CHAPTER 5: MCE

TESTING QUICK START

MCE testing may be started by selecting either the Test Selection or the MCE Auto icons on the toolbar.

Selecting the MCE Auto icon automatically runs the Standard Test followed by the Polarization Index test. It uses the existing testing setup values. MCE Auto is discussed in detail on page 5-7.

Selecting the Test Selection icon allows you to verify and/or change the testing setup values and select which test you want to run. Test Selection is discussed in detail on page 5-3.

1. Start MCEGold.
2. On the Site Navigator or WatchList highlight the asset to be tested.
3. Select the Test Selection icon on the tool bar to open the Test Selection window.
4. In the Test Selection window the default is set to MCE testing. For EMAX testing click the EMAX tab at the top and see Chapters 6 & 7. The asset section tabs along the left side will vary depending on the type of asset being tested. Nameplate Information is automatically filled in by MCEGold from the nameplate data.
5. Select the asset section tab along the left side corresponding to the section to be tested.
6. Select the test to be performed from the list of tests. The available selections are driven by the type of asset and the asset section selected for testing. The Notes section provides instructions that are relevant for the selected test.
7. Select the asset test location by using the drop-down list or using the search button to open the Test Location Selection window.
8. Select the Test Frequency from the drop-down list. The Test Frequency default is driven by the type of asset selected for testing.
9. Select the Resistance-to-Ground by entering in the Mohms if they are different from the default. Check the Low Limit check box if you want the unit to shut down automatically upon measuring a specified low resistance to ground value.
10. Select the Voltage from the drop-down list box. The choices are: 250, 500, 1000, 2500, and 5000.
11. Set the asset Temperature if different from the default value of 40.

12. Select the charge time from the drop-down list box. The choices are in 15 second increments, beginning at 15 and ending at 600 seconds.

13. Click **Save** to save the MCE Test Setup values selected for this particular asset or click **Reset** to restore the original values. Note: Original values may only be reset if new values have not been saved. If you have clicked the Save button it will be necessary to manually change them back to the originals and save them.

14. Click **Test** to go the test window.

15. Click **Test** on the Test window. From this point the process will differ depending on the test being performed. Each test is covered in detail later in this chapter.

INTRODUCTION

The MCE tester measures natural characteristics of a deenergized asset and its circuit to determine its condition. These characteristics are resistance-to-ground, capacitance-to-ground, winding resistance, and winding inductance. MCE testing can identify faults in the power circuit, insulation, stator, rotor, and the air gap between the rotor and stator.

The tests that can be run on a asset vary, depending on the asset type. For AC assets (Induction, Synchronous, and Wound Rotor) the tests are AC Standard Test, Polarization Index (PI) which includes a Dielectric Absorption Ratio, Rotor Influence Check (RIC), and Step Voltage. For DC assets the tests are DC Standard Test, Polarization Index (PI) which includes a Dielectric Absorption Ratio, Bar-to-Bar (Armature Circuit only), and Step Voltage.

Both AC and DC assets have an MCE Auto test which runs the Standard test followed by the Polarization Index test, automatically saves the test results, and displays the Fault Zone Report at the end of testing.

The frequency and type of asset testing you perform is based on your experience with the tester, the condition of each individual asset, and the criticality/application of each asset. Since it may be impossible to test each and every asset in your facility, ask yourself the following questions when deciding which assets to test.

- Is the asset easily replaceable and if so, is a replacement readily available?
- Would buying a new asset cost less than repairing the old asset?
- Is the asset redundant or non-critical?

If you answered yes to all three of these questions, you may not want to consider this asset for your monitoring program.

If you are unfamiliar with an asset, review its maintenance history of test results, problems, and repairs before testing it. Talk with the operators who run it and anyone who may have information about its repair history. This will give you a more complete picture of the condition of the asset.

MCE test results give you a comprehensive picture of the electrical condition of the asset. MCE results can be utilized, along with results obtained from other technologies, to get a complete picture of the health of the asset. Some examples of other technologies include vibration, oil analysis, and infrared thermography.

Some of the MCE tests give you enough information to call an asset good or bad, based on results from one test. Other MCE tests give you data which is best used for trending and comparison.

Trending means comparing sequential test results for the same asset over time. This tracks what the particular asset is doing, how it is holding up, when it may need to be cleaned, when it needs more detailed maintenance, or when a fault develops.

Test frequency depends on the asset's criticality and the condition of the asset when it is first tested. As the asset ages, you may decide to test it more frequently to better track its condition.

When you first start testing with the MCE, the initial test is automatically designated as the baseline test. After maintenance is performed on an asset and it is returned to optimal condition, measure subsequent tests against that condition by designating the first test after the maintenance as the new baseline.

Comparison means comparing individual test results on one asset with test results from an identical asset operating in a similar environment. By identical asset we mean the same manufacturer, voltage and horsepower rating, cable length for MCC, etc. For example, if there are four like assets operating side by side performing the same task, all running at approximately the same load, each running about the same amount of time, the test data should be very close for all of them. If all four assets are tested, and three are basically the same, but the fourth is very different from the other three, look for potential problems with the fourth asset.

MCE testing is performed on a deenergized asset. However, there may be energized circuitry in the same cabinet in which you connect the tester.

FOLLOW ALL ELECTRICAL SAFETY PRECAUTIONS AND PROCEDURES FOR WORKING IN THE VICINITY OF ENERGIZED EQUIPMENT. READ THE ELECTRICAL SAFETY PRECAUTIONS IN CHAPTER ONE BEFORE PERFORMING ANY TESTS.

For AC assets, test lead colors of black, blue, and red connect to phases 1, 2, and 3 (left to right, top to bottom); green connects to ground. For DC assets, test lead colors of black and blue connect to F1/A1 and F2/A2; the red lead is not used; green connects to ground. The DC Bar-to-Bar pistol grip or pencil probe test leads connect to commutator bars.

Some asset circuits may have surge capacitors and/or power factor correction capacitors installed. It is important to know about them since these components affect the values of the collected data and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power or surge capacitors installed, however, surge capacitors must be removed for the accurate measurement of the asset's insulation resistance-to-ground. If an asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.

TEST SELECTION WINDOW

In this chapter, the MCE aspects of asset testing are discussed. EMAX testing is discussed in the Power and Current Analysis chapters. The Test Selection window discussion is followed by the Step-by-step testing procedures, Test Data Analysis on page 5-53, and finally MCE Analysis on page 5-74.

Note: Selecting the MCE Auto test icon on the tool bar bypasses the Test Selection window and automatically runs the Standard Test followed by the Polarization Index test using either the default or previously saved test settings, at the end of testing the test results are saved, and the Fault Zone Report opens.

To open the Test Selection Window click the Test Selection icon on the tool bar.

The Test Selection window is shown in Figure 5-1. The asset name is located on the title bar to the right of the window name. The Test Selection window is used for both MCE and EMAX testing by selecting the desired test type tab.

The asset section tabs are found along the left side of the test selection area and are dependent on the asset type. Possible sections are Armature Circuit, Field Circuit, Resistor Bank, Rotor, and Stator.

- For AC Induction assets, the only option is Stator.
- For AC Synchronous assets, options are Field Circuit and Stator.
- For Wound Rotor assets, options are Stator, Rotor, and Resistor Bank.
- For DC assets, options are Armature and Field Circuit.

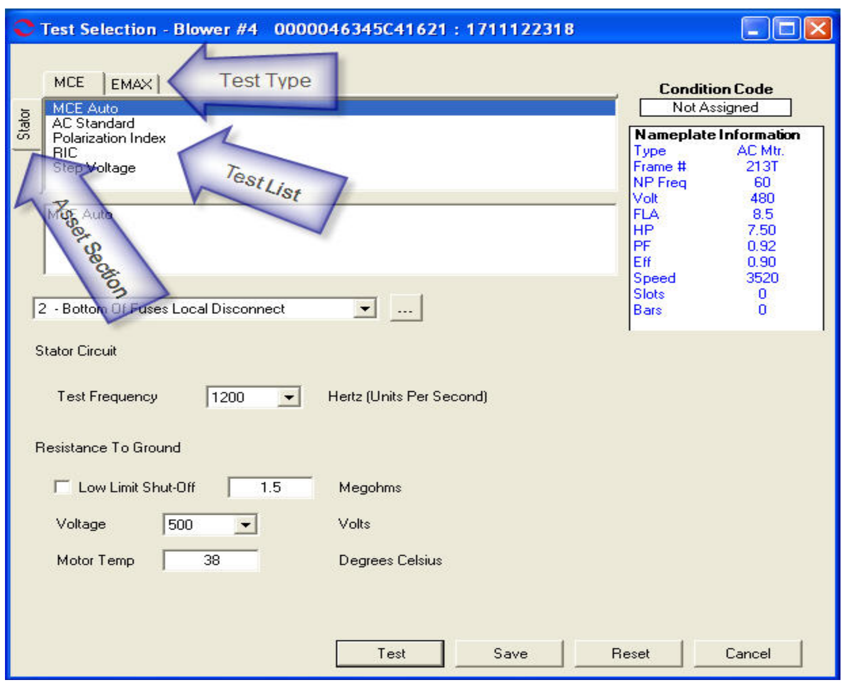


Figure 5-1: Test Selection Window

Test List

The top left section of the window contains a list of test selections for either MCE or EMAX, depending on asset type, test type and asset section tabs selected. The test lists section displays the various tests which may be performed based on the asset type and asset section chosen. When a test is selected, the name of the test is highlighted blue and

the test set up area changes to values appropriate for the test selected. The test list possibilities for MCE testing are:

- MCE Auto
- Standard (AC asset)
- Standard (DC asset)
- Polarization Index
- Rotor Influence Check (RIC)
- Step Voltage
- Synchronous (Synchronous, Field section)
- Resistor Bank (Wound Rotor, Resistor Bank section)
- Commutator Bar-to-Bar (DC asset)

Asset Information

Asset Information is located on the right side. This area displays the Condition Code and nameplate information of the asset being tested. The information comes from the nameplate data that was entered when the asset was set up and cannot be edited on this window. Information displayed, depending on asset type, may include: Type, Frame #, NP Frequency, Voltage, FLA, HP, PF, Eff, Speed, Slots, and Bars. Also, Field Volts and Field Current are listed for DC assets.

MCE Test Setup

The lower half of the Test Selection window is devoted to test set-up selections. The set-up options depend on the asset type and test selected.

Asset Test Location

The Asset Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button. The Test Location Selection window opens displaying a test location graph for the type of asset selected. See Figure 5-2. Use the graph to determine the location, then click the down arrow in the Test Location text box, select the location from the list, and click **OK.**

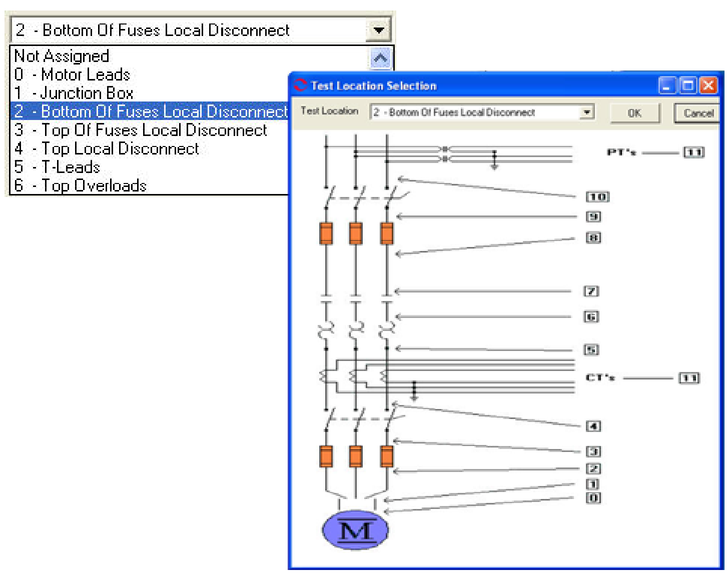


Figure 5-2: AC Asset Test Location

Test Frequency

Test Frequency is selected from a drop-down box. Click the down arrow and select from the list to change the frequency. The choices are 300 or 1200 Hz depending on the section being tested. Test Frequency is not available for the resistor bank section of a wound rotor asset.

Resistance-to-Ground

Resistance-to-Ground provides the option to check (turn on) the Low Limit Shut Off and enter a shut off voltage.

Voltage

Voltage is selected from a drop-down list. Click the down arrow and select from the list to change the voltage. The voltage choices are from 250, 500, 1,000, 2,500, and 5,000.

Select a voltage of 500 or 1000 volts, based on the asset's voltage. EASA (Electrical Apparatus Service Association), in their booklet How to Get the Most From Your Electric Motors, suggests 500 volts for assets rated ≤2400 volts and 1000 volts for assets rated at >2400 volts.

Asset Temperature

The default value is 40° C. The value may be changed by typing in a new value.

Span

Span selection is only available for Bar-to-Bar testing of the armature section of DC assets.

Charge Time

Charge time is available for the Standard test of an AC Induction, Wound Rotor, Synchronous, and DC assets. The default value is 60 seconds. To change the charge time, click the down arrow and select from the list of between 15 and 600 seconds.

Test Button

Click **Test** to advance to the test window.

Save Button

Click **Save** when the test set-up selections are complete. This saves the settings as default values for that asset for subsequent tests, but is not required. If you forget to save and click Test, you will be asked if you want to save your changes.

Reset Button

Click **Reset** to set values back to the pre-changed value. Note: If you have clicked the Save button they will not reset and it will be necessary to manually change them back.

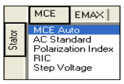
Cancel Button

Click **Cancel** to close the Test Selection window without saving setup changes or proceeding to the test window. You will be asked if you want to save test setup settings.

TEST WINDOW

Once the asset section and setup parameters are selected, you are ready to run the test. This section explains each test by asset type and asset section. The test window is discussed followed by step-by-step testing procedures. Test analysis information begins on page 5-53.

AC Induction Assets



The MCE tests for an AC Induction asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage. They are discussed in detail in this section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test
- Polarization Index (PI)/Dielectric Absorption (DA) If a PI is performed, it is not necessary to perform a separate DA.

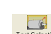
Some circuits may have surge capacitors and power factor correction capacitors installed. This is important since these components affect the values of the collected data and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor capacitors installed. However, a test should be taken with surge capacitors removed for future comparison. If an asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.

MCE Auto Test

MCE Auto test performs a standard test followed by a Polarization Index test, then saves the data and produces a Fault Zone Report.

MCE Auto test can be started by clicking the MCE Auto icon

on the toolbar or selecting MCE Auto from the test list in the Test Selection Window. If you select the MCE Auto icon, the MCE Auto test window opens bypassing the Test Selection window.

If you need to change the test setup settings, select the Test Selection icon 

. The Test Selection window opens, make your changes, and then select MCE Auto from the test list and click **Test**. The MCE Auto Test window, Figure 5-3, opens. The MCE Auto Test window menu consist of three options: File, View, and Options.

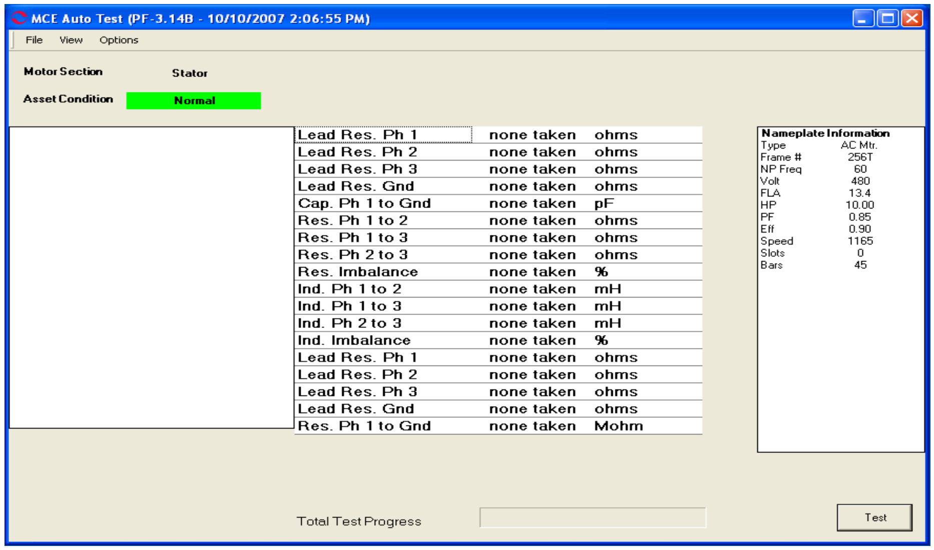


Figure 5-3: MCE Auto Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the MCE Auto Test and Test Selection windows and returns you to the Home window.

View Menu

Create Message . Create Message opens the Compose Asset Message window (Figure 5-4). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

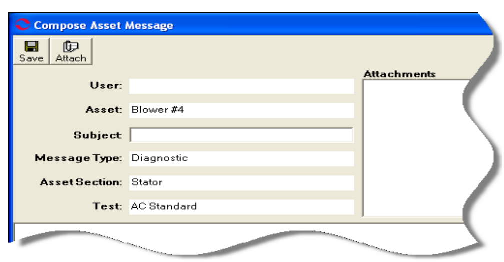


Figure 5-4: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-5). The Asset Condition box on the MCE Auto Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

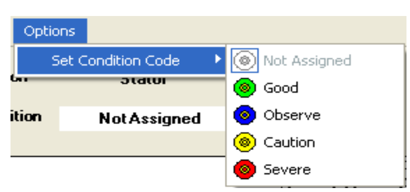


Figure 5-5: Set Condition Code Window

Test Button

To begin testing click **Test**. During testing the menu items are dimmed (not available) and the Test button changes to Stop. The test takes approximately 11 minutes.

The tester automatically proceeds from the Standard test to the Polarization Index (PI) test. A status bar displays the testing progress. During the Standard test there is one Total Test Progress bar. When the PI test is performed there is a PI progress bar, a Total Progress bar, and a graph in the lower left displaying the test results. See Figure 5-6.

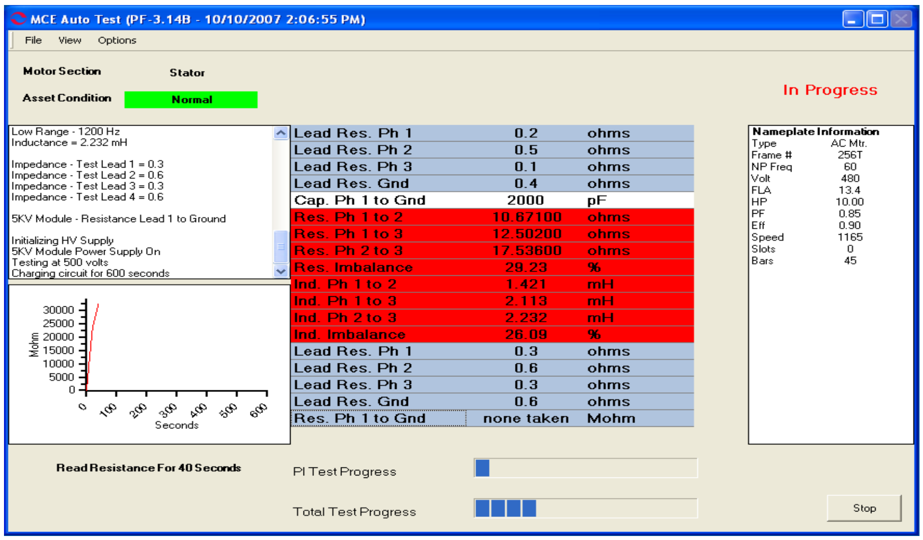


Figure 5-6: MCE Auto Test Window - PI Test

At the end of the PI test, the test results are automatically saved and the Fault Zone Report is generated and displayed. See Figure 5-7.

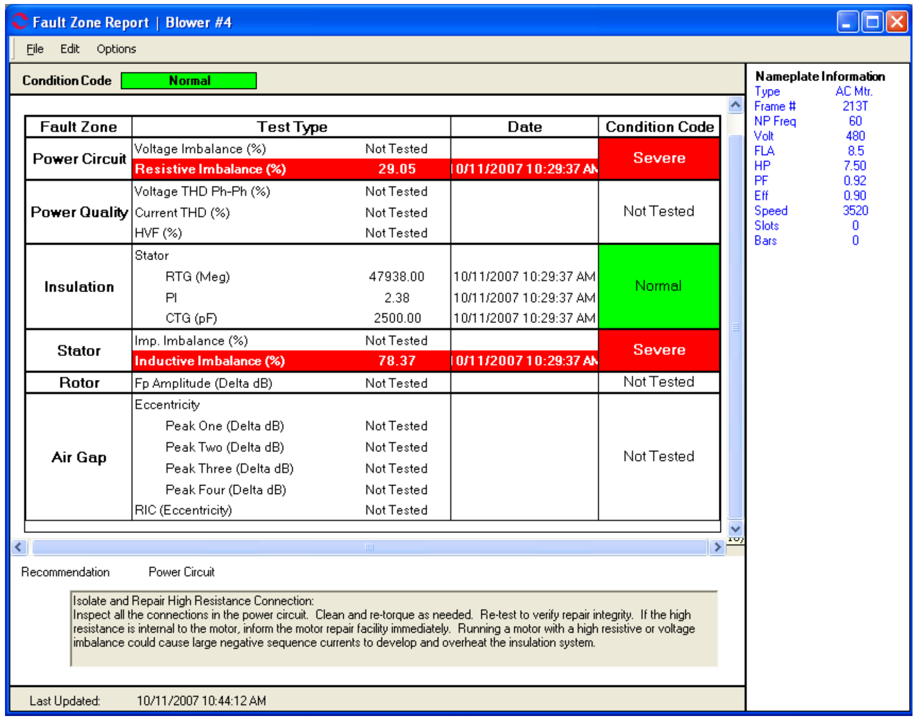


Figure 5-7: MCE Auto Test Fault Zone Report

Fault Zone Report

NOTE: The information for the Fault Zone Report, beginning with File Menu and ending with To View Test History on page 5-12, has been replaced with a new and improved ocular format. A description of the ocular fault zone can be found on page 3-52 in Chapter 3-MCEGold3.

File Menu

Print Preview. Print Preview, shown in Figure 5-8, displays the Fault Zone Report as it will be printed. Using the File menu on the Print Preview window, you can export the report to PDF or HTML or add comments before printing.

To *create a PDF file*, select File, Export to PDF, select the location you wish to save the file in, enter a file name, and click **Save**.

To *create a HTML file*, select File, Export to HTML, select the location you wish to save the file in, enter a file name and click **Save**.

To *add comments*, select File, Add Comments. In the Add Remarks window type your comments and click **Add**. The comments appear in the Comments section at the bottom of the report. They will appear on the printed report, but are not saved for the future. Permanent comments should be entered in the Message Center using Edit, Create Message, which is discussed on page 5-11.

To *print the report* click the **Print** icon on the Print Preview toolbar.

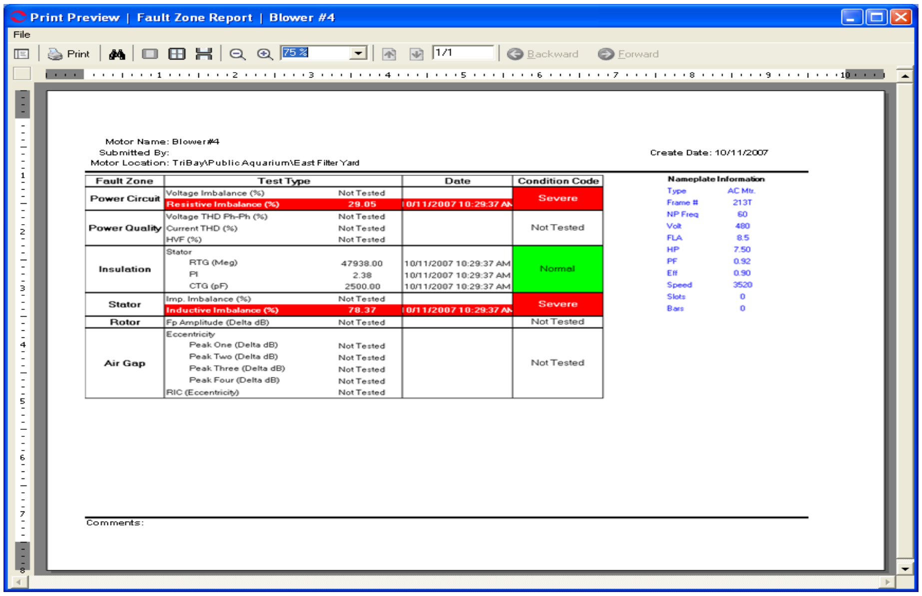


Figure 5-8: Print Preview

Print. Print prints the report to your default printer.

Exit (Ctrl+Q). Exit the report by using File, Exit (Ctrl+Q) or clicking the Close button (red X in the upper right corner).

Edit Menu

Create Message (Ctrl+M). You may enter permanent notes by selecting Create Message (Ctrl+M). This opens the Compose Asset Message window shown in Figure 5-4 on page 5-8. The note is viewed from the Message Center. See the section on Message Center in Chapter 3, page 3-41.

Options Menu

Refresh (Ctrl+R). The Refresh function is used to update the Fault Zone Report when changes have been made to the warning settings.

Set Condition Code. Change the condition code, by selecting an option button, the Condition Code box changes, and a note is automatically generated by the software. The note is viewed from the Message Center. See the section on Message Center, in Chapter 3, page 3-43.

Description/Recommendation

The blank area at the bottom of the report is designed to provide additional information, such as descriptions of the Fault Zones and Test Types or recommended actions for the Condition Code. It is for on screen viewing only and does not appear on the printed report.

To **view a description** of the Fault Zone or Test Type, click on the name in the Fault Zone report. The description will appear in the text box at the bottom of the window.

To **view the recommended course of action** for a condition code, click the condition code name. The recommended course of action will appear in the text box at the bottom of the window. Figure 5-7 shows how the window would appear if severe condition code of the power circuit was selected.

To View Test History

To **open the Test History** click on the test type result value or the date. The Test History window opens.

AC Standard Test

The AC Standard test is reach by selecting AC Standard from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The AC Standard Test Window (Figure 5-9) opens.

