HP Deskjet 3050A

General rules for compatibility

The Baker DX generates PCL3 control codes for printing; therefore, any printer that supports PCL3 should successfully print from the DX. Some things should be considered when selecting a printer for use with the DX.

Most PCL languages are backwards compatible and support PCL3, but there are exceptions. PCL3GUI is a variant of PCL3 that is not compatible with the standard PCL3. Also, PCL6 was a significant change from prior PCL versions and is not backwards compatible. Although PCL6 is not backwards compatible, most printers that support PCL6 also include support for PCL5 to maintain backwards compatibility. This is not true for all printers; as a result, some PCL6 printers will not be backwards compatible and will not support PCL3.

In an effort make PCL6 printers backwards compatible, HP added a module to PCL6 called PCL6 Standard. PCL6 Standard is intended to be equivalent to PCL5 enhanced and should be backwards compatible with prior PCL versions.

It is also worth noting that non-HP printers may not fully support the version of PCL that is stated in the documentation for that printer. Non-HP printers will often claim PCL emulation, which might not fully support the noted PCL version. It is best to stay with HP printers because the PCL support will meet the standard.

The DX should work with any printer that fully supports PCL3 and this would include PCL4 and PCL5, but would exclude PCL3GUI. Also the DX should work with PCL6 printers as long as support has been included for PCL5 or PCL6 Standard. When using a PCL6 printer, you might need to configure the printer to use PCL5 or PCL6 Standard support.

DX printer settings

All successfully tested printers noted above had the following DX printer settings:

- ↳ Color Mode: Color
- ↳ Data Delay: 5

These settings appear to be correct for most printers. Some users have been successful at lower delay settings such as 2, 3, or even 0 in some cases, which yielded faster printing speeds. The color mode can generally be set to **Color** even on black-and-white printers. Setting the mode to **Color** on a black-and-white printer usually yields gray-scale images. Setting the color mode to **B/W** is generally not necessary unless your black-and-white printer does not support gray scale.



NOTE

For users of Hewlett-Packard printers, support includes HP printers that use the Hewlett-Packard PCL 3 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.

Appendix E — RIC templates

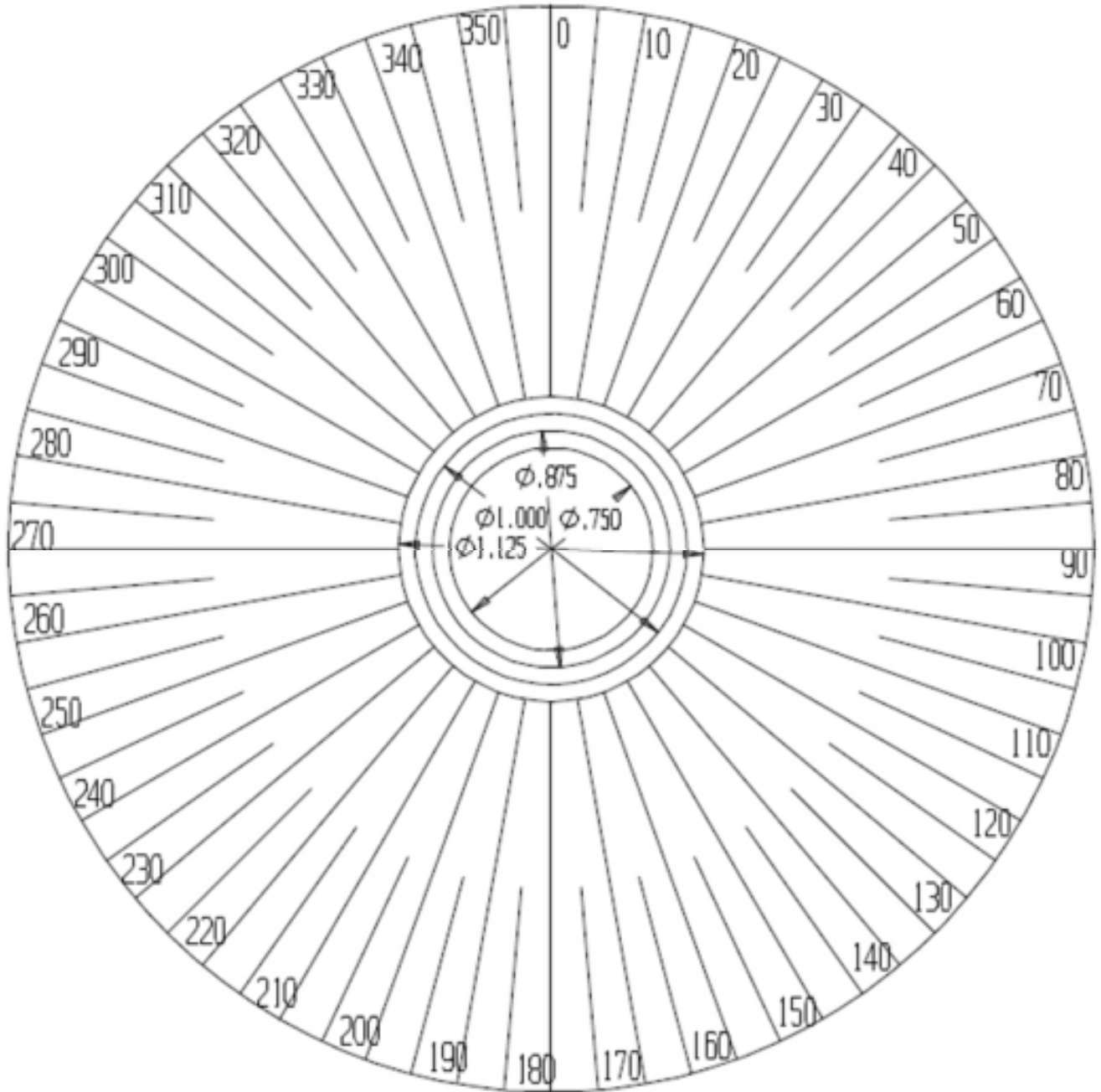


Figure 224. RIC template 1.

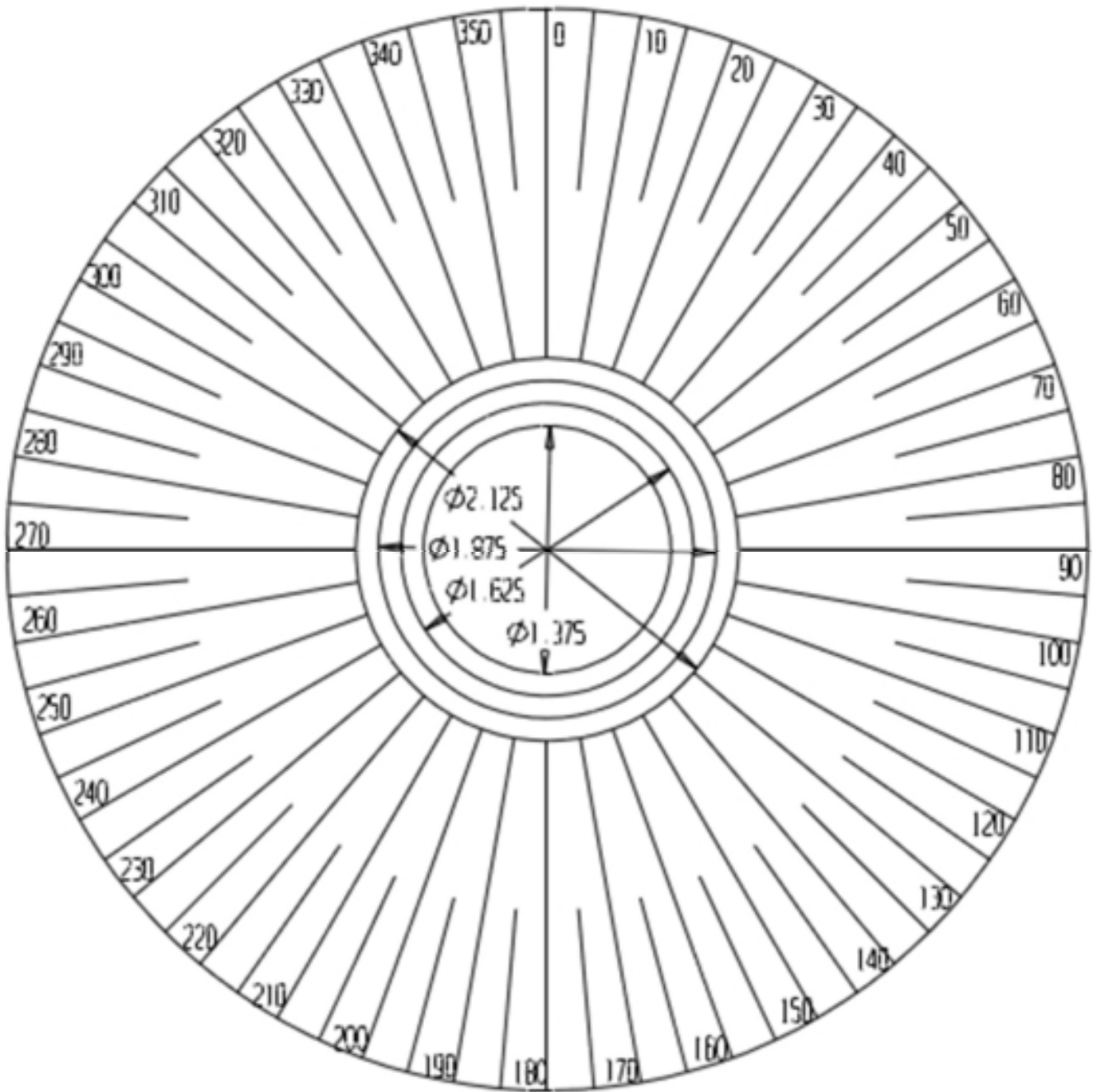


Figure 225. RIC template 2.

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