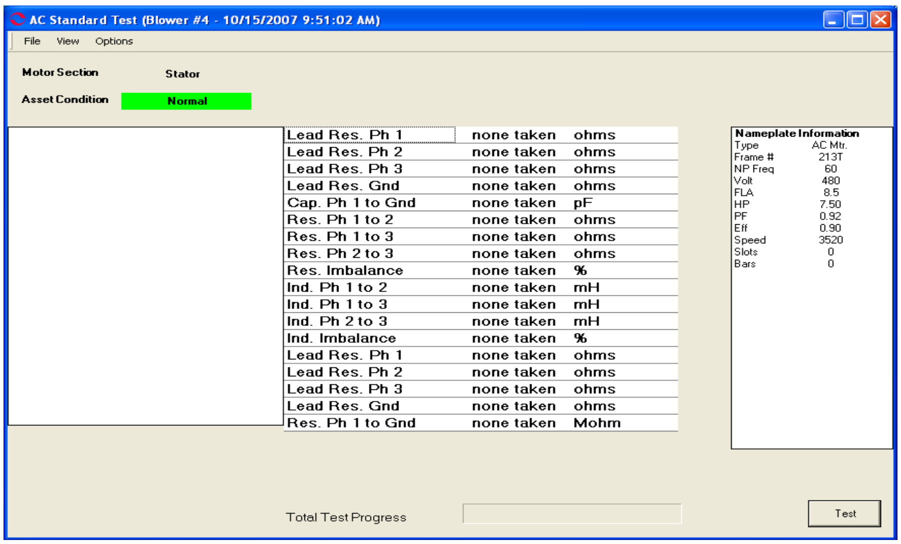


Figure 5-9: AC Standard Test Window

The AC Standard Test window menu consist of three options: File, View, and Options.

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the AC Standard test window and returns you to the MCEGold Home window.

View Menu

Create Message. Create Message opens the Compose Asset Message window (Figure 5-10). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

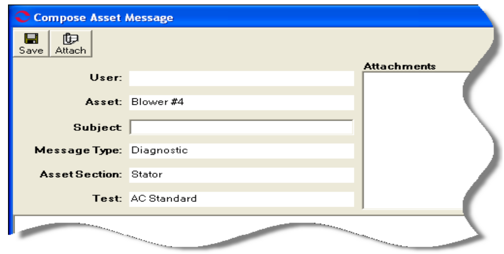


Figure 5-10: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting an option button (Figure 5-11). The Asset Condition box on the AC Standard Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43

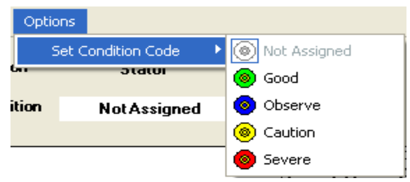


Figure 5-11: Options, Set Condition Code Menu

Step-by-Step AC Standard Testing

1. De-energize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE to the circuit, in the same manner each time, as referenced in Table 5-1. This ensures that the test data is trendable/repeatable.

Table 5-1: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
“T” lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested on the Site Navigator.

5. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-12.

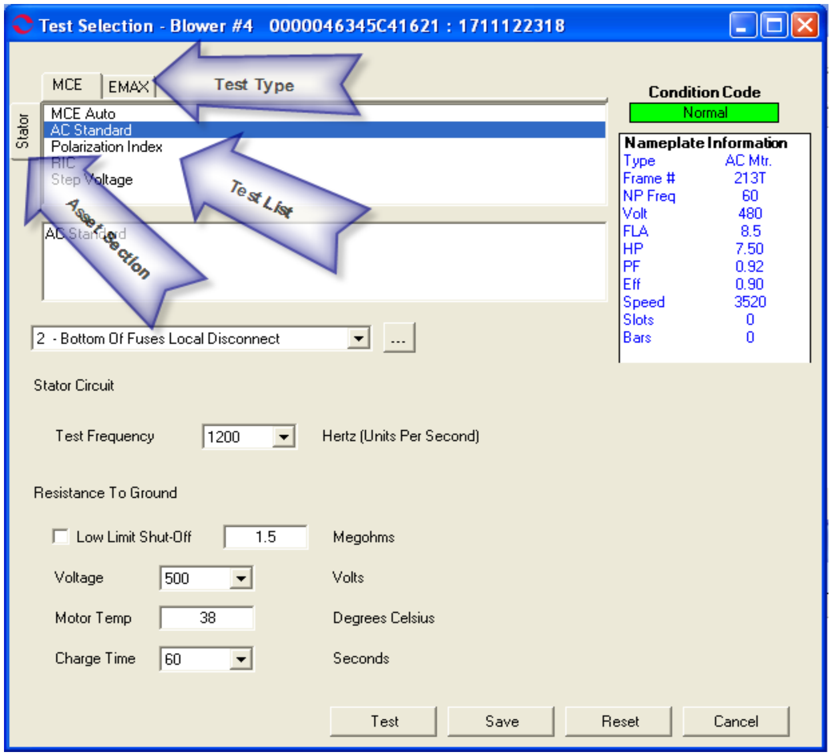


Figure 5-12: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Click AC Standard from the Test List.

   If all of the settings in the MCE Test Setup are correct, click **Test** to go directly to the test. Go to step 16.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-13.

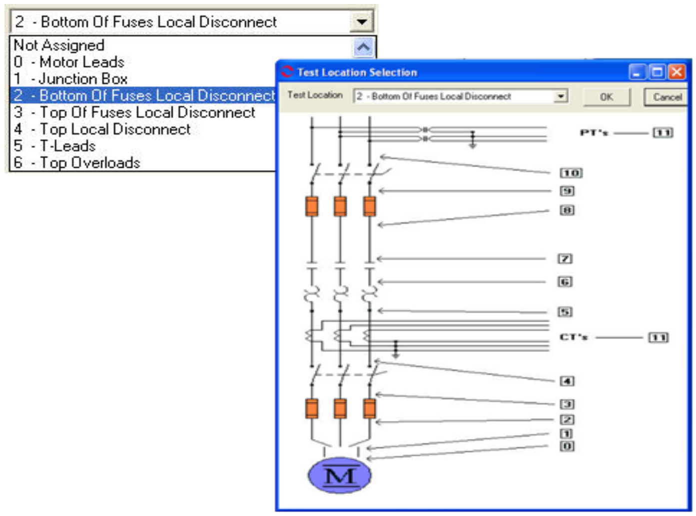


Figure 5-13: Asset Test Location

9. Verify the Test Frequency.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select the Charge Time Seconds.

    Click the down arrow and select the seconds from the drop-down list. The choices are from 30 to 180 seconds at 15 second increments.

14. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the testing window.

16. Click **Test** in the AC Standard Test Window.

17. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

18. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area. See Figure 5-14.

    To stop the test at any time, click **Stop**. Click **Exit** to close the AC Standard test window and return to the Home window.

19. Click **OK** when the test is complete.

20. Re-test any individual point, if needed. If not go to step 21.

    If any portion of the test needs to be re-tested, double click the tab which appears to the right of the individual test point. This rechecks only that test point in “manual mode.” See Figure 5-14.

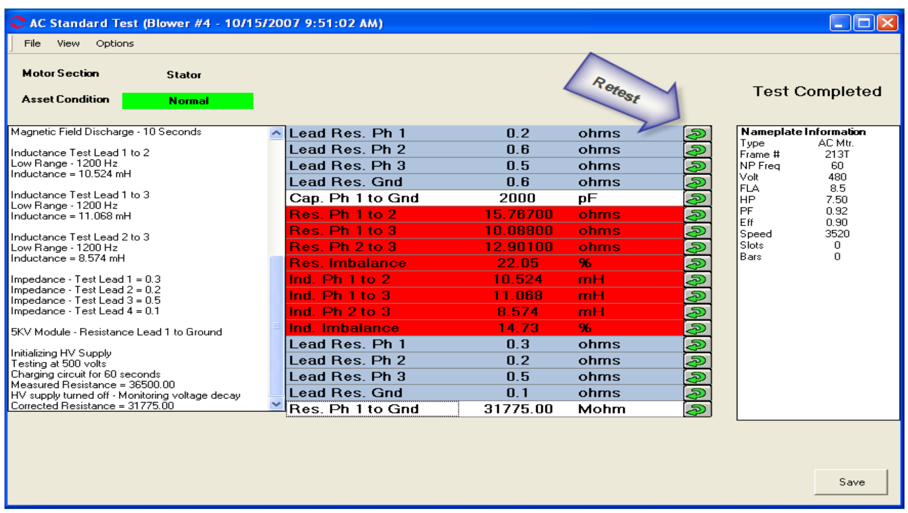


Figure 5-14: AC Standard Test Window

21. When retesting is complete or if no re-testing is needed, click **Save** or select File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

22. Click **OK** in the Save Complete window.

23. Click **Exit** in the AC Standard Test Window.

Polarization Index

The Polarization Index (PI) test is reached by selecting Polarization Index from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information.

Verify that the test set-up settings are correct and click **Test**. The PI test window opens. See Figure 5-15.

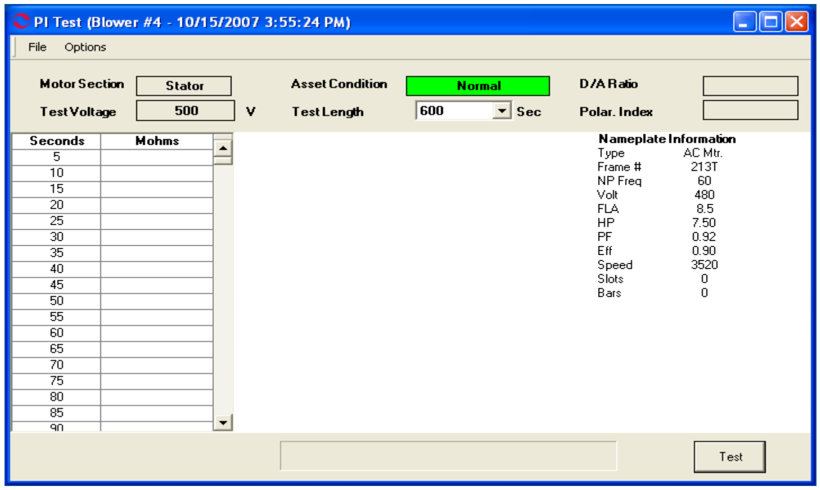


Figure 5-15: PI Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the PI Test window and returns you to the Home window.

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-16). The Asset Condition box on the PI Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

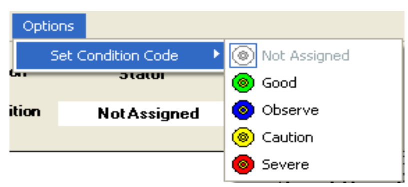


Figure 5-16: Set Condition Code Window

Step-by-Step Polarization Index Testing

The PI test takes ten minutes. During the test the menu items are dimmed (not available) and the **Test** button changes to **Stop**.

1. Deenergize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE to the circuit, in the same manner each time, as referenced in Table 5-2. This ensures that the test data is trendable/repeatable.

Table 5-2: : Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
“T” lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-17.

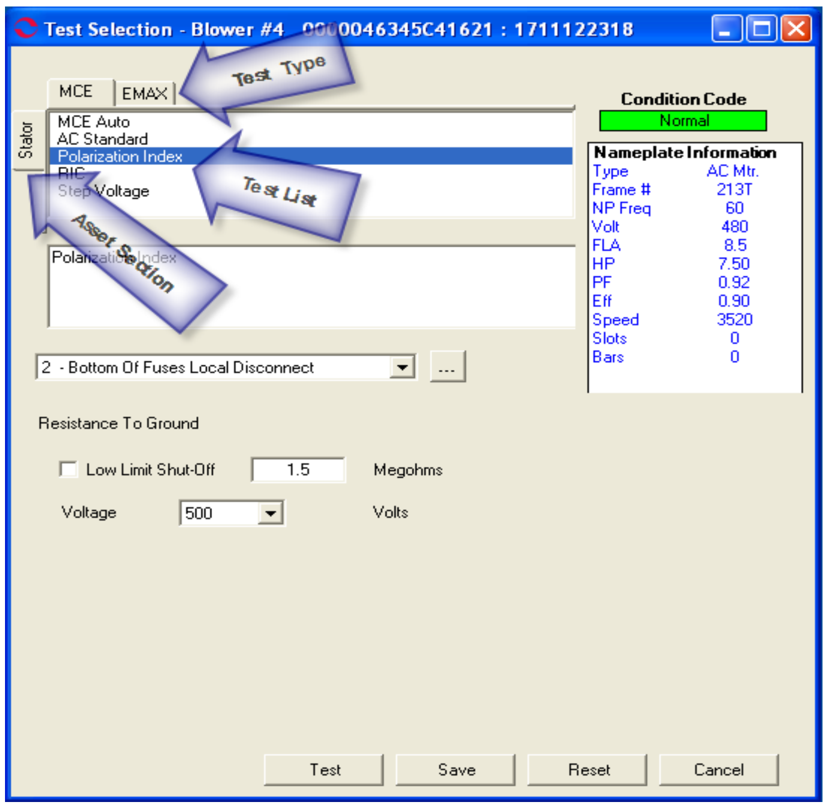


Figure 5-17: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-18.

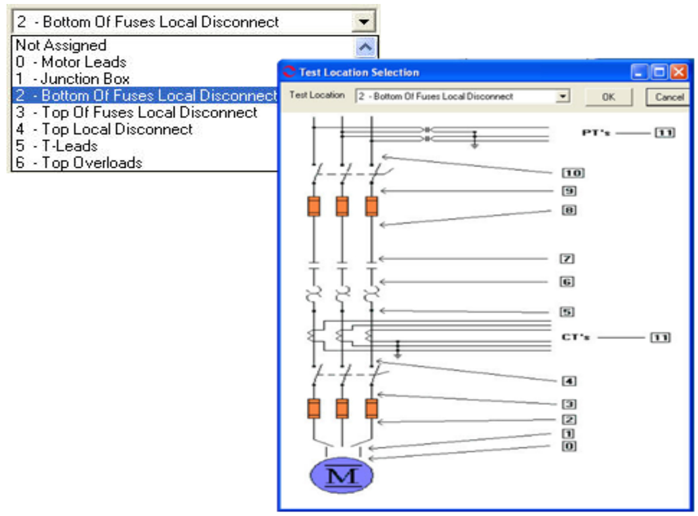


Figure 5-18: Asset Test Location

8. Verify the Low Limit Shut Off condition.

   Check the box to activate the low limit shut off and enter the desired Mohms.

9. Verify the Voltage.

   Click the down arrow and select the voltage from the drop-down list. Select the test voltage based on asset nameplate voltage.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the testing window.

12. Click **Test** in the PI Test window.

13. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

14. As the test proceeds, the test result values are displayed in the table and plotted on the graph. At the end of one minute the D/A ratio is computed and displayed in the D/A Ratio text box. The progress bar displays the progress of the testing.

    Note: To stop the test, click **Stop.**

15. Click **OK** in the Test Completed window. The menu item become active and the **Stop** button is inactive.

16. Exit the PI Test window by selecting File, Exit, or Ctrl+X, or the close button (Red X in the upper right corner).

17. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The PI Test window closes

    If you select **No**, the PI Test window closes. No test data is saved.

RIC

The RIC test is reached by selecting RIC from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The RIC test window opens. See Figure 5-19.

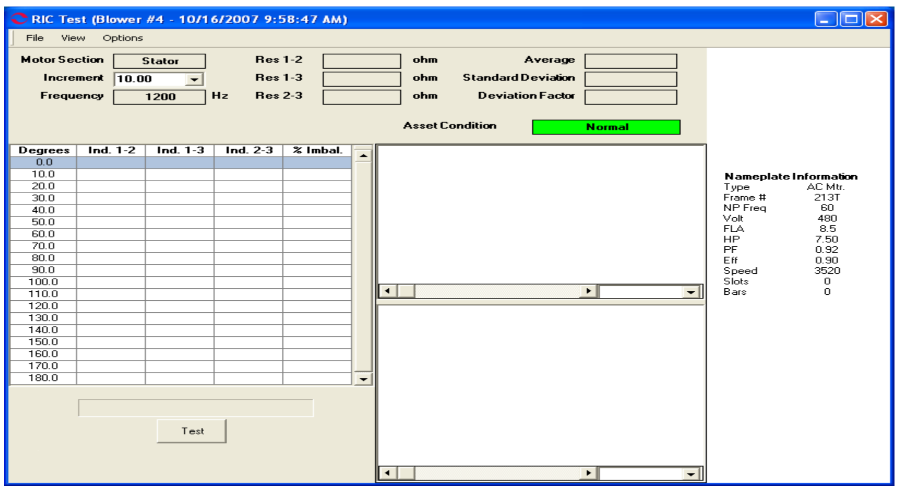


Figure 5-19: RIC Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the RIC Test window and returns you to the Home window.

View Menu

Create Message . Create Message opens the Compose Asset Message window (Figure 5-20). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

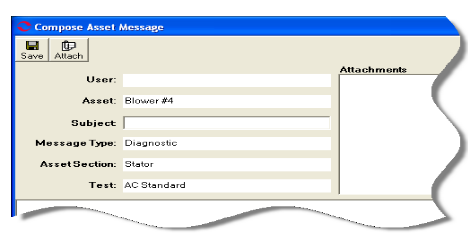


Figure 5-20: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-21). The Asset Condition box on the RIC Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

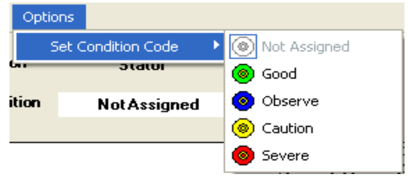


Figure 5-21: Set Condition Code Window

Step-by-Step RIC Testing

During the test the menu items are dimmed (not available). To stop testing, use File, Exit which becomes active after each test point.

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Place the shaft key way in the up position. This ensures a common starting point for all subsequent tests.

4. Ensure that the field is disconnected from the control circuit.

   This is accomplished by isolating/removing the brushes from the slip rings or by disconnecting the field leads from the diode pack in a self-exited asset. This allows the natural magnetic field on the rotor to expand, enhancing the detection of rotor problems.

5. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-3. This ensures that the test data is trendable/repeatable.

Table 5-3: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

6. Highlight the asset to be tested in the Site Navigator.

7. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-22.

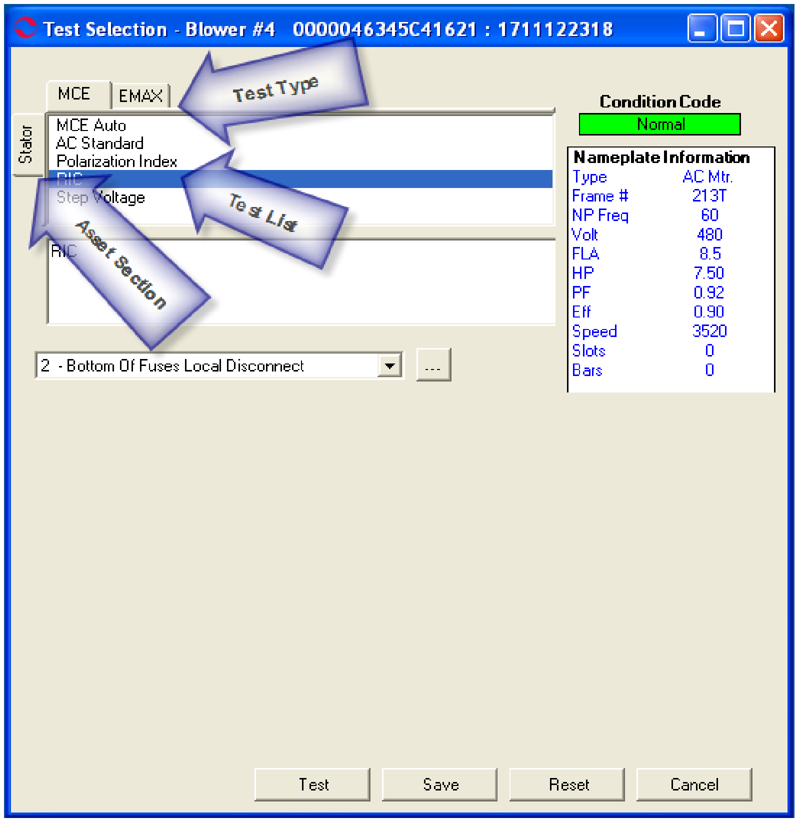


Figure 5-22: Test Selection Window

8. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset section is available.

9. Select RIC from the Test List box.

10. Verify the Test Location in the Test Setup section.

    To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-23.

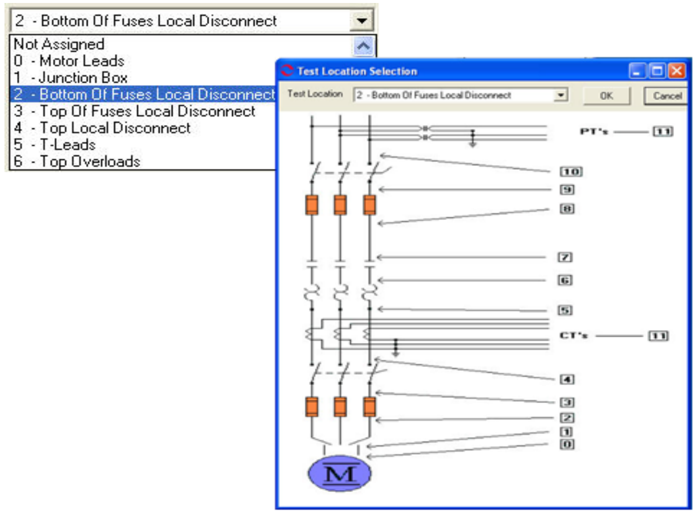


Figure 5-23: Test Locations

11. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

12. Click **Test** to go to the test. The RIC test window, Figure 5-24, opens.

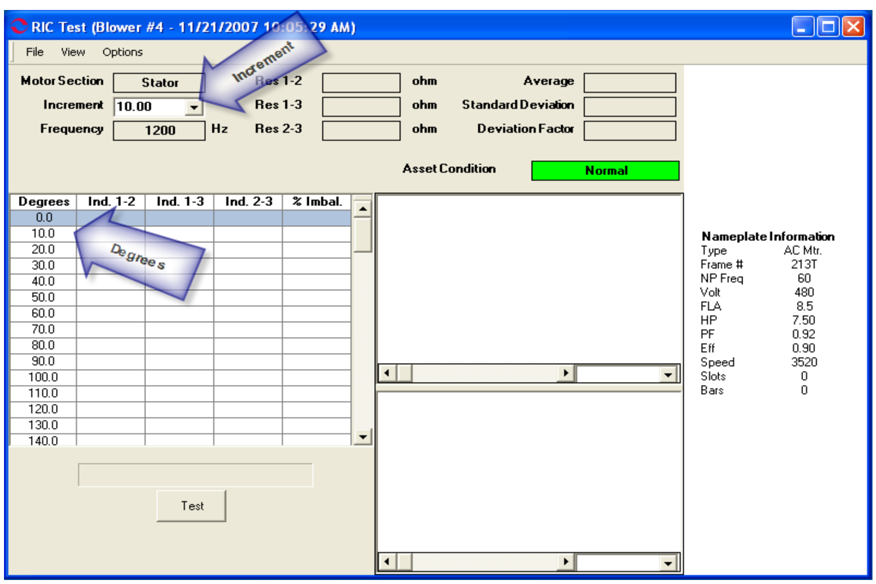


Figure 5-24: RIC Test Window

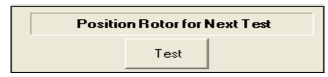
13. Verify that increments to be used during testing are correct. This information is located at the top of the RIC Test window.

    To change the Increments, which automatically computes the appropriate Degrees, click the down arrow and select the increment from the drop-down list.

    The new increments are displayed and the degrees on the test data table is updated.

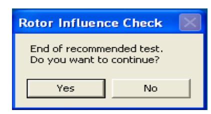
14. Position the rotor to the first position and click **Test** to begin testing.

15. At the end of each test point, you will be reminded to position the rotor for the next test point. Move the rotor and click **Test**. Repeat until the end of the recommended test.



    As the test progresses, the values will be inserted into the table and displayed in the graph areas. The magnification of the graphs can be changed by using the down arrows below each graph area and selecting a new value from the drop down list. The default is Full.

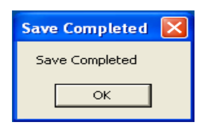
16. At the end of the recommended test you will be asked if you want to continue. Select **Yes** to continue testing or **No** to end testing.



17. Exit the RIC Test window by selecting File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

18. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The RIC Test window closes.



    If you select **No**, the RIC Test window closes. No test data is saved.

Step Voltage

The Step Voltage test is reached by selecting Step Voltage from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Step Voltage Test window opens. Figure 5-25.

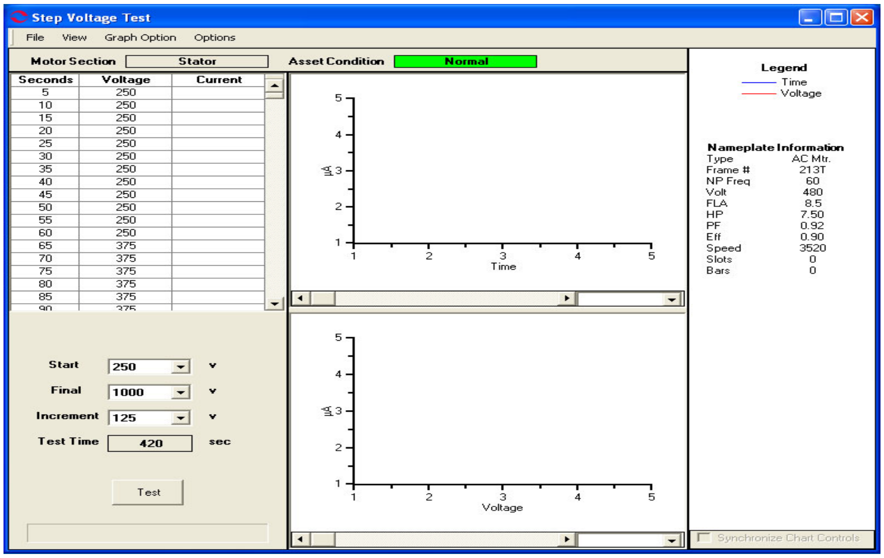


Figure 5-25: Step Voltage Test

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Step Voltage window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-26). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

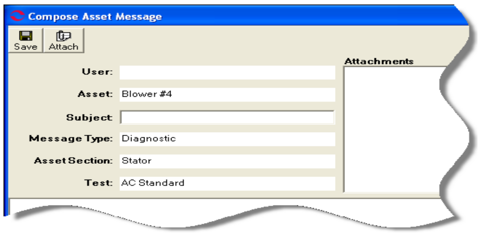


Figure 5-26: Compose Asset Message

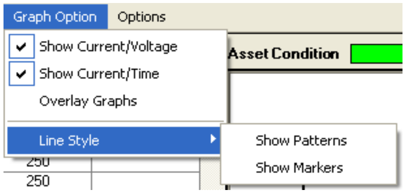
Graph Option Menu

Show Current/Voltage. Show Current/Voltage controls the graph display area. If just Current/Voltage is selected one graph displays on the window. If Show Current/Voltage and Show Current/Time are both selected then two graphs will display.

Show Current/Time. Show Current/Time controls the graph display area. If just Current/Time is selected one graph displays on the window. If Show Current/Time and Show Current/Voltage are both selected then two graphs will display.

Overlay Graphs. Overlay Graphs controls the graph display area. When Overlay Graphs is selected test results are graphed on one graph.

Line Style. Line Style controls the appearance of the line on the graph.



Show Patterns changes the graph line style from a solid to a pattern. When a change is made to the line style it is reflected in the Legend area of the window, which is located just above the Nameplate Information.

Show Markers inserts markers on the graph line. When a change is made to the line style it is reflected in the Legend area of the window, which is located just above the Nameplate Information.

Options Menu

Set Condition Code. Change the condition code, by selecting an option button (Figure 5-27). The Asset Condition box on the Step Voltage Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

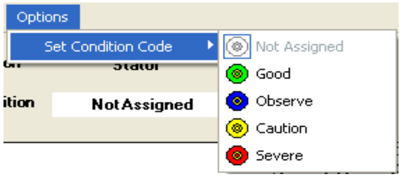


Figure 5-27: Set Condition Code Window

Step-by-Step Step Voltage Testing

During the test the menu items are dimmed (not available).

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-4. This ensures that the test data is trendable/repeatable.

Table 5-4: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-28.

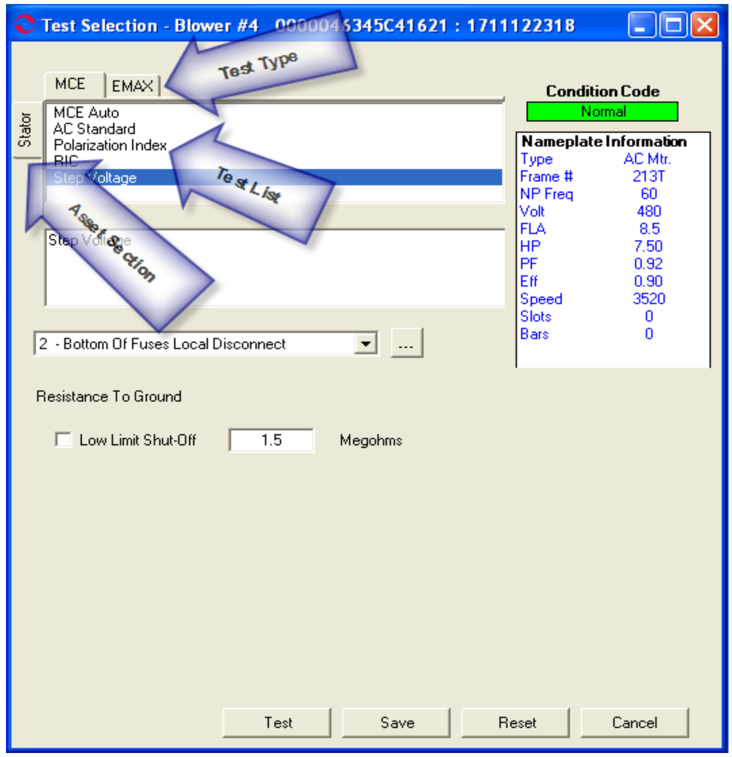


Figure 5-28: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Select Step Voltage from the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-29.

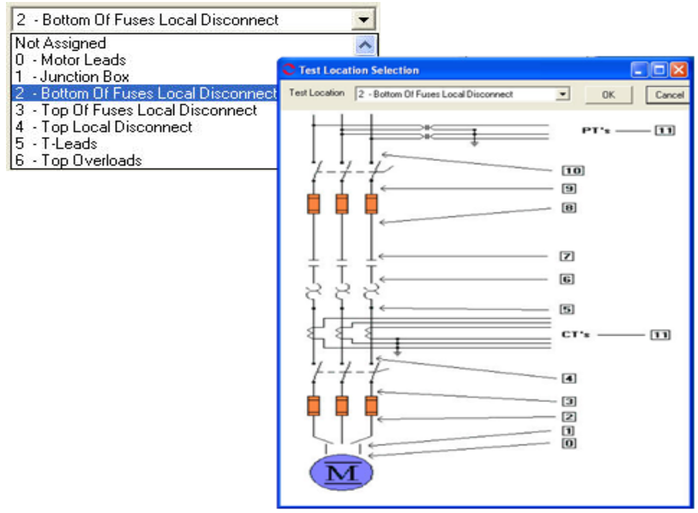


Figure 5-29: Test Locations

9. Verify the Low Limit Shut Off condition.

   Check the box to activate the low limit shut off and enter the desired Mohms.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the Step Voltage test window. See Figure 5-30.

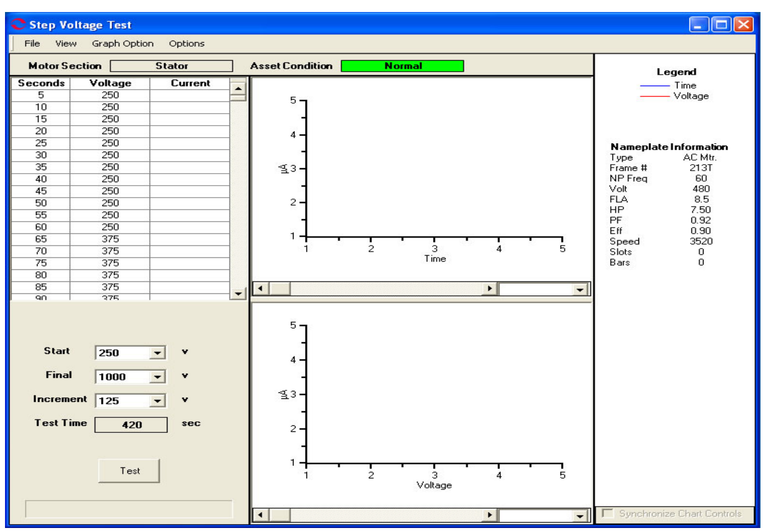


Figure 5-30: Step Voltage Test Window

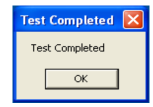
12. To begin the test click **Test**.

13. Verify that you are about to apply "X" volts to the circuit by clicking **Yes**.

14. Test values are entered in the table on the left and are displayed in graph format on the right side of the window. The magnification of the graphs can be changed by using the down arrows below each graph area and selecting a new value from the drop down list. The default is Full. A progress bar at the bottom of the screen tracks the testing progress.

    Note: During the test the **Test** button changes to **Stop**, which allows you to interrupt the testing.

15. At the end of testing click **OK** in the Test Completed window.



16. Exit the Step Voltage Window by selecting File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

17. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The Step Voltage Test window closes.

    If you select **No**, the Step Voltage Test window closes. No test data is saved.

AC Synchronous Assets

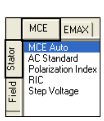
The MCE tests for an AC Synchronous asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage for the *Stator* section and MCE Auto, Synchronous, Polarization Index, and Step Voltage for the *Field* section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test
- Polarization Index (PI)/ Dielectric Absorption (DA). If a PI is performed, it is not necessary to perform a separate DA.

Synchronous assets are divided into two separate sections (Stator and Field Circuit). The asset Section of the Test Selection window defaults to Stator.

Some asset circuits may have surge capacitors and/or power factor correction capacitors installed. This is important since these components affect the values of the collected data, and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor or surge capacitors installed. However, a test should be taken with the surge capacitors removed for future comparison. If a asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.



Stator Section Test

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

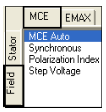
Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

RIC

RIC test is the same as for an AC Induction asset. See RIC on page 5-20.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.



Field Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Synchronous

The Synchronous test is reached by selecting the Field Tab and Synchronous from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Synchronous Test window opens. Figure 5-31.

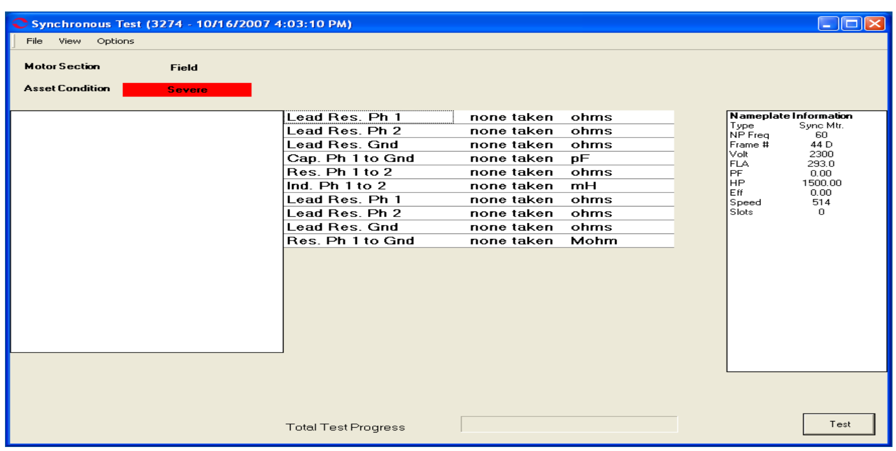


Figure 5-31: Synchronous Test Window

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Synchronous Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-32). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

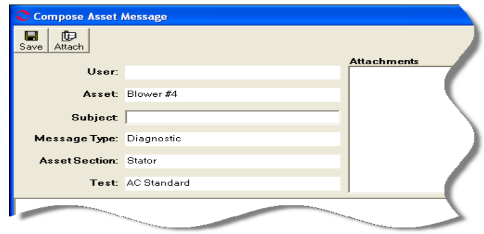


Figure 5-32: Compose Asset Message

Options Menu

Set Condition Code. Change the condition code, by selecting an option button, the Asset Condition box on the Synchronous Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

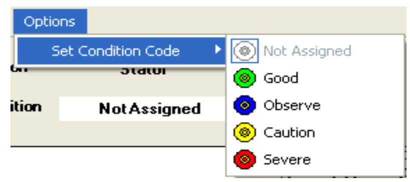


Figure 5-33: Set Condition Code Window

Step-by-Step Synchronous Testing

During the test the menu items are dimmed (not available).

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-5. This ensures that the test data is trendable/repeatable.

Table 5-5: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-34.

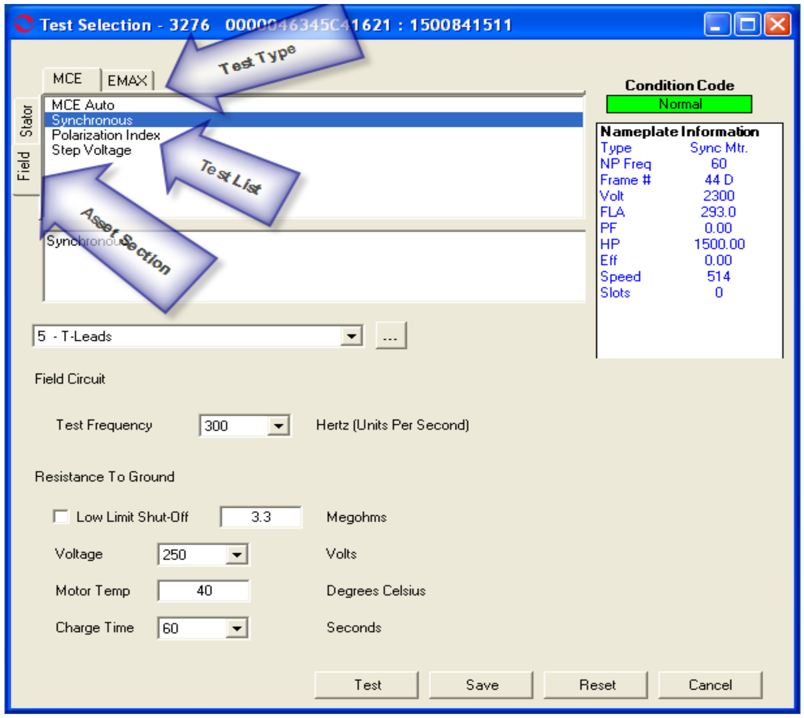


Figure 5-34: Test Selection Window

6. Verify that the MCE (Test Type) and Field (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Select Synchronous from the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-35.

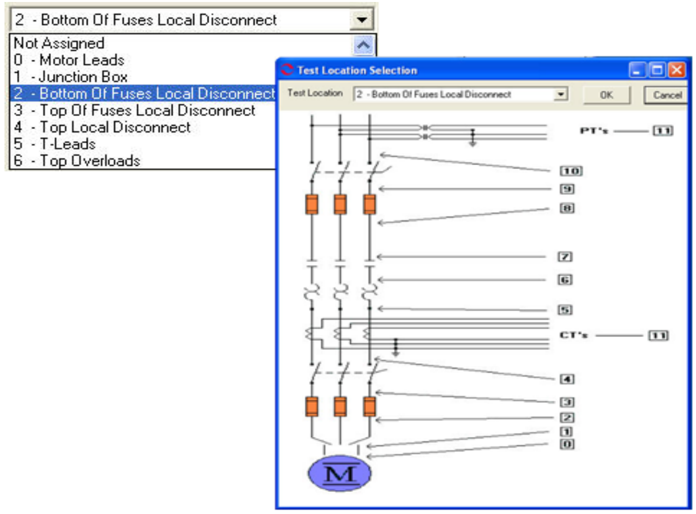


Figure 5-35: Test Locations

9. Verify the Test Frequency.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select the Charge Time Seconds.

    Click the down arrow and select the seconds from the drop-down list. The choices are from 30 to 180 seconds at 15 second increments.

14. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the Synchronous test window.

16. Verify that you are about to apply “X” volts to the circuit and click **Yes**.

17. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds.

18. At the end of testing the **Test** button changes to **Save,** Test Completed appears above the Nameplate Information section, and the progress bars disappear.

19. Re-test any individual point, if needed. If not go to step 20.

    If any portion of the test needs to be re-tested, click the tab which appears to the right of the individual test point. This retests only that test point in “manual mode.” (Figure 5-36)

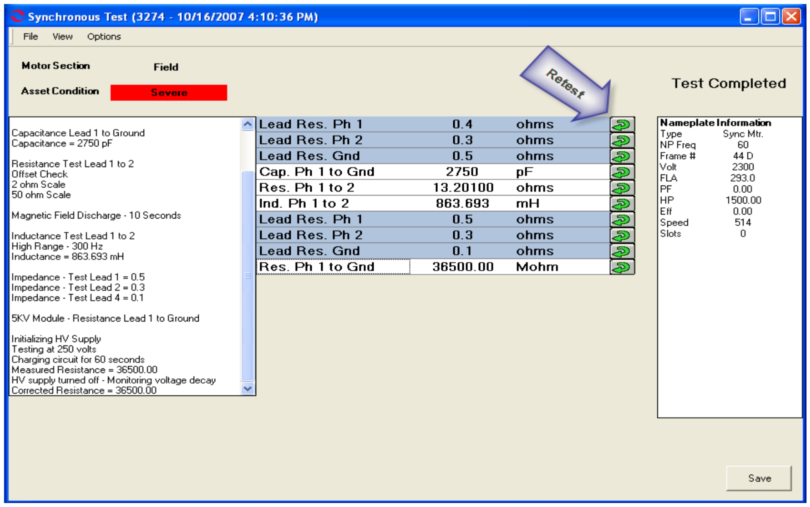


Figure 5-36: Completed Synchronous Test Window

20. When retesting is complete or if no re-testing is needed, click **Save** or File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

21. Click **OK** in the Save Completed window.

22. Click **Exit** to close the window.

AC Wound Rotor Assets

Wound rotor assets (WRMs) are divided into three separate sections (Stator, Rotor, and Resistor Bank). The asset Section box of the Test Selection window defaults to Stator.

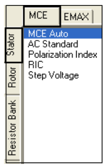
The MCE tests for an AC Wound Rotor asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage for the Stator section. MCE Auto, AC Standard, Polarization Index, and Step Voltage for the Rotor section. MCE Auto, Resistor Bank, Polarization Index, and Step Voltage for the Resistor Bank section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test

- Polarization Index (PI)/ Dielectric Absorption (DA). If a PI is performed, it is not necessary to perform a separate DA.

Some circuits may have surge capacitors and power factor correction capacitors installed. This is important since these components affect the values of the collected data, and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor capacitors installed. However, surge capacitors must be removed to ensure valid test data. If a asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.



Stator Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

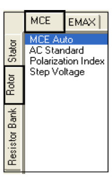
Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

RIC

RIC test is the same as for an AC Induction asset. See RIC on page 5-20.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5- 24.



Rotor Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

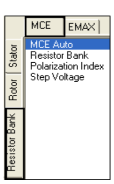
AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5- 24.



Resistor Bank Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Resistor Bank Test

The Resistor Bank test is reached by selecting the Resistor Bank tab and Resistor Bank from the test list on the Test Selection window. See page 1-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Resistor Bank Test window opens. Figure 5-37.

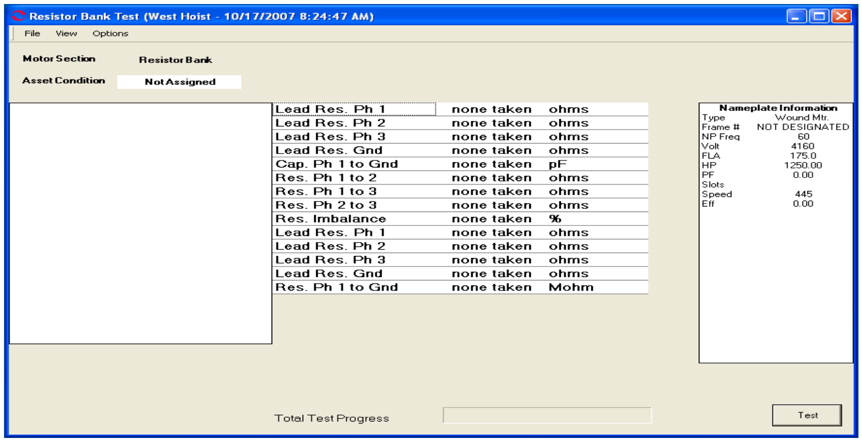


Figure 5-37: Resistor Bank Test Window

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Resistor Bank Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-38). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

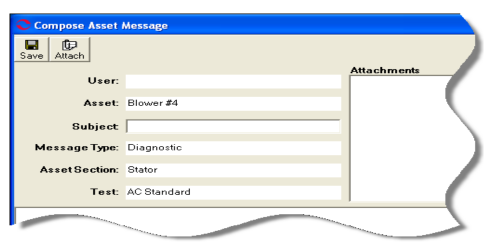


Figure 5-38: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting an option button (Figure 5-39). The Asset Condition box on the Resistor Bank Test window changes and a note is automatically generated by the software.

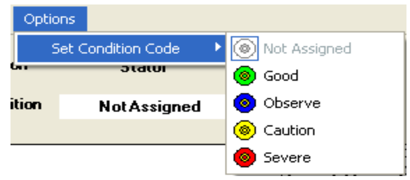


Figure 5-39: Set Condition Code Window

Step-by-Step Resistor Bank Testing

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Lift the brushes to isolate the resistor bank from the rotor field.

4. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-6. This ensures that the test data is trendable/repeatable.

Table 5-6: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
brushes	brushes over slip ring 1	brushes over slip ring 2	brushes over slip ring 3	gnd

5. Highlight the asset to be tested in the Site Navigator.

6. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-40.

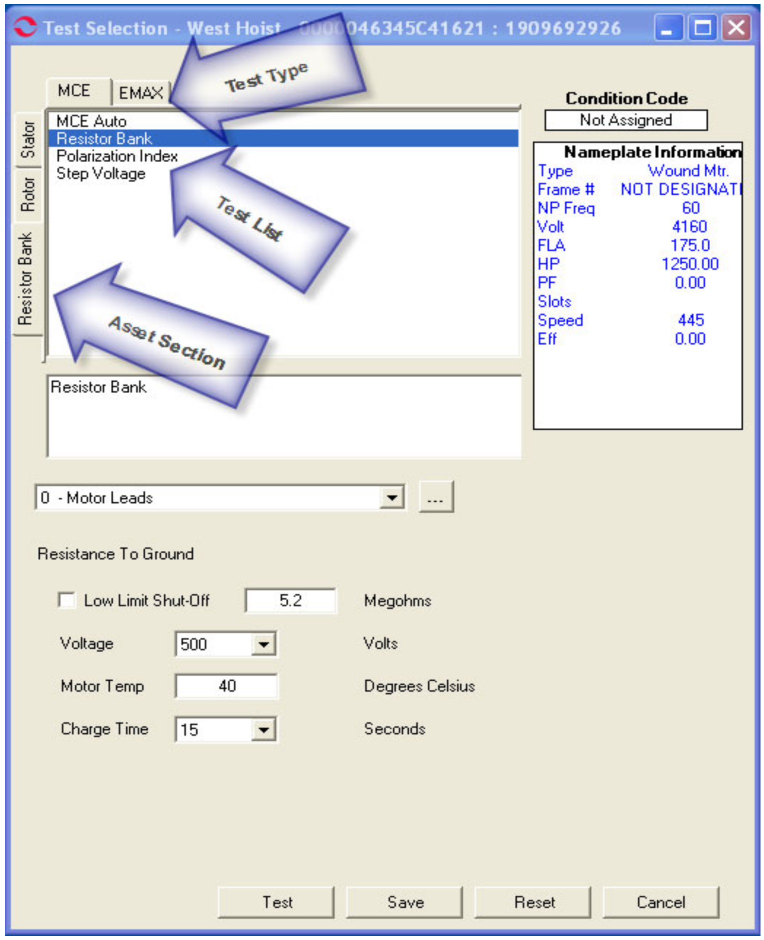


Figure 5-40: Test Selection Window

7. Verify that the MCE (Test Type) and Resistor Bank (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

8. Select Resistor Bank from the Test List box.

9. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-41.

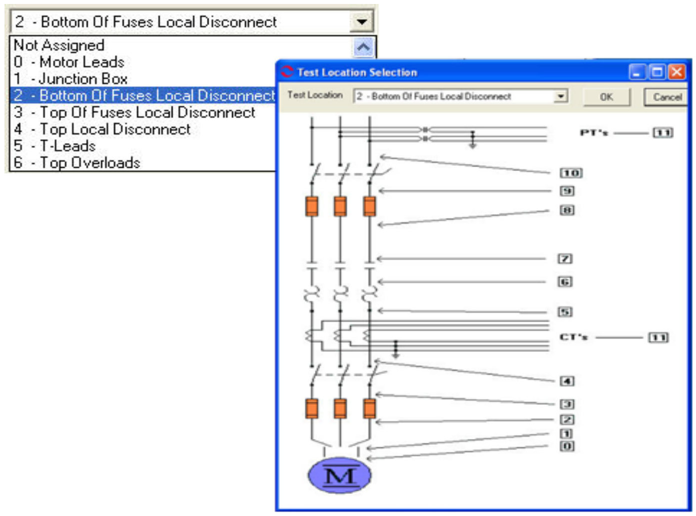


Figure 5-41: Test Locations

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

14. Click **Test** to go to the Resistor Bank Test window.

15. To begin the Resistor Bank Test, click **Test**.

16. Verify that you are about to apply “X” volts to the circuit and click **Yes**.

17. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area.

18. Re-test any individual point, if needed. If not go to step 19.

If any portion of the test needs to be re-tested, click the green arrow to the right of the point. This rechecks only that test point in “manual mode.” See Figure 5-42.

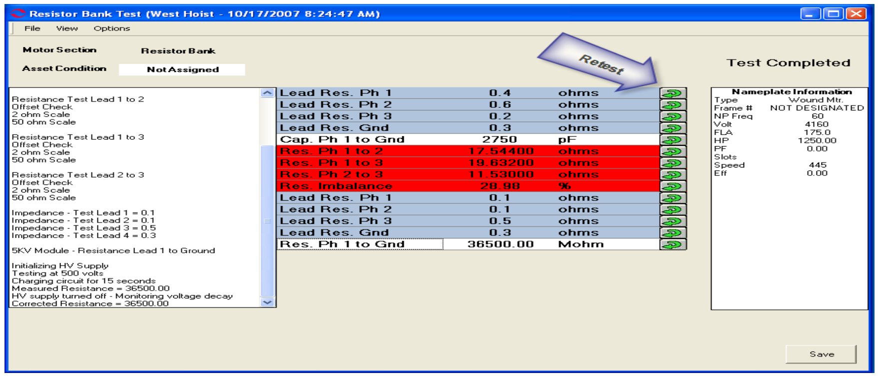


Figure 5-42: Resistor Bank Test Window - Retest Points

19. When retesting is complete or if no re-testing is needed, click **Save,** or File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

20. Click **OK** in the Save Completed window and the Resistor Bank Test window closes.

DC Assets

The MCE tests for a DC asset are MCE Auto, DC Standard, Polarization Index, Bar-to-Bar, and Step Voltage for the *Armature* section. MCE Auto, DC Standard, Polarization Index, and Step Voltage for the *Field* section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Standard Test

- Polarization Index (PI). If a PI is performed, it is not necessary to perform a separate DA.

DC assets are divided into two separate sections (Armature Circuit and Field Circuit). The Asset Section of the Test Selection window defaults to Armature Circuit.

Armature Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

DC Standard Test

The DC Standard Test is reached by selecting DC Standard from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The DC Standard Test Window (Figure 5-43) opens.

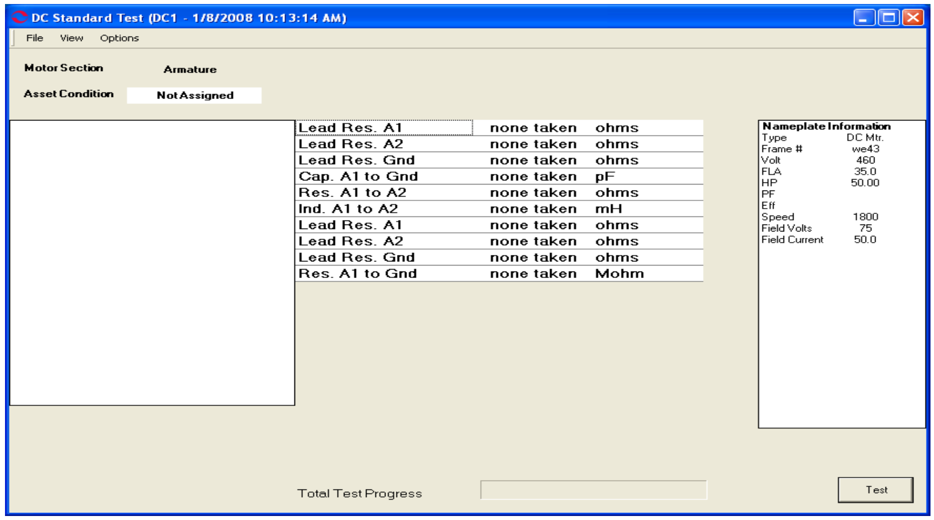


Figure 5-43: DC Standard Test Window

The DC Standard Test window menu consist of three options: File, View, and Options.

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the AC Standard test window and returns you to the MCEGold Home window.

View Menu

Create Message. Create Message opens the Compose Asset Message window (Figure 5-44). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

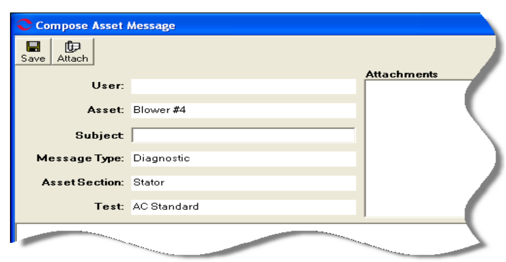


Figure 5-44: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting an option button (Figure 5-45). The Asset Condition box on the AC Standard Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43

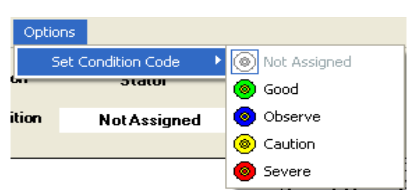


Figure 5-45: Options, Set Condition Code Menu

Step-by-Step DC Standard Testing

1. Deenergize and lock out the starter and asset.

2. Check for low level induced voltage using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit, in the same manner each time, as referenced in Table 5-7 and shown in Figure 5-46. This ensures that the test data is trendable/repeatable.

Table 5-7: Test Lead Connections

MCE test leads	Black	Blue	Green
motor leads	A1; A1 or S1	A2; S2 or A2	ground

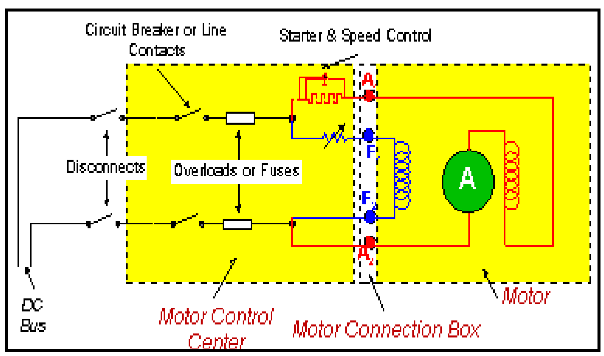
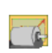


Figure 5-46: DC Asset Circuit Connections

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the tool bar to open the Test Selection window.

6. Verify that Armature Circuit is selected in the asset Section box.

7. Select DC Standard Test in the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button [...] . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-47.

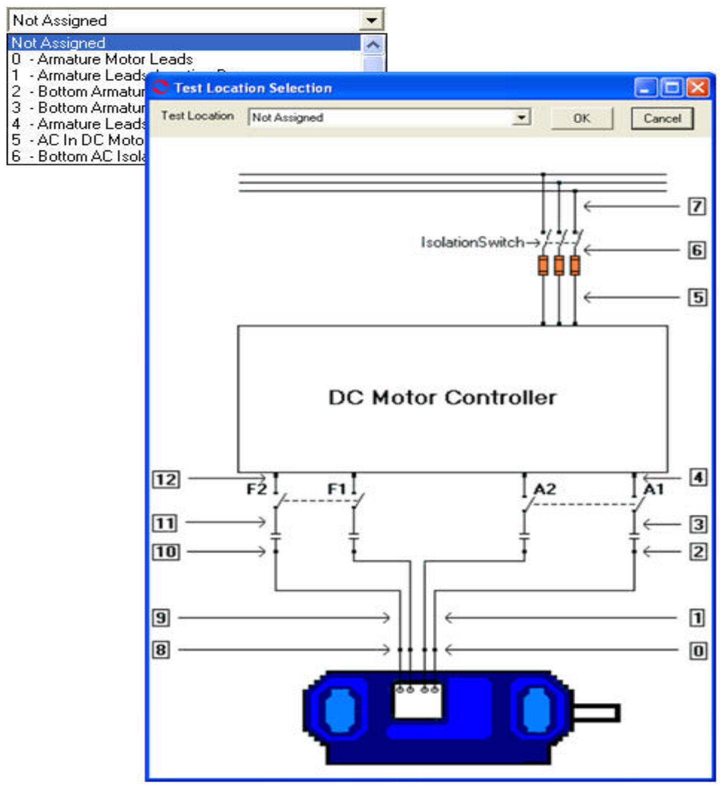


Figure 5-47: DC Asset Test Location

9. Select Test frequency for the Armature Circuit from the drop-down box.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Check the Low Limit Shut Off box and enter Mohms.

11. Select the test voltage for the resistance to ground measurement (500 for ≤ 2400 volts or 1000 for >2400 volts) based on asset nameplate voltage.

    Click the down arrow and select the voltage from the drop-down list.

12. Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select Charge Time seconds.

    Click the down arrow and select the charge time from the drop-down list. The choices are from 15 to 600 seconds.

14. Click **Save**, to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the DC Standard Test Window.

16. Click **Test** to begin testing.

17. Verify that you are about to apply "X" volts to the circuit by clicking **Yes**.

18. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area. See Figure 5-48.

    To stop the test at any time, click **Stop**. Click **Exit** to close the DC Standard test window and return to the Home window.

19. Re-test any individual point, if needed. If not go to step 20.

    If any portion of the test needs to be re-tested, double click the tab which appears to the right of the individual test point. This rechecks only that test point in "manual mode." See Figure 5-48.

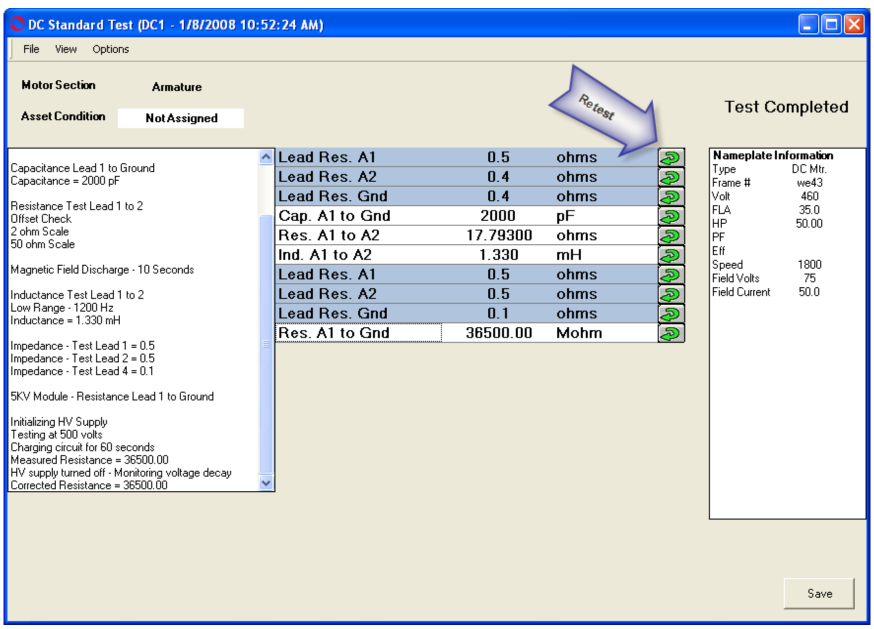


Figure 5-48: DC Standard Test Window

20. When retesting is complete or if no re-testing is needed, click **Save** or select File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

21. Click **OK** in the Save Complete window.

22. Click **Exit** in the DC Standard Test Window.

Step-by-Step Polarization Index Testing

1. Deenergize and lock out the starter asset.

2. Check for low level induced voltage using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground

3. Connect the MCE test leads to the circuit, in the same manner each time, as referenced in Table 5-8 and shown in Figure 5-49. This ensures that the test data is trendable/repeatable.

Table 5-8: Test Lead Connections

MCE test leads	Black	Blue	Green
motor leads	A1; A1 or S1	A2; S2 or A2	ground

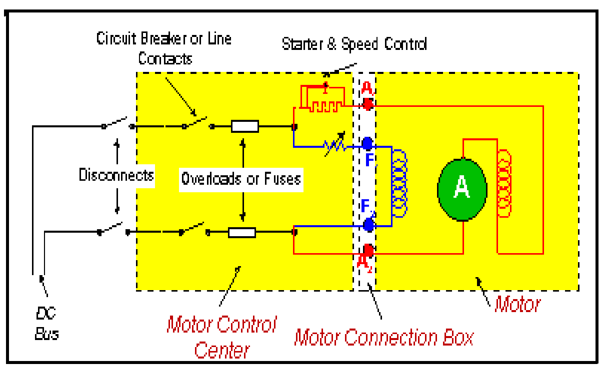
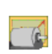


Figure 5-49: Asset Circuit Connections

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the tool bar to open the Test Selection window.

6. Verify that Armature is selected.

7. Select Polarization Index in the Test List Box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-50.

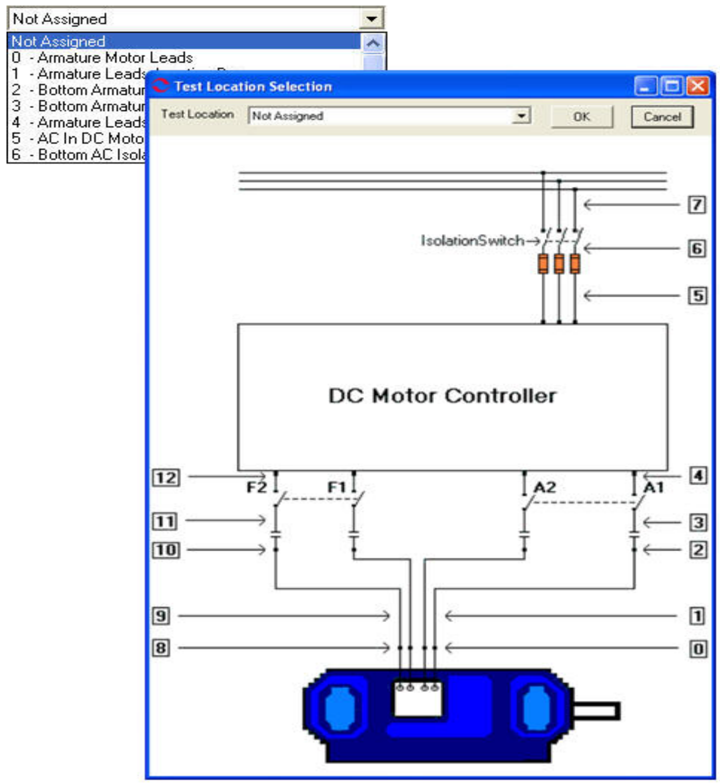


Figure 5-50: DC Asset Test Location

9. Check the Low Limit Shut Off box and enter Mohms.

10. Enter the test voltage for the resistance to ground measurement (500 for ≤ 2400 volts or 1000 for >2400 volts) based on asset nameplate voltage.

    Click the down arrow and select the voltage from the drop-down list.

11. Click **Save**, to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

12. Click **Test** to go to the PI Test Window. See Figure 5-51.

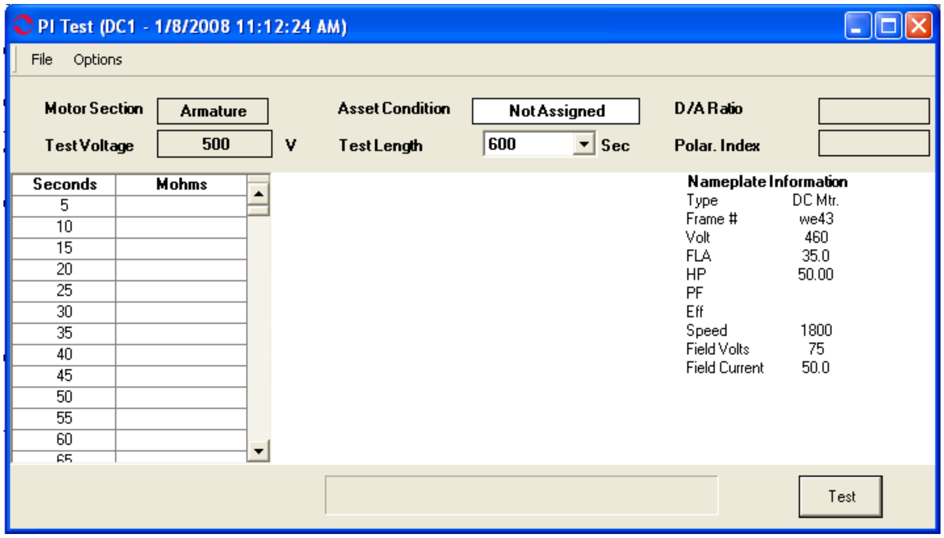


Figure 5-51: PI Test Window

13. Select the test length in seconds from the drop down list.

14. Click **Test** to begin testing.

    To stop the test at any time, click **Stop**. Click **Exit** to return to the Test Selection window.

15. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

16. During the testing the D/A ratio and the Polarization Index will be computed and entered in the appropriate text boxes on the window.

17. Click **OK** at the end of testing in the Test Complete window.

18. Close the PI Test window by selecting File, Exit, or Ctrl+X, or the close button (red X in the upper right corner).

19. Click **Yes** to save test data, in the Save Test Data window. Or **No** to exit without saving test data.

20. Click **OK** in the Save Completed window.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Bar-to-Bar

The Bar-to-Bar test is reached by selecting the Armature tab and Bar-to-Bar from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Bar-to-Bar Test window opens. Figure 5-52.

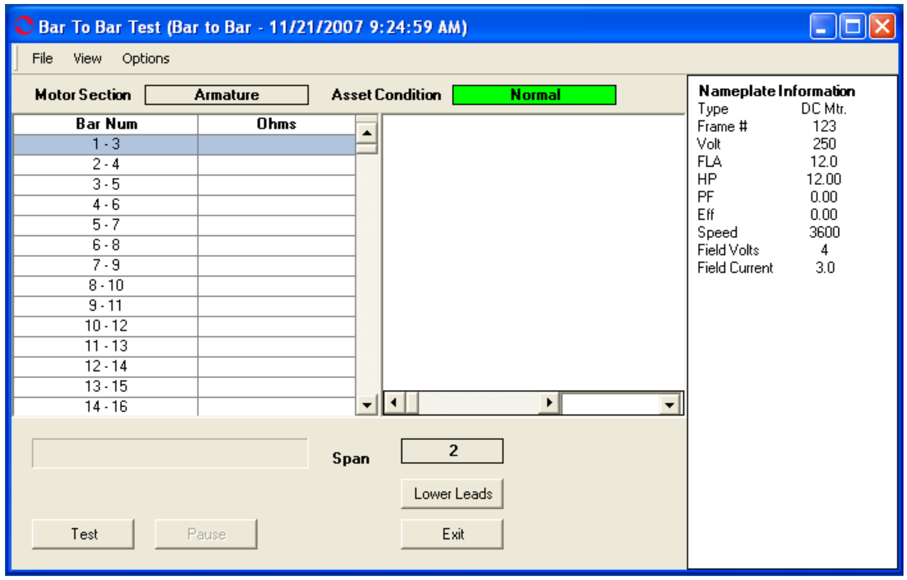


Figure 5-52: Bar-to-Bar Test Window

File Menu

Exit. Exit (Ctrl+X) closes the Bar-To-Bar Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-53). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

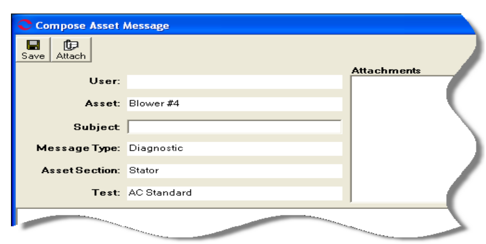


Figure 5-53: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting the desired condition code option button (Figure 5-54). The Asset Condition box on the Bar-To-Bar Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

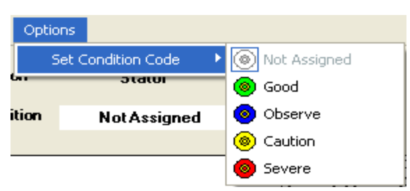


Figure 5-54: Set Condition Code Window

Raise Leads/Lower Leads Button

The Raise Leads/Lower Leads button toggles to signify the action to be taken with the test leads during testing.

Exit Button

The Exit Button is inactive (dimmed) during testing, but is active between moving the leads.

Pause Button

The Pause Button is inactive (dimmed) during testing, but is active between moving the leads.

Test

The lower left area of the Bar-to-Bar test window, Figure 5-55, informs you what action is required. The Test Dialog box displays the testing progress. The software checks for the leads and if no leads are found displays, "Waiting for Leads" in the text box. When the leads are in position, testing begins automatically. During testing the text box displays Read Resistance, Checking Leads, Test Completed, Waiting for Leads.

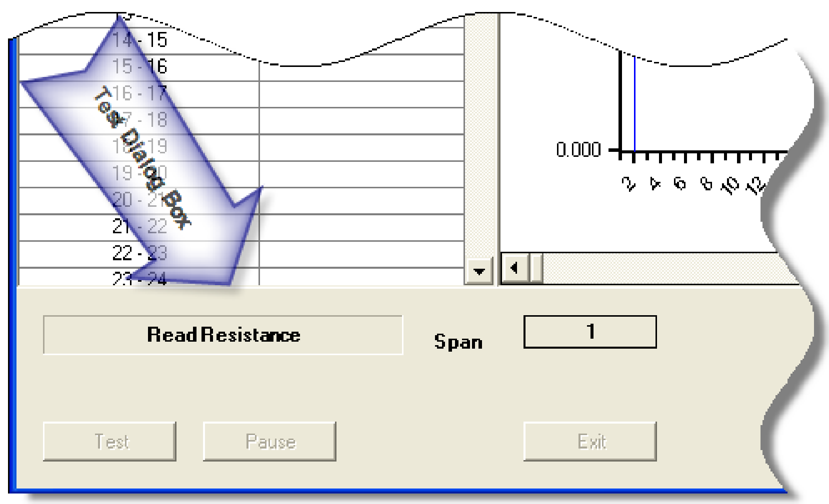


Figure 5-55:

Step-by-Step Bar-to-Bar Testing

1. Deenergize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the bar-to-bar test leads to the MCE and to the laptop parallel port.

4. Highlight the asset to be tested on the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-56.

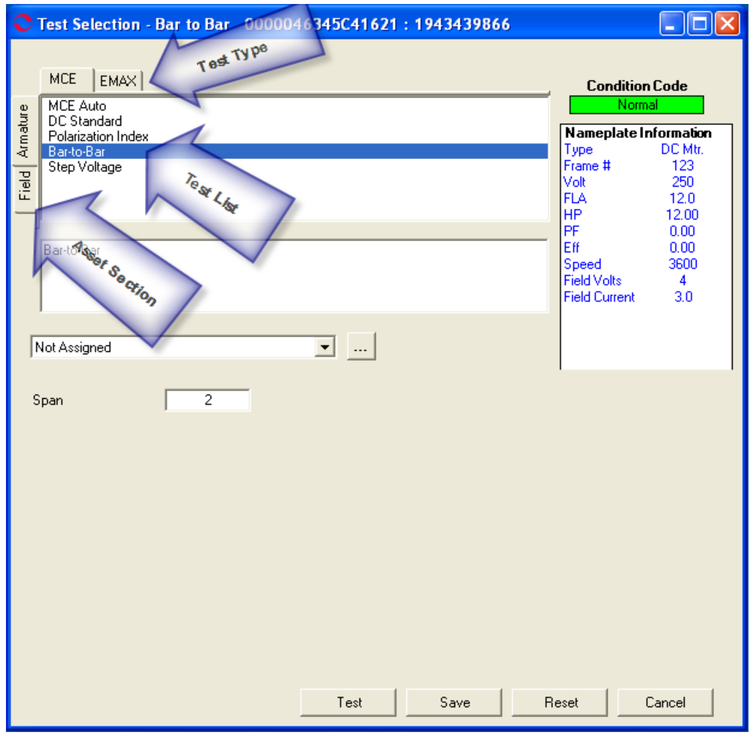


Figure 5-56: Test Selection Window

6. Verify that the MCE (Test Type) and Armature (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Click Bar-To-Bar from the Test List.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-57.

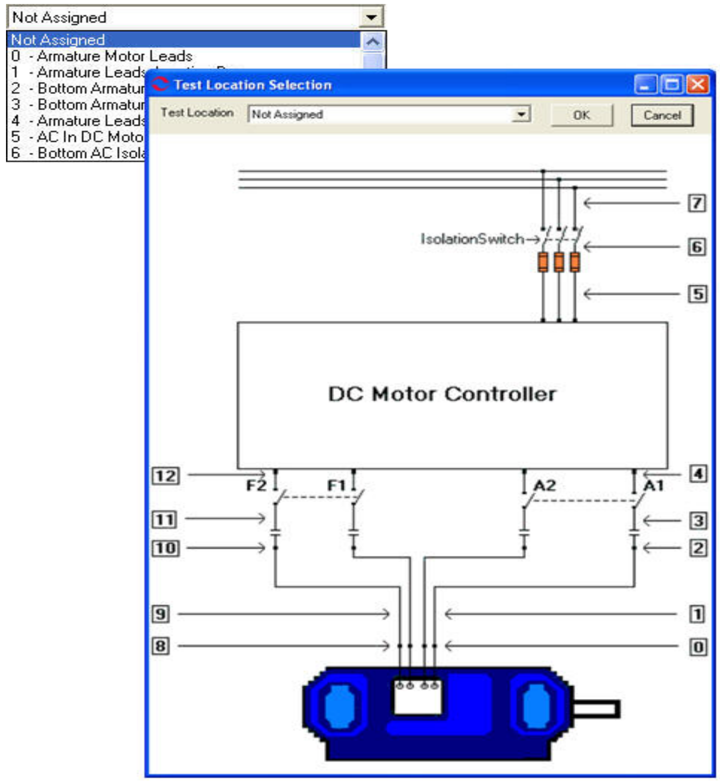


Figure 5-57: DC Asset Test Location

9. Verify the Span is correct.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the testing window

12. To begin the Bar-to-Bar Test, click **Test.**

13. When "Waiting for Leads" appears in the Test Dialog Box, position the leads. Testing will begin automatically. The dialog box will inform you of the testing progress beginning with Read Resistance, Checking Leads, and finally Test Complete. See Figure 5-58.

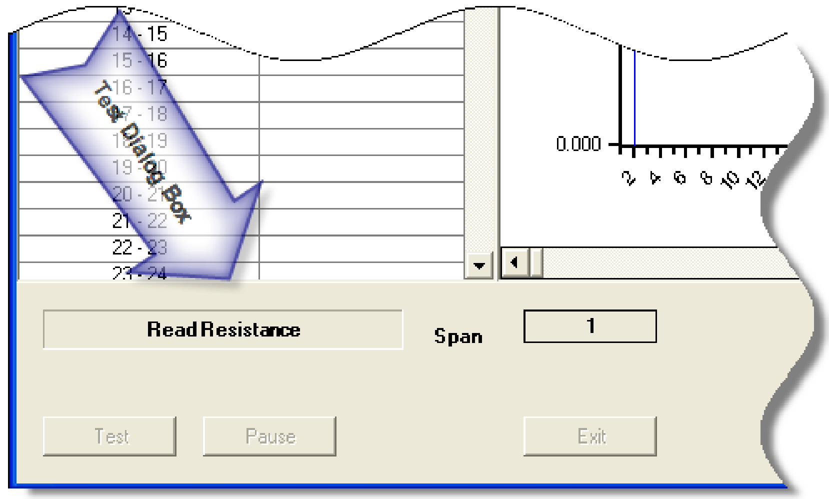


Figure 5-58: Test Dialog Box

14. During testing the test values are entered in the table on the left and are displayed in graph format in the center of the window. The magnification of the graph can be changed by using the down arrows below the graph area and selecting a new value from the drop down list. The default is Full.

15. When Test Complete appears in the Test Dialog box, reposition the leads. Testing will begin automatically.

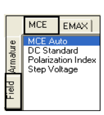
16. Repeat Step 14 until all bars have been tested.

17. At the end of testing, you will be asked if you want to continue testing. Click **Yes** to continue or **No** to end testing.

18. Click **Exit**. You will be asked if you want to save test data.

    Click **Yes** to save the test data. Click **OK** in the Save Completed window. The Bar-to-Bar test window closes.

    Or click **No** to exit the window without saving.



Field Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

DC Standard

DC Standard test for the Field section is the same as for the Armature section. See DC Standard on page 5-40.

Polarization Index

The Polarization Index test for the Field section is the same as for the Armature section. See Polarization Index on page 5-45.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

TEST DATA ANALYSIS INFORMATION

Standard Test

The standard test is similar for both AC and DC assets. In an AC asset, the following are either measured or calculated during a standard test:

Resistance-to-ground
Capacitance-to-ground
Resistance phase-to-phase
Inductance phase-to-phase
Resistive imbalance (calculated)
Inductive imbalance (calculated)
Power loss

In a DC asset, the following are either measured or calculated during the standard test:

Resistance-to-ground
Capacitance-to-ground
Armature and/or field resistance
Armature and/or field inductance

Resistance-to-Ground

What Does it Tell You?

The resistance-to-ground (RTG) measurement indicates the cleanliness and health of the insulation system. As the insulation ages, cracks and small holes develop. It also becomes brittle over time, as the wiring expands due to heating and contracts when it cools off. Aging and temperature variations also break down the molecular structure of the insulation.

These factors allow contaminants and moisture, which collect on the surface of the insulation, to penetrate to the conductor. Since current follows the path of least resistance, some of the total current is diverted from the circuit to these alternate paths, and ultimately to ground. As the RTG value decreases over time, capacitance-to-ground often increases, indicating the presence of many current leakage paths to ground and the accumulation of contaminants.

Why is This Important?

A low RTG value indicates that the insulation needs to be cleaned. If the condition causing the low RTG is not corrected and the RTG value continues to drop, the insulation could completely fail and the asset windings could be damaged. This could require a complete rewind of the stator. If the condition causing the low RTG is corrected, a less expensive clean, dip, and bake may suffice.

Setting Warning Levels

Minimum Value. IEEE (the Institute of Electrical and Electronics Engineers, Inc.) has established a standard for the minimum value of insulation resistance which can be applied to most AC windings, DC armature windings, and AC and DC field windings. The

standard is IEEE Std 43-2001. The equation for most windings made circa 1970 or before, all field windings, and others not noted in the exceptions listed below is IR_{1min}=kV+1.

In the formula:

IR_{1min} is the recommended minimum insulation resistance-to-ground, in megohms, at 40°C (104 °F) at the asset windings

kV is the rated terminal-to-terminal potential, in RMS kilovolts

Examples

A 480 volt asset has a minimum RTG value of 1.48 megohms (480 volts = .480 kilovolts; .48 + 1 = 1.48 megohms)

A 4160 volt asset has a minimum RTG value of 5.160 megohms (4160 volts = 4.160 kilovolts; 4.160 + 1 = 5.160 megohms)

MCEGold computes the minimum acceptable RTG value using this equation. This value is corrected to 40 °C. MCEGold provides both the temperature corrected RTG reading along with the actual measured RTG value. To make comparisons and trending valid, always enter actual asset winding temperature and trend the corrected measurement.

Exceptions to the equation are:

- Most DC armature and AC windings built circa or after 1970 (form wound coils). That standard is $IR_{1\ min}$ = 100.
- Most machines with random-wound stator coils and form-wound coils rated below 1 kV. That standard is IR_{1min}= 5.

Stator of AC Induction, Synchronous, and Wound Rotor Assets; Field and Armature of DC Assets

If the corrected RTG is between R_m and 2 times R_m, then the value is set at caution. The reading appears in yellow on the tester display or underlined on a printed copy of the Test History. If the reading is less than R_m, the value is set at alarm. The reading appears in red on the tester display or bolded on a printed copy.

Wound Rotors, Resistor Banks

Voltages in wound rotors and their three-phase resistor banks are typically too low to use the minimum resistance equation to figure minimum values. The warning levels should be set based on your experience. Establish a baseline test for new assets and assets tested for the first time, and watch the trends. Compare values on similar assets operating under similar conditions.

Exceptions

Some assets may show insulation resistance readings which are lower than the IEEE recommended minimum value and still have “good” insulation. These include:

- Windings with an extremely large surface area
- Large or slow-speed assets
- Assets with commutators

A DC armature with a low RTG value typically has multiple paths for leakage current, not just one. Because of this, finding the exact location of ground faults is almost impossible and repair is very difficult. This problem is much more complex than in AC assets. Therefore, lower minimum acceptable RTG values are generally tolerated. In these cases, the IEEE standard of IR_{1min}= kV + 1 is typically relaxed to IR_{1min}= kV.

Out-of-service assets, without installed heaters operating, may absorb enough moisture to lower insulation resistance to less than the recommended limits.

Interpreting Readings

There are two factors, which require user input, which affect the value of RTG measurements. They are temperature and charge time. In order to compare temperature-corrected RTG readings for similar assets operating under similar conditions, these factors MUST be taken into account.

Temperature

The Test Selection window uses the IEEE standard reference value of 40°C as the default value for the winding temperature. This can be changed. The corrected RTG reading shown at the end of the test and in the Test History is the value that would be expected at 40°C regardless of the *actual* temperature of the asset winding insulation when the test was performed. In other words, if the reading is always corrected to the same temperature, then temperature is removed as an influencing factor. This allows you to use the corrected RTG value from test to test as a valuable trending tool.

Temperature correction is necessary since the resistance of an insulation material decreases significantly as its temperature increases. The materials which make up insulation have a negative temperature coefficient (inversely proportional). In other words, as the temperature increases their ability to stop current flow decreases. This means it is necessary to know the temperature of the asset when determining the condition of the insulation system.

Therefore, as the temperature of the asset increases, the measured insulation resistance decreases. To compare the reading you got today with a reading you got last month, it is important that you compare like results. The way to do this is to calculate the corrected resistance to a given temperature. MCE resistance values are corrected to a standard temperature of 40°C. This temperature is selected because the normal operating temperature for an asset is typically approximately 40°C (104°F). When comparing the results of different tests note the temperature input for possible variations.

Table 5-9 shows the report results for the same insulation with resistance to ground measurements taken at a variety of temperatures and compensated to different temperatures.

Table 5-9: Temperature Compensation

Temperature	Actual Resistance	25 °C Compensated	40 °C Compensated
20 °C	20 Megaohm	14 Megaohm	5 Megaohm
25 °C	14 Megaohm	14 Megaohm	5 Megaohm
30 °C	10 Megaohm	14 Megaohm	5 Megaohm
35 °C	7 Megaohm	14 Megaohm	5 Megaohm
40 °C	5 Megaohm	14 Megaohm	5 Megaohm
45 °C	3.5 Megaohm	14 Megaohm	5 Megaohm
50 °C	2.5 Megaohm	14 Megaohm	5 Megaohm

It can be seen from the chart that if temperature compensation is not performed, the reported (actual) resistance to ground changes with temperature. When temperature compensation is performed, the reported resistance does not change when the test temperature changes. In order to compare results, all measurements MUST be compensated to the same temperature.

Test Voltage and Charge Time

The ground wall insulation in a asset has a conductor on either side. On one side of the insulation is the stator windings, the conductors that make up the individual coils in each pole group for each phase. On the other side is the stator core, formed by the stator laminations connected to the frame/casing of the asset. This design has the fundamental components which make up a capacitor. When a DC potential is applied, the insulation “charges” the way a capacitor does. This is important because if the resistance to ground reading is recorded as soon as the test potential is applied, it is lower than if it is recorded after the insulation is “charged.”

A rule of thumb for performing RTG measurements is to *apply the test potential for 1 minute or until the reading has stabilized*. This allows for different technicians to obtain values from test to test which can be compared. However, this is not very accurate. On the MCE, the duration of time the voltage is applied to the insulation system is selectable.

Test voltage potential can be from 250 to 5000 volts, based on asset nameplate voltage. Charge time can be set between 15 and 600 seconds, at 15 second intervals. Defaults are set at 500 volts and 60 seconds. Again, using the same values every time makes comparison and trending a valuable tool.

Data Interpretation

If the RTG value is low, isolate the problem to either the power circuit or the asset. Assuming the first test was made at the MCC, perform another test at the asset connection box. Disconnect the asset leads and test the asset. If the RTG value is higher testing the asset, the fault is in the cables between the MCC and the asset. Check the connections in the asset connection box, look for moisture in the conduit, and examine the cables. The cables may require cleaning, drying, or replacement.

If the RTG value at the asset connection box is still low, the fault is in the asset. If the value is in caution, the asset may need to be dried, cleaned in place, or removed for a clean, dip, and bake. If the value is in alarm, the asset may need to be rewound. If the RTG value is less than the IEEE minimum, look for a ground fault and clear this condition before starting the asset.

Examples

A conveyor asset was tested and had <.1 Megohm RTG. When the technician removed the terminal box cover, he found that one of the taped connections had arced to ground. The leads were repaired and the asset was retested. RTG increased to 263 Megohms.

A compressor asset was tested and had <.1 Megohm RTG. When the technician removed the terminal box cover, he saw that the box was half full of water. The leads were dried and the asset was retested. RTG increased to 21.5 Megohms

Capacitance-to-Ground

What Does it Tell You?

The capacitance-to-ground (CTG) measurement is indicative of the cleanliness of the windings and cables. As dirt and contaminants build up on windings and cables, CTG values increase. An increasing trend showing rising CTG values indicates that the asset needs to be cleaned.

Why is This Important?

A capacitor is formed by any two conducting materials, called plates, separated from each other by a dielectric material. Dielectric material is anything that is “unable to conduct direct electric current.” A cable or winding surrounded by insulation provides one conductor and the dielectric material. The second plate is formed by the stator core and casing iron.

Normally, when the outside of the insulation is clean and dry, it is not a good conductor. When dirt, moisture, and other contaminates begin to cover the stator windings inside the asset, they cause the outer insulation surface areas to become conductive. Since this surface is in contact with the ground, it allows an AC current path to ground. Cables in the power circuit are also subjected to the same affect, when moisture penetrates the outer casing. The cleanliness of the windings and cables can be determined by looking at the CTG value.

With a buildup of material on them, dirty windings and cables produce higher capacitance values than clean ones do. Over time, CTG values steadily increasing indicate an accumulation of dirt and that cleaning is necessary. This can be correlated with decreasing RTG values.

Dirt and contamination also reduce a asset’s ability to dissipate the heat generated by its operation, resulting in premature aging. A general rule of thumb is that insulation life decreases by 50% for every 10 °C (50 °F) increase in operating temperature above the design temperature of the insulation system. This holds true with the asset operating at or above a 75% load. Heat raises the resistance of conductor materials and breaks down the insulation. These factors accelerate the development of cracks in the insulation, providing paths for unwanted current to flow to ground. If capacitance is higher than normal, a low RTG reading is an indication that such a path already exists.

Setting Warning Levels

Preset warning levels for CTG values in MCEGold are based on a percent change from the baseline measurement. This is merely a comparison warning. A 100% increase from baseline produces a caution (yellow on the computer display or underlined on the printed copy). A 200% increase from baseline produces an alarm (red on the computer display or bold on the printed copy). These values are guidelines. As you gather data on a single

asset or on similar assets operating in the same environment, reset the warning levels to reflect your specific conditions.

Data Interpretation

Capacitance-to-ground is a function of many factors. Therefore, comparison of CTG values is more revealing of a asset's condition than is the analysis of a single snapshot CTG value. For example, capacitance to ground is influenced by the design of each individual asset, the length of the cable between the MCE and asset, the type of insulation on the cables and asset windings, and the number and type of connectors in the circuit.

A new or recently refurbished asset may have a very low CTG reading. A "normal" capacitance value can vary from asset to asset and is NOT an absolute value. CTG must be analyzed by trending readings on the same asset or by comparing values taken on similar assets, with similar histories, operating under the same conditions. If CTG increases over time, dirt, moisture, and/or contaminants are building up on the windings, cables, or both.

Surge capacitors are used in some circuits and will affect CTG readings. Whenever possible, CTG tests should be performed with the capacitors in the circuit as well as disconnected, to indicate the health of the capacitors. This allows for trending the condition of the capacitors as well as the CTG of the asset.

Examples

Capacitors and surge caps were left in the circuit for tests of two chillers used to cool vital computers. Table 5-10 shows how several values were affected. Notice the difference in the readings when the power factor capacitors were removed.

Table 5-10: Effects of Power Correction Capacitors

	With Power Factor Capacitors Installed		With Power Factor Capacitors Removed	
	Chiller #1	Chiller #2	Chiller #1	Chiller #2
Balance of Resistance	1.74%	2.164%	0.050%	2.000%
Balance of Inductance	16.0%	0.520%	2.560%	0.500%
CTG	999,999 pF	999,999 pF	38,750 pF	37,250 pF
RTG	0 Megohms	0 Megohms	>2,000 Megohms	> 2,000 Megohms

A conveyor asset was tested and had <.1 Megohm RTG and 999,999 pF CTG. When the technician removed the terminal box cover, he found that one of the taped connections had arced to ground. The leads were repaired and the asset was retested. RTG increased to 263 Megohms and CTG decreased to 67,750 pF.

A compressor asset was tested and had <.1 Megohm RTG and 83,000 pF. When the technician removed the terminal box cover, he saw that the box was half full of water. The leads were dried and the asset was retested. RTG increased to 21.5 Megohms and CTG decreased to 8,000 pF.

Phase-To-Phase Resistance

What Does it Tell You?

Phase-to-phase resistance is the measured DC resistance between phases of the stator in an AC asset and between polarities of the armature and field coils in a DC asset.

In AC induction assets, use the phase-to-phase resistance values and resistive imbalances for trending, troubleshooting, and quality control. In DC assets, use trending and relative comparison to determine the condition of the phases in the asset and power circuits. This includes comparing readings taken from identical assets operating in similar conditions and comparing current readings against past readings for the same asset.

An increasing resistive imbalance or a changing resistance over time can indicate one or more of the following:

- High resistance connections
- Coil-to-coil, phase-to-phase, or turn-to-turn current leakage paths
- Corroded terminals or connections
- Loose cable terminals or bus bar connections
- Open windings
- Poor crimps or bad solder joints
- Loose, dirty, or corroded fuse clips or manual disconnect switches
- Loose, pitted, worn, or poorly adjusted contacts in asset controllers or circuit breakers
- Mismatched components (incompatible materials, wrong sizes, etc.)
- Undersized conductors (misassembled or improperly engineered)

Why is This Important?

Circuit resistance is determined by the length, size, width, composition, condition, type and temperature of the conductors and connectors. When two different conductors are connected, dirt, corrosion, or an improper connection increases the circuit resistance. Also, inadequate connections cause heating of the conductor, which increases resistance even more. This could be caused if only a few strands of a conductor or portions of a soldered joint are improperly connected to a terminal or if undersized connectors are used.

In a three-phase asset circuit, the resistance in the conductor paths should be balanced. A “resistive imbalance” occurs when the phases have unequal resistances. The formula below shows that a very small resistive imbalance results in a high voltage imbalance. This produces uneven current flow and excessive heat.

$$Vimb = \frac{\frac{2}{3} \times (Rmax - Rmin) \times FLA}{Vl - \left(\left(\frac{2}{3}\right) \times (Rmax - Rmin) \times FLA\right)} x100$$

In the formula:

Vimb = voltage imbalance
Rmax = maximum winding resistance value
Rmin = minimum winding resistance value

FLA = full load amp rating of asset
Vl = line voltage
100 = converts number to percentage

When voltage applied across three-phase asset leads is unbalanced, circulating currents, called “negative sequence currents”, are induced. When these negative sequence currents are present, they cause heating in the windings. EPRI’s (the Electric Power Research Institute) Handbook to Assess the Insulation Condition of Large Rotating Machines states “a 3.5% voltage imbalance can raise winding temperature 25% in the winding(s) affected by such currents.” EASA (the Electrical Apparatus Service Association) says a 1% voltage imbalance results in a 6-7% current imbalance.

The most extreme case of resistive imbalance occurs when a asset “single phases.” This “single phasing” quickly causes the asset to fail because the remaining two phases compensate by increasing current by 200% to 300% of normal. Rapid heating of the windings which are still connected destroys the insulation surrounding them.

Resistance to the flow of current in a circuit is of concern from the standpoints of safety, energy conservation, and insulation life. High resistance points in conductors generate heat both at the point where the resistance is located and in the three-phase assets being supplied.

Regardless of the source, some of the effects of increased heat production in the asset include:

- Higher resistance due to heat in conductor materials adjacent to the fault
- Deterioration (accelerated aging) of the surrounding and supporting insulating materials
- Imbalance in multi-phase circuits, which adversely affects equipment performance and life
- Increased power consumption in all cases
- Fire or failure in extreme situations

Setting Warning Levels

The preset warning levels in MCEGold are based on both actual values and on a % change from the baseline value.

Data Interpretation

Resistive imbalance above the setpoint indicates that a problem exists in either the power circuit or in the stator windings. First, isolate the problem to the asset or the circuit. Looking at individual resistance readings can help isolate the problem to a phase. Also, look for the following characteristics which indicate faulty connections.

- Aluminum cables connected to lugs marked for copper wire only
- Discoloration of insulation or contacts
- Damaged insulation having small cracks, bare conductors, or metal components
- Mismatched cables in common circuits
- Poor lug crimps on T-Leads
- Oxidation of conductor metals
- Presence of contaminants such as dirt

Example

The following information is from a 7,000 HP vertical reactor coolant pump asset at a nuclear power plant. A high resistance solder joint between phases 1 and 3 produced a resistive imbalance of 37.15%. The cost associated with the power loss was calculated to be $58,517.84 per year. Multiple tests, shown in Table 5-11, were performed to verify the problem.

Table 5-11: MCE Tests Used in Troubleshooting Efforts

Test Date	5/31/96	5/31/96	5/31/96
Test ID:	331	332	333
Frequency	1200	1200	1200
	BASELINE		
Mohm Ph 1 to Gnd			
Charge Time	30	30	30
Voltage	1000	1000	1000
Motor Temp	40	40	40
Measured Mohm	>2000	>2000	>2000
Corrected Mohm	OVR	OVR	OVR
pF Ph 1 to Gnd	116250	116250	116250
ohm Ph 1 to 2	0.27450	0.26800	0.27400
ohm Ph 1 to 3	0.43750	0.43700	0.44100
ohm Ph 2 to 3	0.24500	0.24300	0.24200
mH Ph 1 to 2	6.750	6.750	6.750
mH Ph 1 to 3	6.755	6.750	6.750
mH Ph 2 to 3	6.745	6.745	6.745
% Res. Imbalance	37.15	38.29	38.24
% Ind. Imbalance	0.07	0.05	0.05
$ Power Loss	58517.84	58973.83	60493.78

Phase-to-Phase Inductance

What Does it Tell You?

In AC assets, phase-to-phase inductance readings can:

- Indicate the condition of the stator windings
- Detect phase-to-phase and coil-to-coil current leakage paths
- Reveal poor or incorrect rework

These readings can also be used to detect faults in power cables. A Rotor Influence Check (RIC) can be performed to further troubleshoot the asset to reveal faults such as:

- Broken/cracked rotor bars or end rings
- Porosity and lamination damage
- Eccentricity problems

In DC assets, inductance changes within the field or armature can indicate current leakage paths in the windings.

Inductance changes when leakage paths develop. These paths can be either within the winding coils, or directly to ground. Leakage paths result from mechanical, thermal, environmental, or electrical damage to the insulation system of the windings. Additionally phase-to-phase and turn-to-turn shorts can occur. In either case, current flow bypasses some coils, thereby reducing inductive reactance and increasing current in other phases of the stator. Temperature rises in the remaining conductors and in the surrounding insulation. This accelerates the deterioration, which can cause an avalanche effect, as heat produces more insulation failures, resulting in more leakage paths and more coils removed from the circuit, further increasing temperature.

As there are fewer winding turns in a given phase actively creating the magnetic field upon which the asset is functioning, the windings in the other phases compensate to meet the requirements of the load on the asset. These windings in turn draw more current than is normally supplied by a balanced asset.

Why is This Important?

A large inductive imbalance causes torque-induced vibration at two-times line frequency ($2F_L$). This vibration can be linked to mechanical degradation. Also, inductive imbalance can contribute to other problems, among which are:

- Bearing damage
- Coupling damage
- Loosened rotor bars
- Insulation failure at winding end turns or at exit of stator slots

Setting Warning Levels

The preset warning levels in MCEGold are based on both actual values and on a change from the baseline value.

Data Interpretation

Many factors affect inductance readings, including asset winding coils, the stator iron, the rotor, and the number of rotor bars. The power circuit has little or no effect on the inductance readings unless there are power factor or surge capacitors in the circuit.

Power correction and surge capacitors are used in some circuits and will affect phase-to-phase inductance readings. Whenever possible, phase-to-phase inductance tests should be performed with the capacitors in the circuit as well as disconnected, to indicate the health of the capacitors. This allows for trending the condition of the capacitors as well as the phase-to-phase inductance of the asset.

If both inductive and resistive imbalance are high, look for a leakage path in a coil or an open coil. If resistive imbalance is low, the fault may be in the rotor.

A rotor bar/cage anomaly may not produce a large inductive imbalance on one single test. If inductive imbalance has increased or is high, perform a RIC to further define the problem. Excessive vibration can also be an indicator of inductive imbalance. If you notice high vibration readings, perform a RIC to collaborate the data.

Example

A new asset with a cast aluminum rotor was load-tested prior to installation. The asset failed to reach rated HP. A RIC was conducted and indicated the presence of broken rotor bars.

When the rotor bars were cast, high resistance connections were formed. Operating the asset during the load-test produced excessive heat at those points. The melted paint on the rotor identified the high resistance connections beneath them.

Test Lead Check

The MCE verifies the resistance of the test leads before and after each test. This ensures test lead continuity and proper connection prior to running the test. If any test lead resistance exceeds a predetermined value, the MCE stops the test. That lead must then be reconnected and retested successfully to continue. This ensures maximum accuracy and repeatability of the collected data.

Resistive Imbalance

Resistive imbalance is calculated from the three individual phase-to-phase resistance readings taken during the standard test. It is displayed as a percentage and will be put into a caution or alarm state if it exceeds a specific limit. This limit can be changed in the MCEGold software. Because this value is calculated from *three* phase-to-phase readings, there is no resistive imbalance value for DC assets.

In AC assets, resistive imbalance is an indication of one or more high-resistance connections in the circuit or shorted turns. Assuming the original test was performed at the MCC, isolate the problem to the asset or to the power circuit by retesting the asset at the connection box. If the resistive imbalance remains, the problem is in the asset. If the resistive imbalance goes away, the problem is in the cables or power circuit. Look at the individual resistance readings to determine the faulty phase.

Inductive Imbalance

Inductive imbalance is calculated from the three individual phase-to-phase inductance readings taken during the standard test. It is displayed as a percentage and will be put into a caution or alarm state if it exceeds a specific limit. This limit can be changed in the MCEGold software. Due to the fact that this value is calculated from *three* phase-to-phase readings, there is no inductive imbalance value for DC assets.

In AC assets, this calculated value can indicate the condition of the stator and rotor/stator relationship. Turn-to-turn or phase-to-phase shorts in the stator causes a high inductive imbalance. Rotor/stator eccentricity causes a varying value of inductive imbalance, as seen on subsequent standard tests. To isolate a problem to the rotor or the stator, perform a Rotor Influence Check.

Power factor capacitors, line reactors, and other power correction devices can impact inductance values. Separation of these devices from the circuit may be required when troubleshooting the asset.

Average Inductance

Average inductance is calculated from the three individual phase-to-phase inductance readings taken during the standard test. Due to the fact that this value is calculated from *three* phase-to-phase readings, there is no inductance imbalance value for DC assets. In AC assets, this calculated value can indicate the condition of the rotor and rotor/stator relationship. Rotor defects will cause an increase in the average inductance. To isolate a problem to the rotor or the stator, perform a Rotor Influence Check.

Polarization Index Test

What Does it Tell You?

The Polarization Index (PI) and Dielectric Absorption (DA) ratios indicate the condition of the insulation system of the asset and power circuit. Both of these tests use ratios of measurements of insulation resistance taken at two different times. The PI is the ratio of the reading taken at 10 minutes and divided by the reading taken at 1 minute. The DA is the ratio of the reading taken at 60 seconds divided by the reading taken at 30 seconds.

There are three different currents that flow through an insulator when a voltage potential is applied. Since the RTG test measures the voltage and current to calculate insulation resistance, all of these currents must be taken into account.

- First, the “capacitive current” starts out high and drops to nearly zero after the insulation has been charged to full test voltage. This is normally negligible after the first few seconds of the test.
- Second, the “absorption current” also starts out high and drops off. The majority of this current dissipates after one minute, but continues to decay for up to 5 to 10 minutes.
- Finally, the “conduction” or “leakage current” is a small, mostly steady current which becomes a factor after the absorption current drops to a negligible value. This current should remain steady for the remainder of the test.

The relationship between all these currents is shown in Figure 5-59.

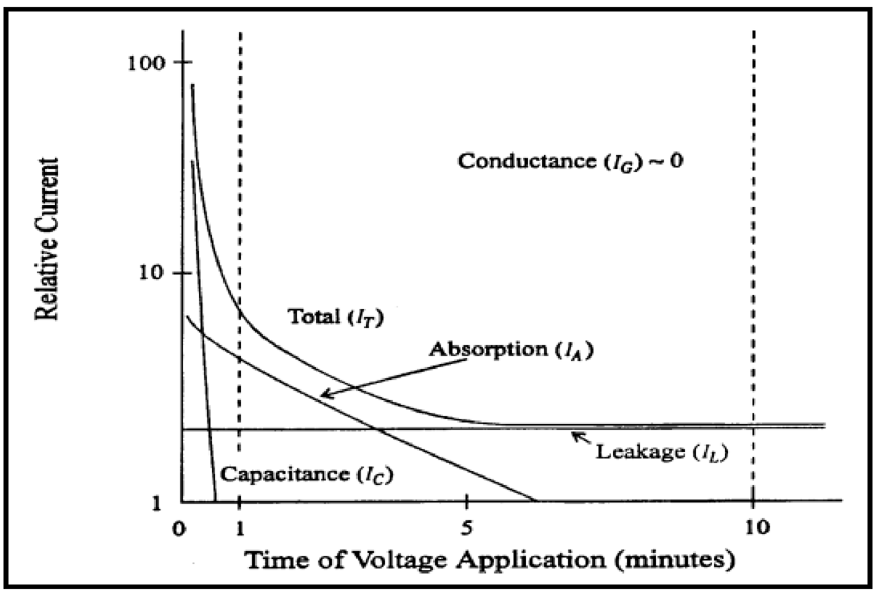


Figure 5-59: Current Relationships

As the asset accumulates dirt and as the insulation ages and cracks, the PI and DA ratios decrease. Dirt accumulates based on the operation and environment of the asset. The insulation cracks as a function of heat and aging of the asset.

Because of the effects of each of these varying currents, the resistance to ground measured by any insulation tester varies with the amount of time the voltage is applied to the insulation. In order to trend or compare insulation RTG values, the charge time for all tests

MUST be the same. If the charge time is not the same, the trend or comparison may not be valid.

Finally, the charging developed by these three different currents does not dissipate immediately when the voltage is removed at the end of the test. The insulation system must be allowed to discharge sufficiently between resistance to ground tests in order to obtain accurate results. A rule of thumb states that insulation takes four times the amount of charge time to discharge.

Why Is This Important?

Resistance-to-ground readings involve three different current components: capacitive, absorption, and leakage. The PI test allows the charging and absorption currents to decay so that only actual leakage current is measured. As a voltage is continuously applied, healthy insulation slowly polarizes and the absorption current diminishes. This causes a steady rise in resistance until the majority of the current is from the small amount leaking to ground. In poor insulation, leakage current is high enough to overshadow the lowering absorption current and provide little increase in the resistance over time.

Setting Warning Levels

In Managing Motors, Richard Nailen, P.E., offers the following guidelines for interpreting PI and DA ratios. If the PI ratio is less than 2 or the DA ratio is less than 1.5, look for insulation degradation.

	Unacceptable	Acceptable
PI	1 to 1.5	2 to 4
DA	≤1.25	>1.50

IEEE recommends the following values for PI. Machines rated at 10,000 kVA and less should have values at least as large as the acceptable values listed below before operation or hi-pot testing.

	PI
Class A	1.5
Class B, F, H	2.0

Data Interpretation

Because the PI and DA values are ratios, temperature correction is unnecessary. PI and DA can be used for both on-the-spot, one-time checks and for trending over time. Individual readings can be compared to the recommended setpoints.

A good PI Profile (PIP) shows a sharp rise followed by a steady, but slowly increasing trend. A downward trend suggests deteriorating conditions. A flat or ragged trace indicates short-term current transients. Such traces indicate insulation breakdown, possibly due to contamination or moisture in the power circuit or asset. Observing the readings over time permits scheduling of cleaning or reconditioning before failure occurs.

If the PI or DA ratio is low, isolate the problem to the circuit or the asset. Assuming the first test was made at the MCC, run another test from the MCC with the “T” leads disconnected.

If the low value is gone, the problem is in the power circuit. If the low value still exists, test the asset at the asset connection box with the leads to the MCC disconnected. If the

low value is gone, the problem is in the cables between the asset and the MCC. If the low value still exists, the problem is in the asset.

Examine the cables in the asset connection box. They could require cleaning, drying, or replacement. Also, check for water in the conduit.

If the PI or DA ratio is < 1.0, look for a ground fault. Clear this fault before starting the asset.

Some exceptions to be aware of include:

- Moisture or contamination on the windings decreases the PI
- The PI can be lowered by certain semiconducting materials which are used for corona elimination on the end windings of some high-potential AC machines
- Performing PI testing in ambient temperatures less than the dew point may significantly impact the PI values

Examples

The following pictures show the response of the insulation in both a good (Figure 5-60) and a bad (Figure 5-61) asset, with a constant voltage applied for a 10 minute period. The increase in the RTG value is due to the decrease in current through the insulation.

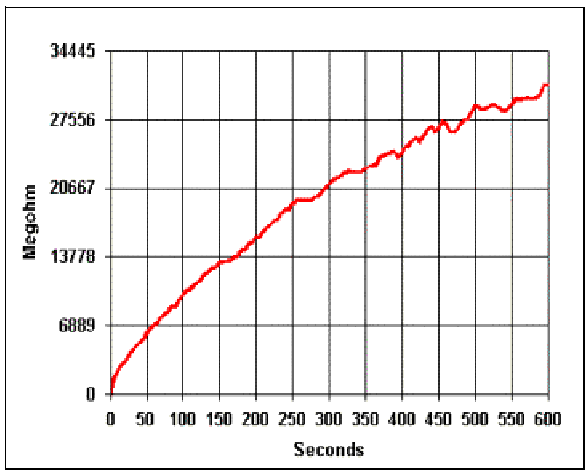


Figure 5-60: Asset with a Good PI

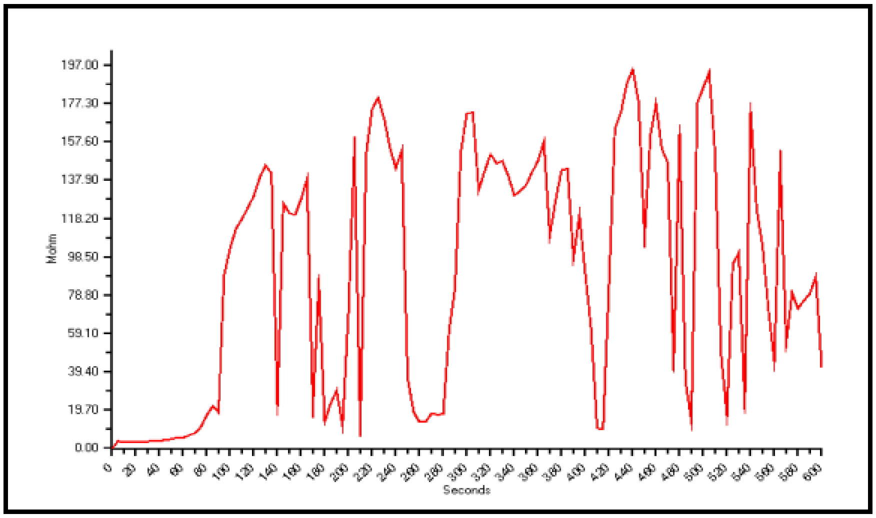


Figure 5-61: Asset With a Bad PI

The unstable RTG readings in the bad PI are a result of low level discharges occurring in faults in the insulation.

ROTOR INFLUENCE CHECK (RIC)

What Does It Tell You?

The Rotor Influence Check (RIC) is a graphical representation of the rotor/stator relationship. By analyzing variations in the magnetic flux while rotating the rotor, eccentricity and rotor defects are identified. The RIC can also be used to confirm stator faults. Figure 5-62 shows a RIC graph for a motor with no defects.

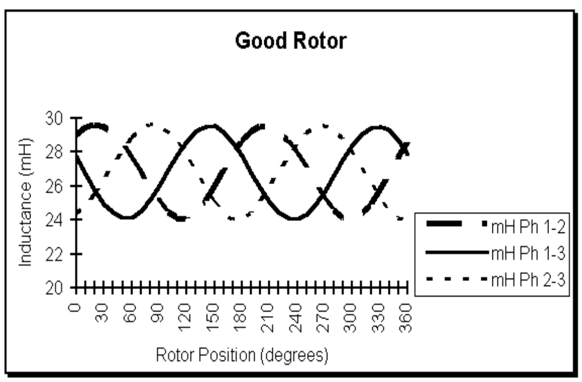


Figure 5-62: RIC from a Good Asset

A motor acts similar to an electromagnet. The rotor acts like the “core” and the stator acts like the windings of the electromagnet. A RIC shows how the rotor’s residual magnetism influences the stator inductance in different positions. As the magnetic field of the rotor interacts with more of the coils in each stator winding, the inductance of that winding changes. This influence causes repeatable patterns of change in the graph of the stator inductance, shown above as sinusoidal waveforms.

Why Is This Important?

Broken rotor bars can cause extreme heat and vibration, which can result in winding failure, bearing failure, and loss of torque in a motor. Eccentricity, a non-uniformity of the air gap between the rotor and stator, can cause excessive vibration, which can result in winding and bearing failure.

Rotor Position And Aliasing

Each RIC consists of a series of inductance measurements taken at predetermined positions of the rotor. The amount by which the rotor is moved for each measurement and the total rotation of the rotor for the test are determined by the number of poles in the asset. The increment and total rotation are calculated to show the RIC pattern for one complete pole group. If additional readings are taken beyond the total and at the same increments, the pattern should repeat itself. Table 5-12 shows the recommended increments and total rotation to cover one pole face for a asset with a given number of poles.

Table 5-12: RIC Degree Increments vs. Number of Poles

Poles	Increment	Total
2	10.0°	180°
4	5.0°	90°
6	3.3°	60°
8+	2.5°	45°

The number of increments and total rotation are automatically calculated by MCEGold, based on the entered nameplate data. You may reduce the increment and perform more tests to cover the recommended total rotation. Increasing the increments and performing fewer measurements than the default values is not recommended because doing this results in “aliasing.” Because not enough points are taken to reveal a true picture of the curve, aliasing produces an inaccurate and incomplete graph.

The following example shows how to determine the number of poles a asset has, the number of total degrees to turn the rotor, and the increments by which to turn it. Start with the basic equation:

$$F = \frac{NP}{120}$$

In the formula:

F = line frequency (60 Hertz in the US)
N = synchronous asset speed
P = number of poles in the asset
120 = 120 degrees of electrical spacing between poles

For a asset whose synchronous speed is 1800 rpm, use a variation of this equation to find the number of poles:

P = 120F/N
P = (120)x(60)/1800
P = 4 poles

Next, determine the number of degrees per pole face. To find this, divide 360 by the number of poles.

360/4 = 90 degrees per pole face.

Next, determine the increments, in degrees, by which to position the rotor to generate an accurate RIC pattern. To find this, divide the number of degrees per pole face by 18.

90/18 = 5 degrees.

Thus, the following would apply for a asset whose synchronous speed is 1800 rpm:

4 poles
90 degrees per pole face
5 degree increments per rotation to develop an accurate RIC

The increments were chosen since the RIC pattern typically repeats itself by the same number of poles in the asset through a complete 360° rotation of the rotor. Using these increments is recommended to increase consistency and reduce aliasing. Also, use the same increments and total rotation each time you perform a RIC. This ensures that the RIC is started and run the same way for each test. Doing this enables you to reliably compare the data and graph to subsequent tests for trending.

When the RIC is started, the MCE measures the resistance of each phase winding. At each increment the inductance of each winding pair is measured and recorded. Between measurements you are prompted to move the rotor to the next position.

Data Interpretation

Aliasing

Aliasing occurs when too few measurements are taken too far apart to show the true shape of the curve. The following figures show RICs which exhibit aliasing.

Figure 5-63 shows two waveforms of a good rotor in a 6-pole asset. The waveform with the connected circles was generated with measurements taken at the recommended interval of 3.3°. The waveform with the dashed lines was generated with measurements taken at 15° intervals. The waveform from measurements taken at 15° intervals shows a lack of definition.

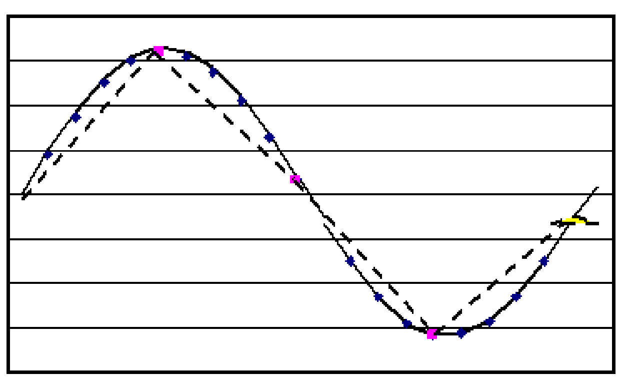


Figure 5-63: Aliasing

Figure 5-64 shows two waveforms taken on a asset which has known rotor faults. The presence of the fault is hidden when the measurements are taken at 15° increments (dashed waveform). When they were made at the recommended 3.3° increments (circles), the presence of the rotor fault is indicated by the flattened peaks. Note that the dashed waveforms shown in Figure 5-63 and 5-64 appear identical masking the true rotor conditions.

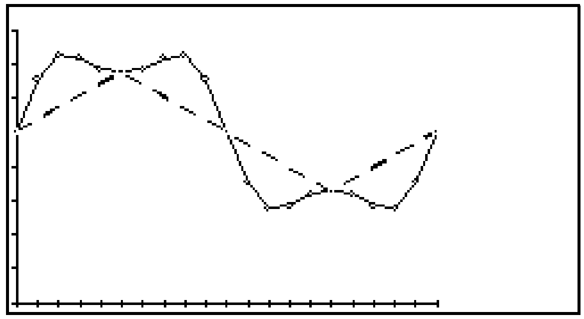


Figure 5-64: Aliasing

Good Asset

Figure 5-65 shows a RIC test for a typical AC induction asset with a good rotor. The three graphs resemble sine waves which are 120° out of phase with each other. The sinusoidal pattern is smooth and repeatable. The amplitude of the sine waves varies from asset to asset, due to factors specific to each asset, such as winding configuration, air gap, core steel quality, and rotor construction and design.

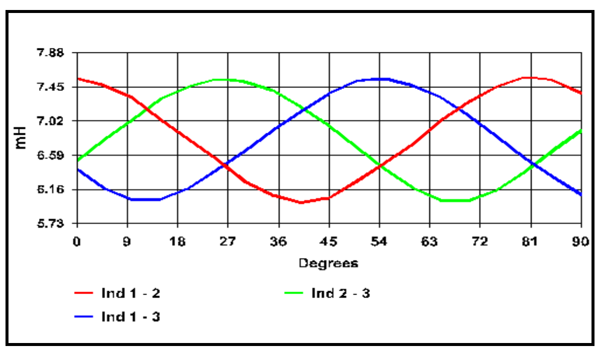


Figure 5-65: RIC from Good Asset

In some assets, the amplitude changes of the graphs are very small and may appear erratic. This erratic appearance may be due to measurement resolution steps, and not due to actual changes in inductance. This condition may indicate a low influence rotor with no rotor defects. One such low influence rotor is shown in the RIC graph in Figure 5-66.

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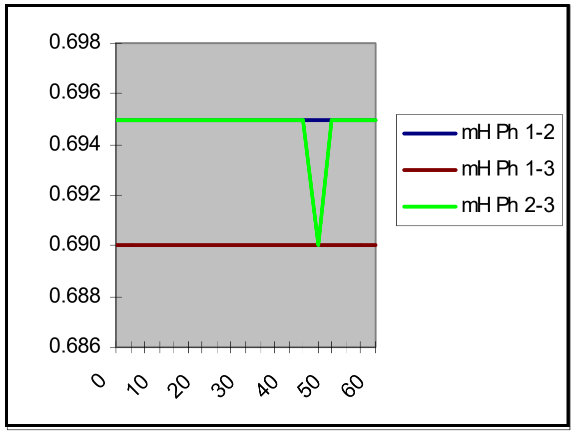


Figure 5-66: RIC from Asset with Low Influence Rotor

Eccentricity

Eccentricity is defined as the condition of the air gap between the rotor and stator, all the way around 360° of the asset. This gap should be the same width all the way around. If the rotor is bowed, the bearing clearances improperly set, or the end bell not aligned properly, the air gap will not be equal. An unequal air gap produces a phase-to-phase inductance graph that is markedly higher at one end of the graph than at the other. This is shown in Figure 5-67.

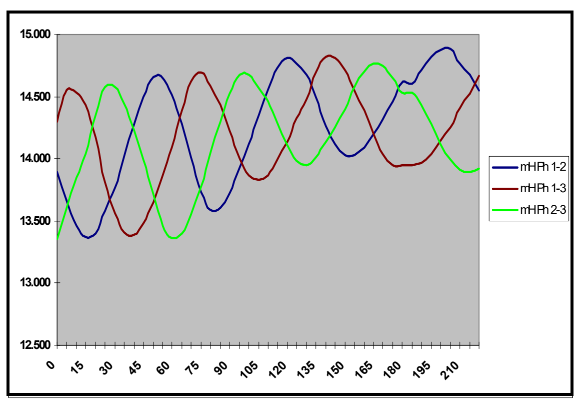


Figure 5-67: RIC from Asset with Eccentricity

If an eccentricity problem is suspected, continue performing the RIC to include at least two pole faces beyond the default increment setting. An exception to be aware of is when sleeve bearings are used in the asset. Due to their oil film, they can falsely indicate eccentricity problems since the rotor "settles" when the asset is not running.

Broken Rotor Bars

A rotor with broken bars produces graphs with anomalies in their wave shapes, such as flattened and staggered peaks.

Figure 5-68 shows a motor with ten broken rotor bars. These were found following a RIC. The flattening of the peaks in the phase-to-phase inductance graphs results from the influence of the broken bars. The irregularities in these traces are repeatable in each phase.

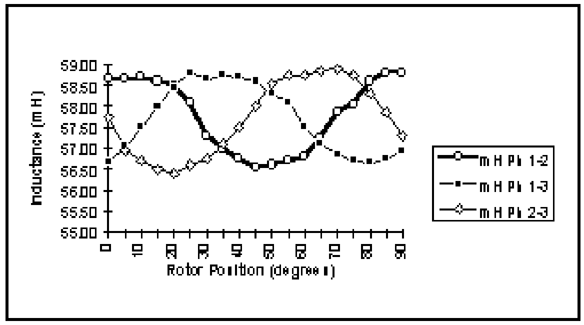


Figure 5-68: RIC from Motor with Broken Rotor Bars

Figure 5-69 shows a motor with cracked welded joints at the shorting rings. The cracked welded joints were found in 14 out of 122 rotor bars after a RIC was taken. The erratic pattern of flattened and staggered peaks points to the presence of the broken bars.

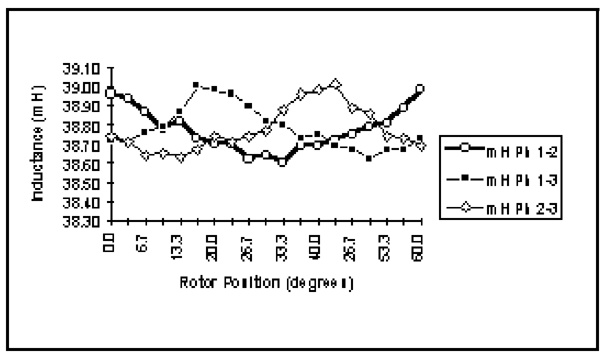


Figure 5-69: RIC from Motor with Broken Rotor Bars

Figure 5-70 shows the RIC test of a 480 volt 60 HP AC induction motor with broken rotor bars and a slight air gap problem. Note the flattened peaks in each phase-to-phase graph.

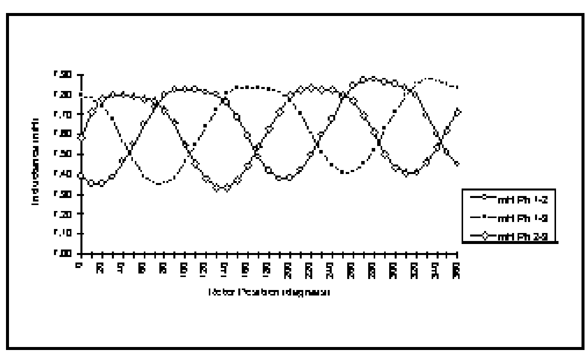


Figure 5-70: RIC from Motor with Broken Rotor Bars

Figure 5-71 shows the staggered peaks in a RIC for a 480 volt 5 HP motor. A rotor anomaly was determined to be the cause for these peaks. This was the result of a maintenance supervisor drilling a hole in one rotor bar as a demonstration.

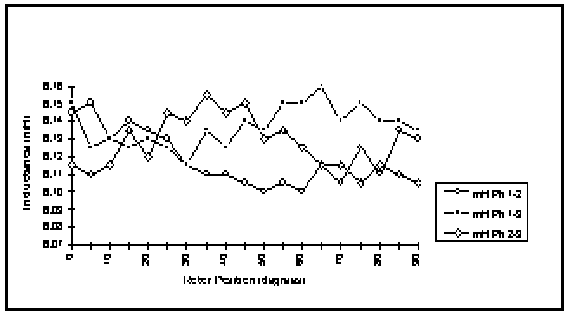


Figure 5-71: RIC from Motor with Broken Rotor Bars

One-Up/Two-Down and Two-Up/One-Down

Phase-to-phase or turn-to-turn stator winding shorts can result in either a one-up/two-down or two-up/one-down RIC pattern. This is shown in the graphs in Figure 5-72.

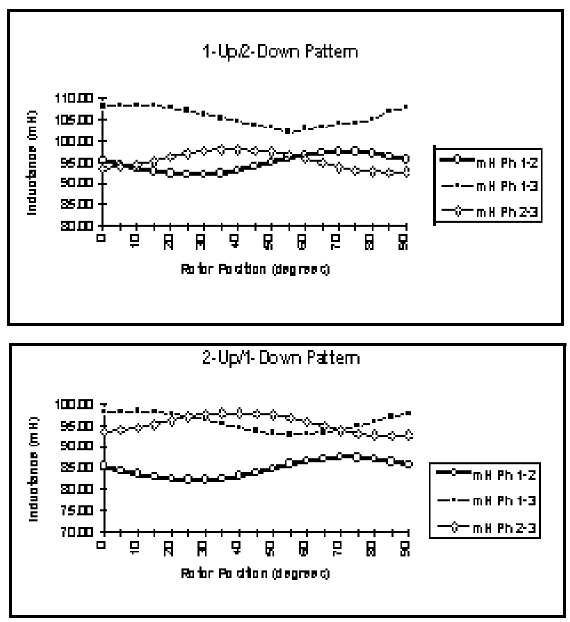


Figure 5-72: RIC from Motor with Phase-to-Phase or Turn-to-Turn Shorts

To assist in the analysis, compare the RIC with the phase-to-phase resistance readings on the standard test. If the same phases are affected resistively and inductively, this further confirms a winding defect. If resistance readings do not confirm this condition, evaluate the asset for eccentricity/air gap problems.

DC Bar-to-Bar Test

What Does It Tell You?

Testing the resistance between commutator bars gives an indication of the comparative value of resistance that exists between all like electrical circuits in an armature.

Why Is This Important?

The commutator consists of insulated segments assembled into a cylinder and held together by insulated rings. Electric current is transferred to the armature windings by “brushes” made mainly of carbon and graphite. Brush wear creates carbon dust, a conductive contaminant, which penetrates into crevices, cracks and openings of the armature. Copper particles add to the contaminant accumulation when the wrong brushes are installed or the brushes are improperly installed, or when maintenance is inadequate. If the insulating material on the commutator bars or their risers has cracked, these contaminants can short entire windings.

Also, high resistance connections can develop at the risers causing open or high-resistance armature coils. Equalizing connections can break and cause an imbalance due to the loss of equalization.

Data Interpretation

The resistance readings between bars are in the microhm range for medium to large machines. Most DC assets of this size have armatures constructed with equalizing jumpers or compensating shorting connections. The effect of these connections on the Bar-to-Bar test results shows as a regular pattern of change from bar to bar. Good bars have 1 or 2 different values. If a bar differs greatly from either of these 2 values then look for faults.

Armatures with 50% compensation have every other bar equalized; with 33% compensation have every 3rd bar equalized; with 25% compensation have every 4th bar equalized.

MCE ANALYSIS

AC Induction Assets

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - repeatable erratic inductance throughout the peaks of the waveforms
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity sometimes causes a consistent separation in the three sine waves, coupled with a low inductive imbalance.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase) or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA in Caution or Alarm indicates changing or excessive surface contamination.
- Breakdown of insulation system.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

AC Synchronous Assets

Stator

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - appears like a normal sine wave but has a larger than normal inductive imbalance
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity can sometimes cause a consistent separation in the three sine waves.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.

- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase), circuit defect (cable short or power factor correction capacitor failure), or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information on the rotor condition.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio- PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Field Circuit

Synchronous Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - Resistance in Caution or Alarm indicates a high or low resistance of the field windings.

  NOTE: The Caution and Alarm limits are set based on nameplate field voltage and current values at normal operating temperature of the asset. Testing on a cold asset may indicate values outside the Caution and Alarm settings.

- Low Inductance - Low Inductance in Caution or Alarm indicates turn-to-turn faults in the field coils.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

AC Wound Rotor Assets

Stator

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - appears like a normal sine wave but has a larger than normal inductive imbalance
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity can sometimes cause a consistent separation in the three sine waves, coupled with a low inductive imbalance.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase) or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Rotor

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red for recommended actions.

- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection on the slip ring or winding connections. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase). Refer to the individual phase-to-phase inductance readings to assist in locating the fault.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Resistor Bank

Resistor Bank

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection between the resistors or a faulty resistor. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

DC Assets

Armature Circuit

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - values in Caution or Alarm indicate high resistance connection in the switchgear, disconnect, or asset connection box. This can also indicate improper brush wear/seating or a poor commutator film.
- High/Low Inductance - values in Caution or Alarm indicate a winding defect (turn-to-turn or coil-to-coil).

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Bar-to-Bar

- High/Low Resistance - values significantly above or below the average resistance reading indicate an open or a short in the armature winding or commutator segments.

Field Circuit

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - values in Caution or Alarm indicate a high resistance connection in the switchgear, disconnect, or asset connection box.
- High/Low Inductance - values in Caution or Alarm indicate a winding defect (turn-to-turn or coil-to-coil).

Polarization Index/Dielectric Absorption

- Low PI or DA Ratio - PI or DA Ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

CHAPTER 5: MCE

TESTING QUICK START

MCE testing may be started by selecting either the Test Selection or the MCE Auto icons on the toolbar.

Selecting the MCE Auto icon automatically runs the Standard Test followed by the Polarization Index test. It uses the existing testing setup values. MCE Auto is discussed in detail on page 5-7.

Selecting the Test Selection icon allows you to verify and/or change the testing setup values and select which test you want to run. Test Selection is discussed in detail on page 5-3.

1. Start MCEGold.
2. On the Site Navigator or WatchList highlight the asset to be tested.
3. Select the Test Selection icon on the tool bar to open the Test Selection window.
4. In the Test Selection window the default is set to MCE testing. For EMAX testing click the EMAX tab at the top and see Chapters 6 & 7. The asset section tabs along the left side will vary depending on the type of asset being tested. Nameplate Information is automatically filled in by MCEGold from the nameplate data.
5. Select the asset section tab along the left side corresponding to the section to be tested.
6. Select the test to be performed from the list of tests. The available selections are driven by the type of asset and the asset section selected for testing. The Notes section provides instructions that are relevant for the selected test.
7. Select the asset test location by using the drop-down list or using the search button to open the Test Location Selection window.
8. Select the Test Frequency from the drop-down list. The Test Frequency default is driven by the type of asset selected for testing.
9. Select the Resistance-to-Ground by entering in the Mohms if they are different from the default. Check the Low Limit check box if you want the unit to shut down automatically upon measuring a specified low resistance to ground value.
10. Select the Voltage from the drop-down list box. The choices are: 250, 500, 1000, 2500, and 5000.
11. Set the asset Temperature if different from the default value of 40.

12. Select the charge time from the drop-down list box. The choices are in 15 second increments, beginning at 15 and ending at 600 seconds.

13. Click **Save** to save the MCE Test Setup values selected for this particular asset or click **Reset** to restore the original values. Note: Original values may only be reset if new values have not been saved. If you have clicked the Save button it will be necessary to manually change them back to the originals and save them.

14. Click **Test** to go the test window.

15. Click **Test** on the Test window. From this point the process will differ depending on the test being performed. Each test is covered in detail later in this chapter.

INTRODUCTION

The MCE tester measures natural characteristics of a deenergized asset and its circuit to determine its condition. These characteristics are resistance-to-ground, capacitance-to-ground, winding resistance, and winding inductance. MCE testing can identify faults in the power circuit, insulation, stator, rotor, and the air gap between the rotor and stator.

The tests that can be run on a asset vary, depending on the asset type. For AC assets (Induction, Synchronous, and Wound Rotor) the tests are AC Standard Test, Polarization Index (PI) which includes a Dielectric Absorption Ratio, Rotor Influence Check (RIC), and Step Voltage. For DC assets the tests are DC Standard Test, Polarization Index (PI) which includes a Dielectric Absorption Ratio, Bar-to-Bar (Armature Circuit only), and Step Voltage.

Both AC and DC assets have an MCE Auto test which runs the Standard test followed by the Polarization Index test, automatically saves the test results, and displays the Fault Zone Report at the end of testing.

The frequency and type of asset testing you perform is based on your experience with the tester, the condition of each individual asset, and the criticality/application of each asset. Since it may be impossible to test each and every asset in your facility, ask yourself the following questions when deciding which assets to test.

- Is the asset easily replaceable and if so, is a replacement readily available?
- Would buying a new asset cost less than repairing the old asset?
- Is the asset redundant or non-critical?

If you answered yes to all three of these questions, you may not want to consider this asset for your monitoring program.

If you are unfamiliar with an asset, review its maintenance history of test results, problems, and repairs before testing it. Talk with the operators who run it and anyone who may have information about its repair history. This will give you a more complete picture of the condition of the asset.

MCE test results give you a comprehensive picture of the electrical condition of the asset. MCE results can be utilized, along with results obtained from other technologies, to get a complete picture of the health of the asset. Some examples of other technologies include vibration, oil analysis, and infrared thermography.

Some of the MCE tests give you enough information to call an asset good or bad, based on results from one test. Other MCE tests give you data which is best used for trending and comparison.

Trending means comparing sequential test results for the same asset over time. This tracks what the particular asset is doing, how it is holding up, when it may need to be cleaned, when it needs more detailed maintenance, or when a fault develops.

Test frequency depends on the asset's criticality and the condition of the asset when it is first tested. As the asset ages, you may decide to test it more frequently to better track its condition.

When you first start testing with the MCE, the initial test is automatically designated as the baseline test. After maintenance is performed on an asset and it is returned to optimal condition, measure subsequent tests against that condition by designating the first test after the maintenance as the new baseline.

Comparison means comparing individual test results on one asset with test results from an identical asset operating in a similar environment. By identical asset we mean the same manufacturer, voltage and horsepower rating, cable length for MCC, etc. For example, if there are four like assets operating side by side performing the same task, all running at approximately the same load, each running about the same amount of time, the test data should be very close for all of them. If all four assets are tested, and three are basically the same, but the fourth is very different from the other three, look for potential problems with the fourth asset.

MCE testing is performed on a deenergized asset. However, there may be energized circuitry in the same cabinet in which you connect the tester.

FOLLOW ALL ELECTRICAL SAFETY PRECAUTIONS AND PROCEDURES FOR WORKING IN THE VICINITY OF ENERGIZED EQUIPMENT. READ THE ELECTRICAL SAFETY PRECAUTIONS IN CHAPTER ONE BEFORE PERFORMING ANY TESTS.

For AC assets, test lead colors of black, blue, and red connect to phases 1, 2, and 3 (left to right, top to bottom); green connects to ground. For DC assets, test lead colors of black and blue connect to F1/A1 and F2/A2; the red lead is not used; green connects to ground. The DC Bar-to-Bar pistol grip or pencil probe test leads connect to commutator bars.

Some asset circuits may have surge capacitors and/or power factor correction capacitors installed. It is important to know about them since these components affect the values of the collected data and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power or surge capacitors installed, however, surge capacitors must be removed for the accurate measurement of the asset's insulation resistance-to-ground. If an asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.

TEST SELECTION WINDOW

In this chapter, the MCE aspects of asset testing are discussed. EMAX testing is discussed in the Power and Current Analysis chapters. The Test Selection window discussion is followed by the Step-by-step testing procedures, Test Data Analysis on page 5-53, and finally MCE Analysis on page 5-74.

Note: Selecting the MCE Auto test icon on the tool bar bypasses the Test Selection window and automatically runs the Standard Test followed by the Polarization Index test using either the default or previously saved test settings, at the end of testing the test results are saved, and the Fault Zone Report opens.

To open the Test Selection Window click the Test Selection icon on the tool bar.

The Test Selection window is shown in Figure 5-1. The asset name is located on the title bar to the right of the window name. The Test Selection window is used for both MCE and EMAX testing by selecting the desired test type tab.

The asset section tabs are found along the left side of the test selection area and are dependent on the asset type. Possible sections are Armature Circuit, Field Circuit, Resistor Bank, Rotor, and Stator.

- For AC Induction assets, the only option is Stator.
- For AC Synchronous assets, options are Field Circuit and Stator.
- For Wound Rotor assets, options are Stator, Rotor, and Resistor Bank.
- For DC assets, options are Armature and Field Circuit.

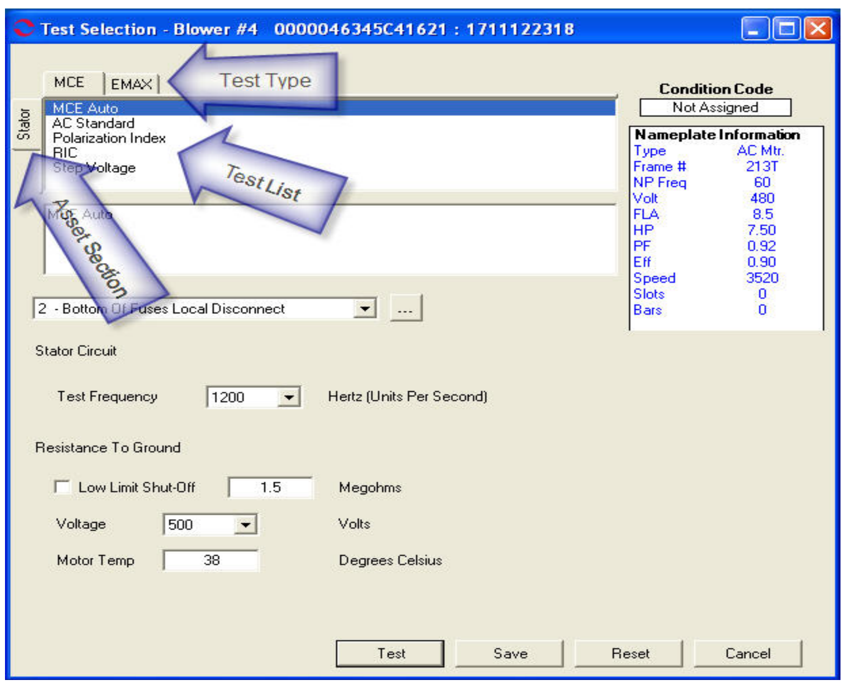


Figure 5-1: Test Selection Window

Test List

The top left section of the window contains a list of test selections for either MCE or EMAX, depending on asset type, test type and asset section tabs selected. The test lists section displays the various tests which may be performed based on the asset type and asset section chosen. When a test is selected, the name of the test is highlighted blue and

the test set up area changes to values appropriate for the test selected. The test list possibilities for MCE testing are:

- MCE Auto
- Standard (AC asset)
- Standard (DC asset)
- Polarization Index
- Rotor Influence Check (RIC)
- Step Voltage
- Synchronous (Synchronous, Field section)
- Resistor Bank (Wound Rotor, Resistor Bank section)
- Commutator Bar-to-Bar (DC asset)

Asset Information

Asset Information is located on the right side. This area displays the Condition Code and nameplate information of the asset being tested. The information comes from the nameplate data that was entered when the asset was set up and cannot be edited on this window. Information displayed, depending on asset type, may include: Type, Frame #, NP Frequency, Voltage, FLA, HP, PF, Eff, Speed, Slots, and Bars. Also, Field Volts and Field Current are listed for DC assets.

MCE Test Setup

The lower half of the Test Selection window is devoted to test set-up selections. The set-up options depend on the asset type and test selected.

Asset Test Location

The Asset Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. See Figure 5-2. Use the graph to determine the location, then click the down arrow in the Test Location text box, select the location from the list, and click **OK.**

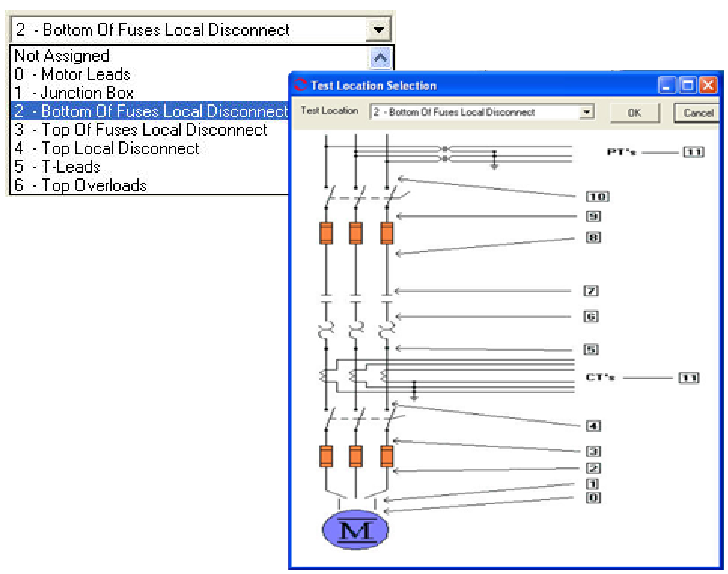


Figure 5-2: AC Asset Test Location

Test Frequency

Test Frequency is selected from a drop-down box. Click the down arrow and select from the list to change the frequency. The choices are 300 or 1200 Hz depending on the section being tested. Test Frequency is not available for the resistor bank section of a wound rotor asset.

Resistance-to-Ground

Resistance-to-Ground provides the option to check (turn on) the Low Limit Shut Off and enter a shut off voltage.

Voltage

Voltage is selected from a drop-down list. Click the down arrow and select from the list to change the voltage. The voltage choices are from 250, 500, 1,000, 2,500, and 5,000.

Select a voltage of 500 or 1000 volts, based on the asset's voltage. EASA (Electrical Apparatus Service Association), in their booklet How to Get the Most From Your Electric Motors, suggests 500 volts for assets rated ≤2400 volts and 1000 volts for assets rated at >2400 volts.

Asset Temperature

The default value is 40° C. The value may be changed by typing in a new value.

Span

Span selection is only available for Bar-to-Bar testing of the armature section of DC assets.

Charge Time

Charge time is available for the Standard test of an AC Induction, Wound Rotor, Synchronous, and DC assets. The default value is 60 seconds. To change the charge time, click the down arrow and select from the list of between 15 and 600 seconds.

Test Button

Click **Test** to advance to the test window.

Save Button

Click **Save** when the test set-up selections are complete. This saves the settings as default values for that asset for subsequent tests, but is not required. If you forget to save and click Test, you will be asked if you want to save your changes.

Reset Button

Click **Reset** to set values back to the pre-changed value. Note: If you have clicked the Save button they will not reset and it will be necessary to manually change them back.

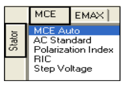
Cancel Button

Click **Cancel** to close the Test Selection window without saving setup changes or proceeding to the test window. You will be asked if you want to save test setup settings.

TEST WINDOW

Once the asset section and setup parameters are selected, you are ready to run the test. This section explains each test by asset type and asset section. The test window is discussed followed by step-by-step testing procedures. Test analysis information begins on page 5-53.

AC Induction Assets



The MCE tests for an AC Induction asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage. They are discussed in detail in this section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test
- Polarization Index (PI)/Dielectric Absorption (DA) If a PI is performed, it is not necessary to perform a separate DA.

Some circuits may have surge capacitors and power factor correction capacitors installed. This is important since these components affect the values of the collected data and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor capacitors installed. However, a test should be taken with surge capacitors removed for future comparison. If an asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.

MCE Auto Test

MCE Auto test performs a standard test followed by a Polarization Index test, then saves the data and produces a Fault Zone Report.

MCE Auto test can be started by clicking the MCE Auto icon on the toolbar or selecting MCE Auto from the test list in the Test Selection Window. If you select the MCE Auto icon, the MCE Auto test window opens bypassing the Test Selection window.

If you need to change the test setup settings, select the Test Selection icon. The Test Selection window opens, make your changes, and then select MCE Auto from the test list and click **Test**. The MCE Auto Test window, Figure 5-3, opens. The MCE Auto Test window menu consist of three options: File, View, and Options.

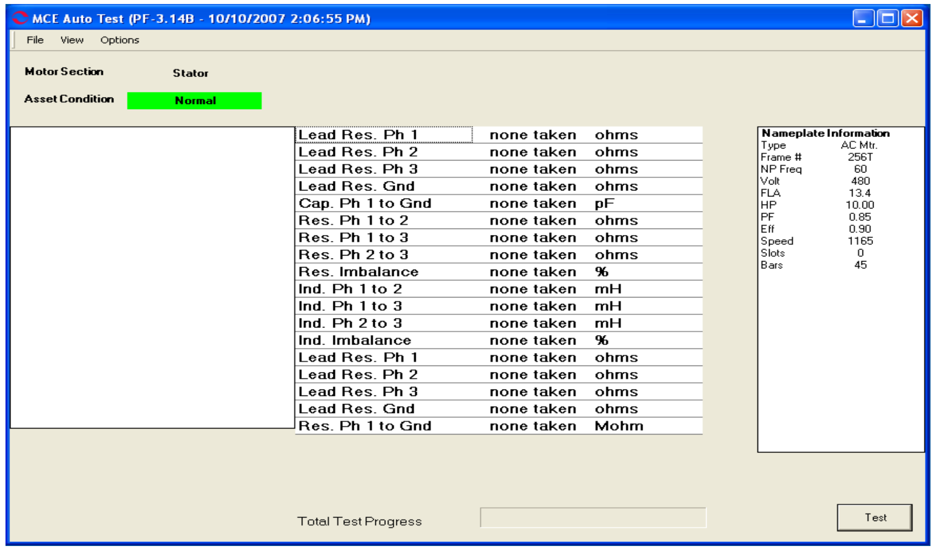


Figure 5-3: MCE Auto Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the MCE Auto Test and Test Selection windows and returns you to the Home window.

View Menu

Create Message . Create Message opens the Compose Asset Message window (Figure 5-4). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

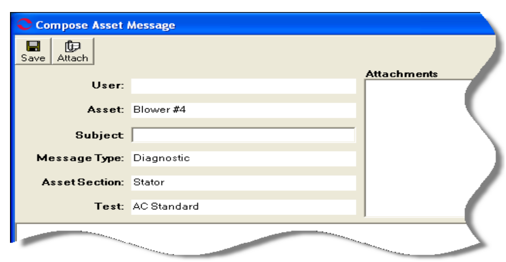


Figure 5-4: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-5). The Asset Condition box on the MCE Auto Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

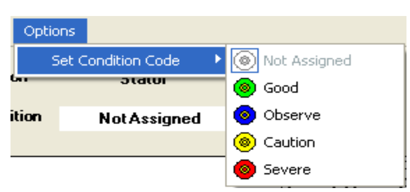


Figure 5-5: Set Condition Code Window

Test Button

To begin testing click **Test**. During testing the menu items are dimmed (not available) and the Test button changes to Stop. The test takes approximately 11 minutes.

The tester automatically proceeds from the Standard test to the Polarization Index (PI) test. A status bar displays the testing progress. During the Standard test there is one Total Test Progress bar. When the PI test is performed there is a PI progress bar, a Total Progress bar, and a graph in the lower left displaying the test results. See Figure 5-6.

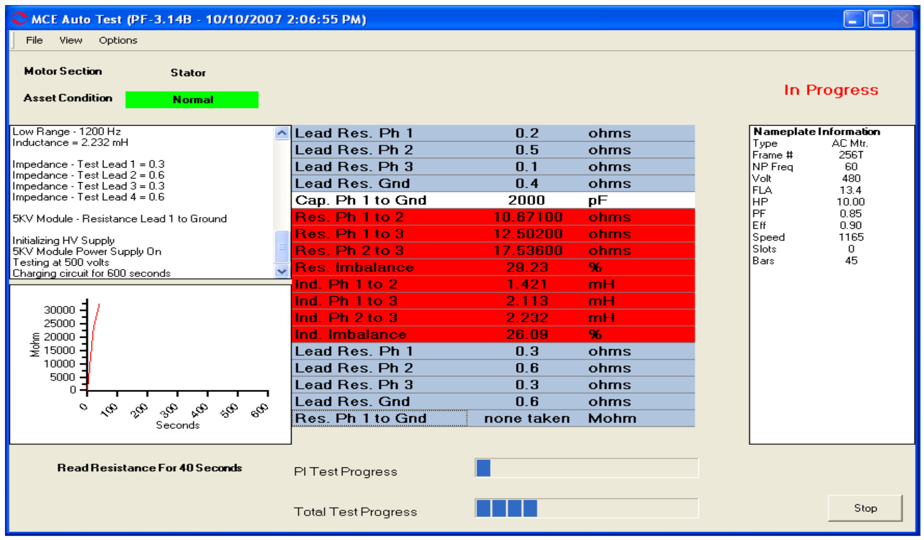


Figure 5-6: MCE Auto Test Window - PI Test

At the end of the PI test, the test results are automatically saved and the Fault Zone Report is generated and displayed. See Figure 5-7.

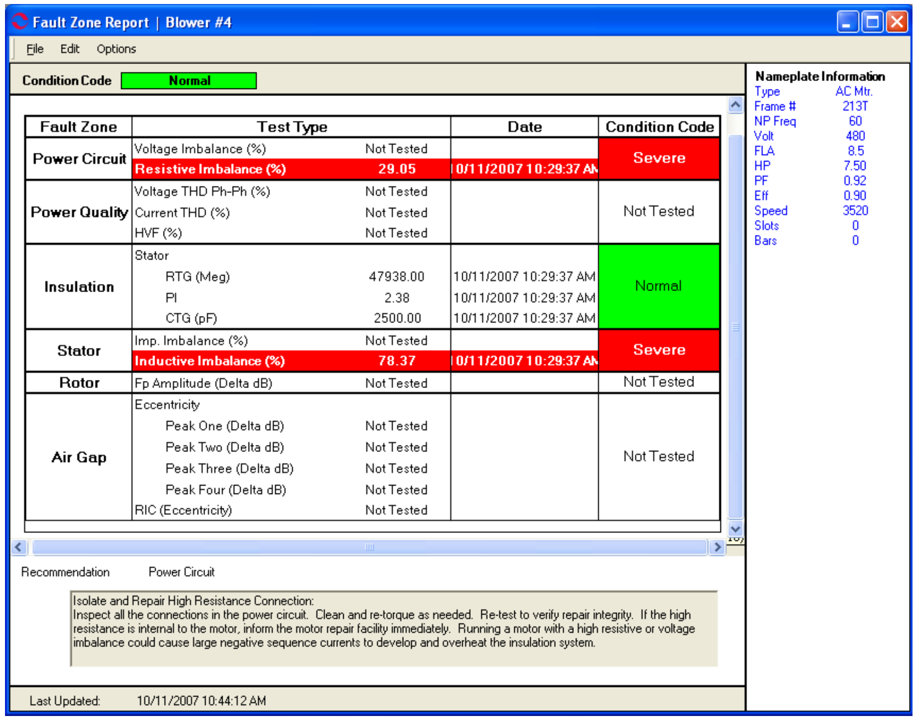


Figure 5-7: MCE Auto Test Fault Zone Report

Fault Zone Report

NOTE: The information for the Fault Zone Report, beginning with File Menu and ending with To View Test History on page 5-12, has been replaced with a new and improved ocular format. A description of the ocular fault zone can be found on page 3-52 in Chapter 3-MCEGold3.

File Menu

Print Preview. Print Preview, shown in Figure 5-8, displays the Fault Zone Report as it will be printed. Using the File menu on the Print Preview window, you can export the report to PDF or HTML or add comments before printing.

To *create a PDF file*, select File, Export to PDF, select the location you wish to save the file in, enter a file name, and click **Save**.

To *create a HTML file*, select File, Export to HTML, select the location you wish to save the file in, enter a file name and click **Save**.

To *add comments*, select File, Add Comments. In the Add Remarks window type your comments and click **Add**. The comments appear in the Comments section at the bottom of the report. They will appear on the printed report, but are not saved for the future. Permanent comments should be entered in the Message Center using Edit, Create Message, which is discussed on page 5-11.

To *print the report* click the **Print** icon on the Print Preview toolbar.

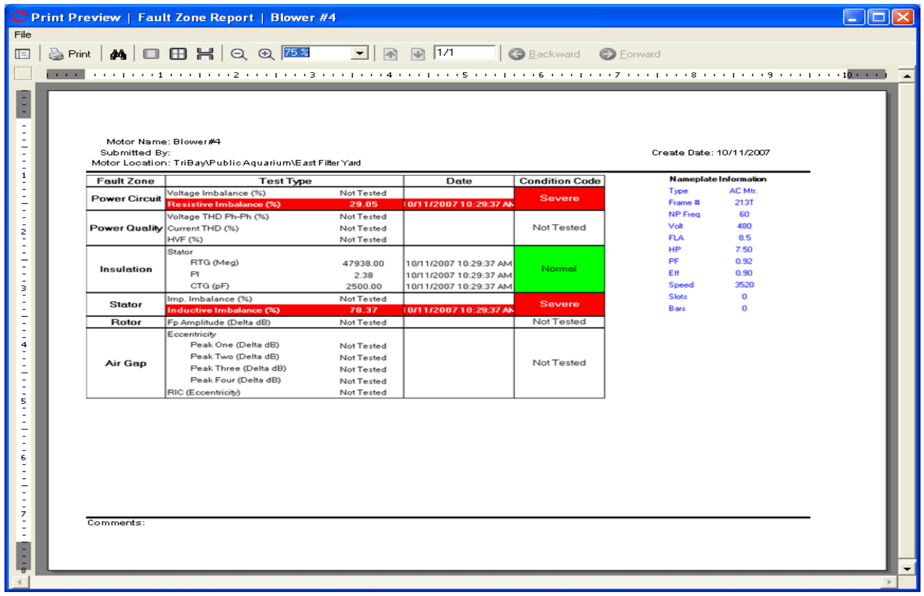


Figure 5-8: Print Preview

Print. Print prints the report to your default printer.

Exit (Ctrl+Q). Exit the report by using File, Exit (Ctrl+Q) or clicking the Close button (red X in the upper right corner).

Edit Menu

Create Message (Ctrl+M). You may enter permanent notes by selecting Create Message (Ctrl+M). This opens the Compose Asset Message window shown in Figure 5-4 on page 5-8. The note is viewed from the Message Center. See the section on Message Center in Chapter 3, page 3-41.

Options Menu

Refresh (Ctrl+R). The Refresh function is used to update the Fault Zone Report when changes have been made to the warning settings.

Set Condition Code. Change the condition code, by selecting an option button, the Condition Code box changes, and a note is automatically generated by the software. The note is viewed from the Message Center. See the section on Message Center, in Chapter 3, page 3-43.

Description/Recommendation

The blank area at the bottom of the report is designed to provide additional information, such as descriptions of the Fault Zones and Test Types or recommended actions for the Condition Code. It is for on screen viewing only and does not appear on the printed report.

To **view a description** of the Fault Zone or Test Type, click on the name in the Fault Zone report. The description will appear in the text box at the bottom of the window.

To **view the recommended course of action** for a condition code, click the condition code name. The recommended course of action will appear in the text box at the bottom of the window. Figure 5-7 shows how the window would appear if severe condition code of the power circuit was selected.

To View Test History

To **open the Test History** click on the test type result value or the date. The Test History window opens.

AC Standard Test

The AC Standard test is reach by selecting AC Standard from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The AC Standard Test Window (Figure 5-9) opens.

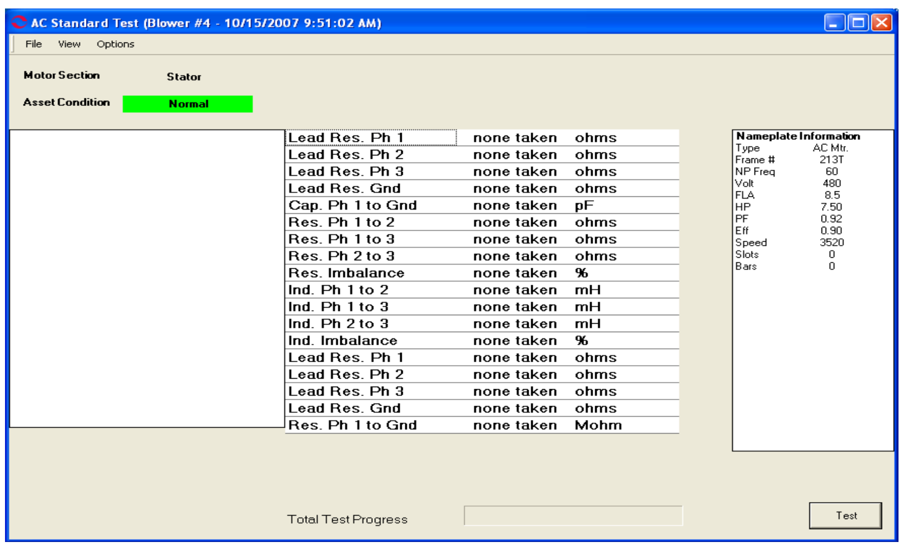


Figure 5-9: AC Standard Test Window

The AC Standard Test window menu consist of three options: File, View, and Options.

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the AC Standard test window and returns you to the MCEGold Home window.

View Menu

Create Message. Create Message opens the Compose Asset Message window (Figure 5-10). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

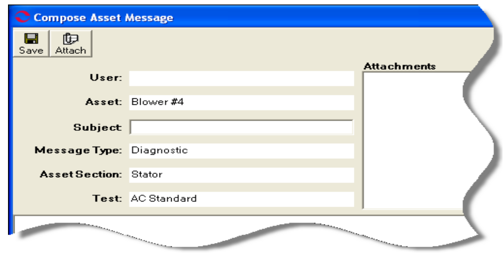


Figure 5-10: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting an option button (Figure 5-11). The Asset Condition box on the AC Standard Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43

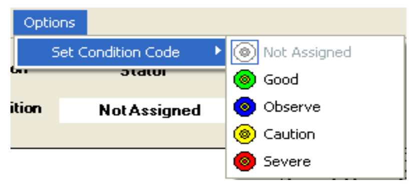


Figure 5-11: Options, Set Condition Code Menu

Step-by-Step AC Standard Testing

1. De-energize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE to the circuit, in the same manner each time, as referenced in Table 5-1. This ensures that the test data is trendable/repeatable.

Table 5-1: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
“T” lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested on the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-12.

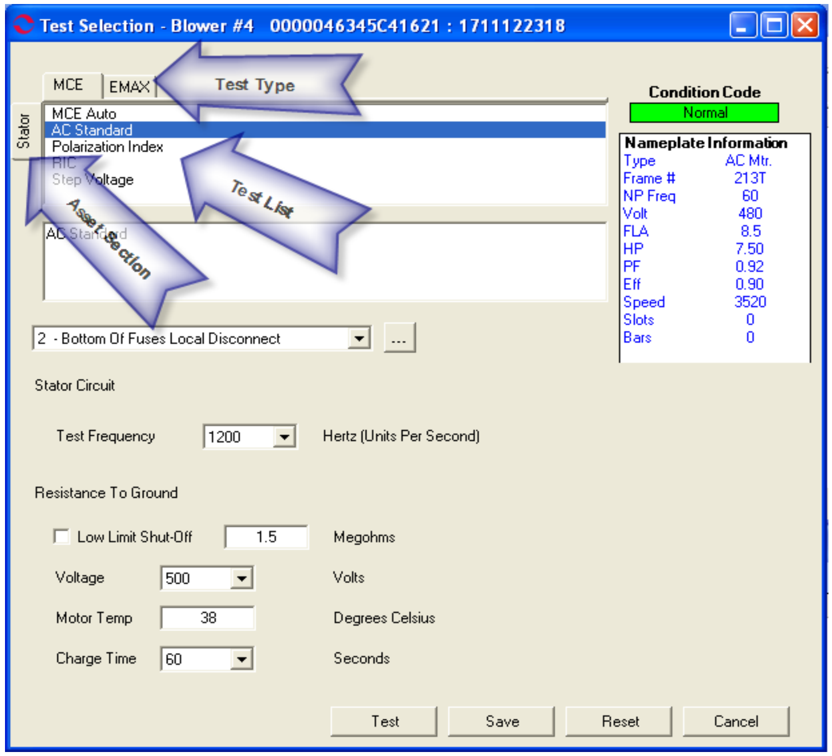


Figure 5-12: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Click AC Standard from the Test List.

   If all of the settings in the MCE Test Setup are correct, click **Test** to go directly to the test. Go to step 16.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-13.

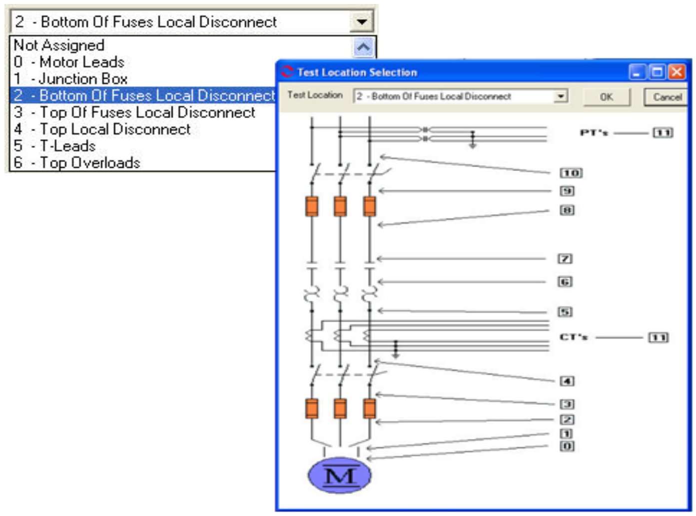


Figure 5-13: Asset Test Location

9. Verify the Test Frequency.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select the Charge Time Seconds.

    Click the down arrow and select the seconds from the drop-down list. The choices are from 30 to 180 seconds at 15 second increments.

14. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the testing window.

16. Click **Test** in the AC Standard Test Window.

17. Verify that you are about to apply "X" volts to the circuit by clicking **Yes**.

18. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area. See Figure 5-14.

    To stop the test at any time, click **Stop**. Click **Exit** to close the AC Standard test window and return to the Home window.

19. Click **OK** when the test is complete.

20. Re-test any individual point, if needed. If not go to step 21.

    If any portion of the test needs to be re-tested, double click the tab which appears to the right of the individual test point. This rechecks only that test point in "manual mode." See Figure 5-14.

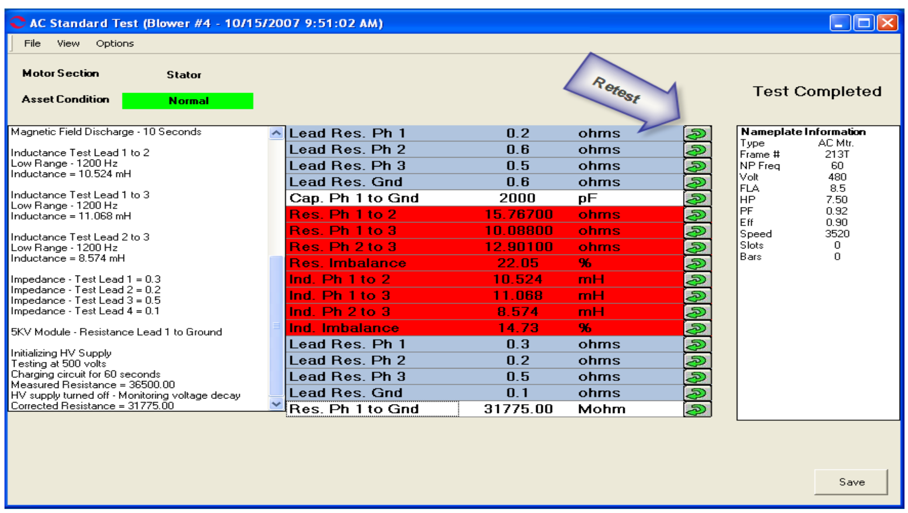


Figure 5-14: AC Standard Test Window

21. When retesting is complete or if no re-testing is needed, click **Save** or select File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

22. Click **OK** in the Save Complete window.

23. Click **Exit** in the AC Standard Test Window.

Polarization Index

The Polarization Index (PI) test is reached by selecting Polarization Index from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information.

Verify that the test set-up settings are correct and click **Test**. The PI test window opens. See Figure 5-15.

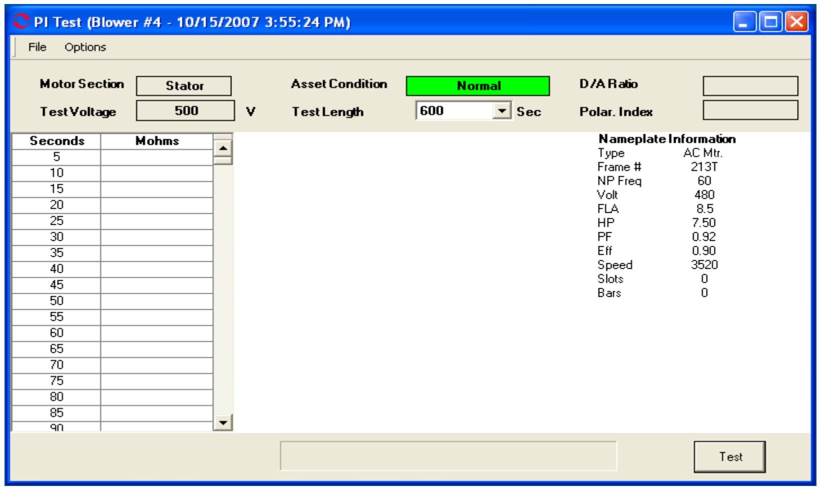


Figure 5-15: PI Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the PI Test window and returns you to the Home window.

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-16). The Asset Condition box on the PI Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

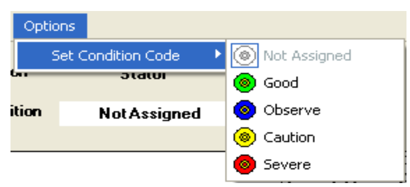


Figure 5-16: Set Condition Code Window

Step-by-Step Polarization Index Testing

The PI test takes ten minutes. During the test the menu items are dimmed (not available) and the **Test** button changes to **Stop**.

1. Deenergize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE to the circuit, in the same manner each time, as referenced in Table 5-2. This ensures that the test data is trendable/repeatable.

Table 5-2: : Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
“T” lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-17.

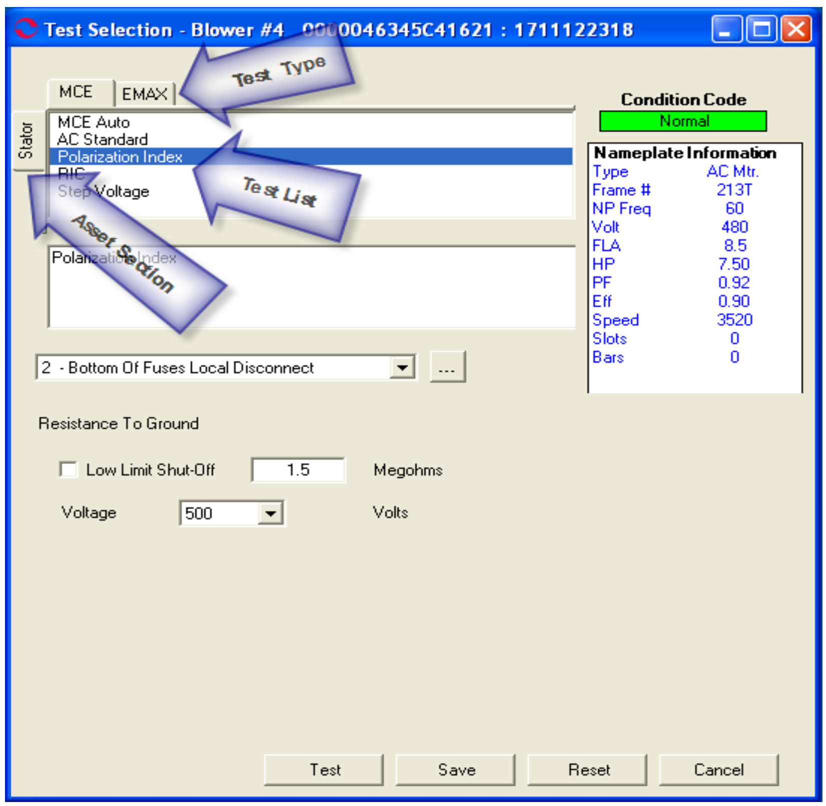


Figure 5-17: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-18.

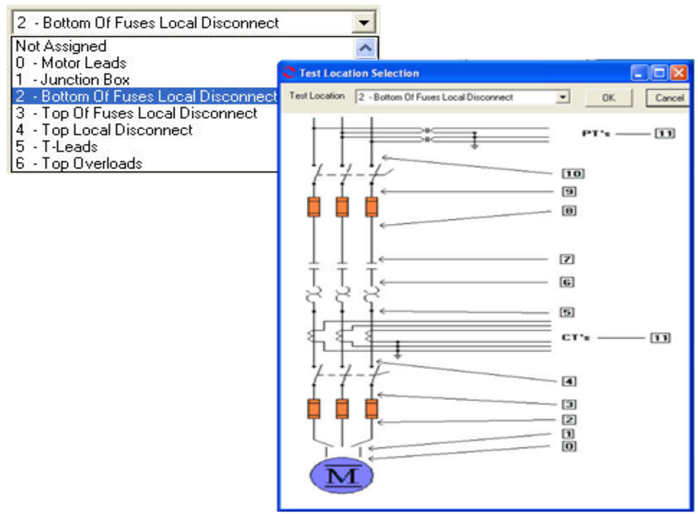


Figure 5-18: Asset Test Location

8. Verify the Low Limit Shut Off condition.

   Check the box to activate the low limit shut off and enter the desired Mohms.

9. Verify the Voltage.

   Click the down arrow and select the voltage from the drop-down list. Select the test voltage based on asset nameplate voltage.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the testing window.

12. Click **Test** in the PI Test window.

13. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

14. As the test proceeds, the test result values are displayed in the table and plotted on the graph. At the end of one minute the D/A ratio is computed and displayed in the D/A Ratio text box. The progress bar displays the progress of the testing.

    Note: To stop the test, click **Stop.**

15. Click **OK** in the Test Completed window. The menu item become active and the **Stop** button is inactive.

16. Exit the PI Test window by selecting File, Exit, or Ctrl+X, or the close button (Red X in the upper right corner).

17. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The PI Test window closes

    If you select **No**, the PI Test window closes. No test data is saved.

RIC

The RIC test is reached by selecting RIC from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The RIC test window opens. See Figure 5-19.

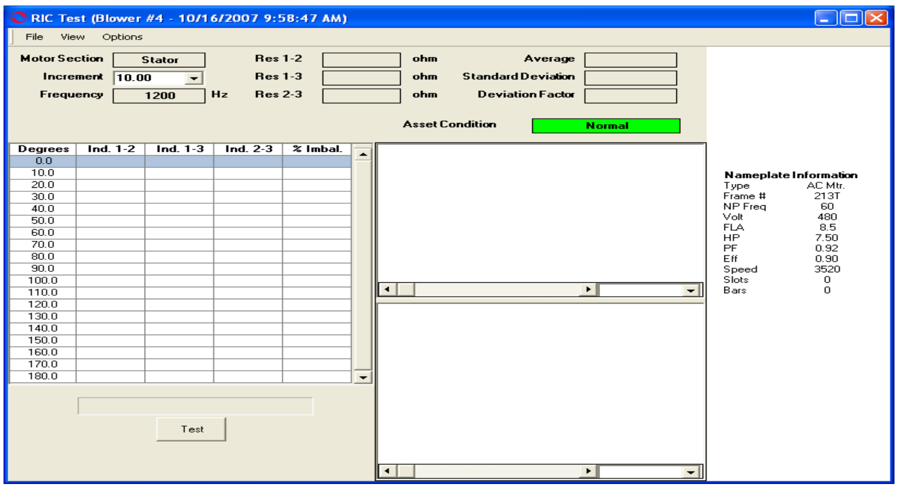


Figure 5-19: RIC Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the RIC Test window and returns you to the Home window.

View Menu

Create Message . Create Message opens the Compose Asset Message window (Figure 5-20). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

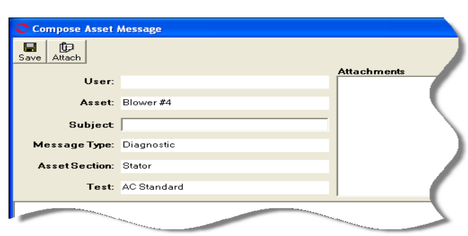


Figure 5-20: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-21). The Asset Condition box on the RIC Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

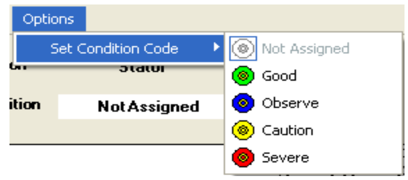


Figure 5-21: Set Condition Code Window

Step-by-Step RIC Testing

During the test the menu items are dimmed (not available). To stop testing, use File, Exit which becomes active after each test point.

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Place the shaft key way in the up position. This ensures a common starting point for all subsequent tests.

4. Ensure that the field is disconnected from the control circuit.

   This is accomplished by isolating/removing the brushes from the slip rings or by disconnecting the field leads from the diode pack in a self-exited asset. This allows the natural magnetic field on the rotor to expand, enhancing the detection of rotor problems.

5. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-3. This ensures that the test data is trendable/repeatable.

Table 5-3: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

6. Highlight the asset to be tested in the Site Navigator.

7. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-22.

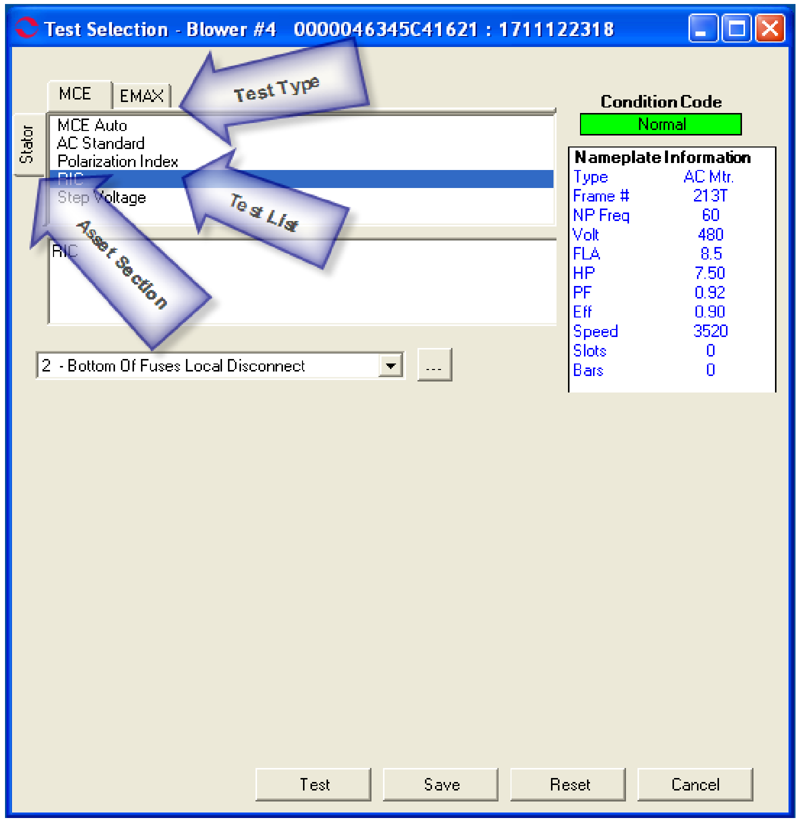


Figure 5-22: Test Selection Window

8. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset section is available.

9. Select RIC from the Test List box.

10. Verify the Test Location in the Test Setup section.

    To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-23.

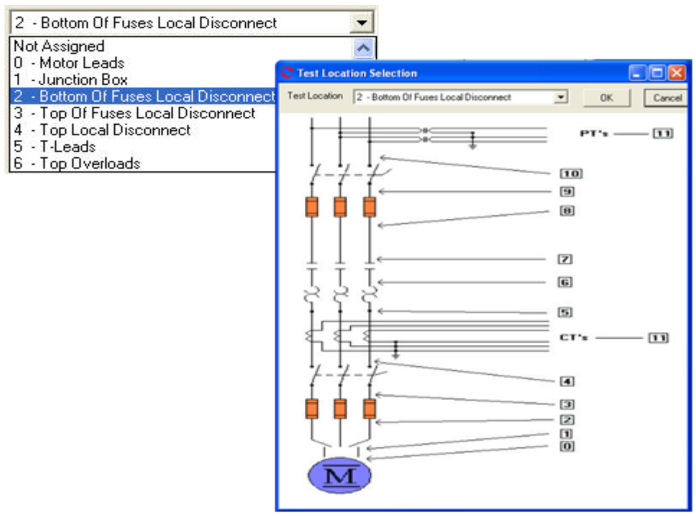


Figure 5-23: Test Locations

11. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

12. Click **Test** to go to the test. The RIC test window, Figure 5-24, opens.

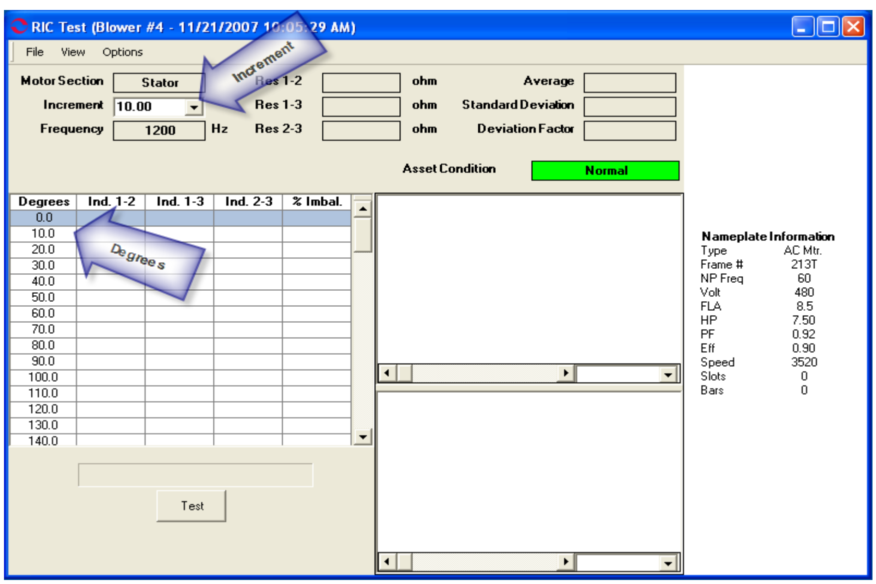


Figure 5-24: RIC Test Window

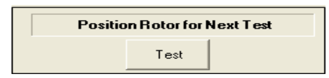
13. Verify that increments to be used during testing are correct. This information is located at the top of the RIC Test window.

    To change the Increments, which automatically computes the appropriate Degrees, click the down arrow and select the increment from the drop-down list.

    The new increments are displayed and the degrees on the test data table is updated.

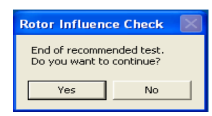
14. Position the rotor to the first position and click **Test** to begin testing.

15. At the end of each test point, you will be reminded to position the rotor for the next test point. Move the rotor and click **Test**. Repeat until the end of the recommended test.



    As the test progresses, the values will be inserted into the table and displayed in the graph areas. The magnification of the graphs can be changed by using the down arrows below each graph area and selecting a new value from the drop down list. The default is Full.

16. At the end of the recommended test you will be asked if you want to continue. Select **Yes** to continue testing or **No** to end testing.



17. Exit the RIC Test window by selecting File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

18. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The RIC Test window closes.

    If you select **No**, the RIC Test window closes. No test data is saved.

Step Voltage

The Step Voltage test is reached by selecting Step Voltage from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Step Voltage Test window opens. Figure 5-25.

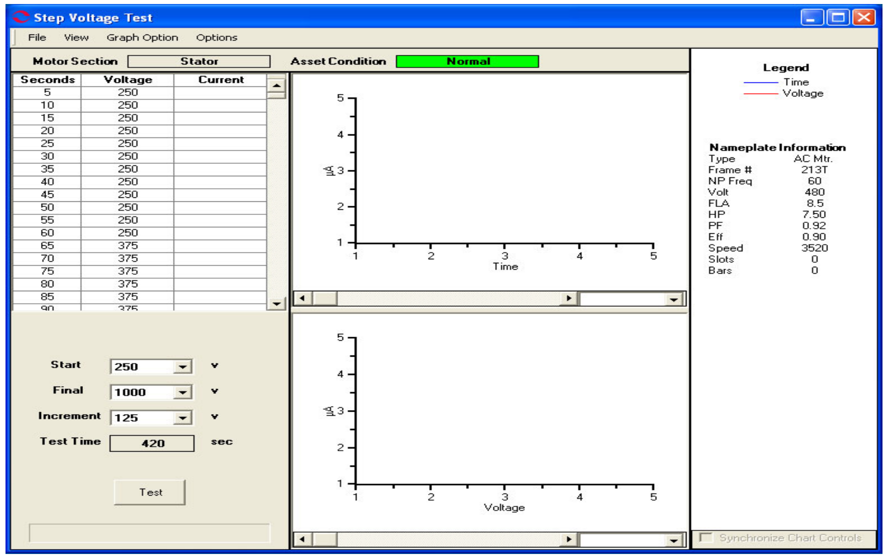


Figure 5-25: Step Voltage Test

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Step Voltage window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-26). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

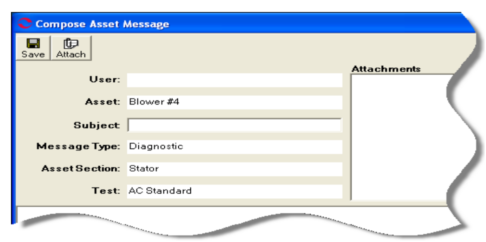


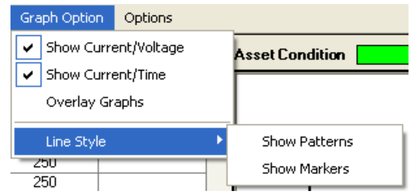
Figure 5-26: Compose Asset Message

Graph Option Menu

Show Current/Voltage. Show Current/Voltage controls the graph display area. If just Current/Voltage is selected one graph displays on the window. If Show Current/Voltage and Show Current/Time are both selected then two graphs will display.

Show Current/Time. Show Current/Time controls the graph display area. If just Current/Time is selected one graph displays on the window. If Show Current/Time and Show Current/Voltage are both selected then two graphs will display.

Overlay Graphs. Overlay Graphs controls the graph display area. When Overlay Graphs is selected test results are graphed on one graph.



Line Style. Line Style controls the appearance of the line on the graph.

Show Patterns changes the graph line style from a solid to a pattern. When a change is made to the line style it is reflected in the Legend area of the window, which is located just above the Nameplate Information.

Show Markers inserts markers on the graph line. When a change is made to the line style it is reflected in the Legend area of the window, which is located just above the Nameplate Information.

Options Menu

Set Condition Code. Change the condition code, by selecting an option button (Figure 5-27). The Asset Condition box on the Step Voltage Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

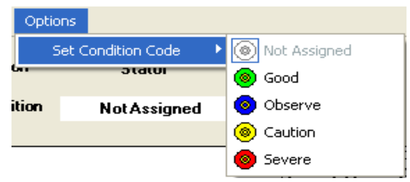


Figure 5-27: Set Condition Code Window

Step-by-Step Step Voltage Testing

During the test the menu items are dimmed (not available).

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-4. This ensures that the test data is trendable/repeatable.

Table 5-4: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-28.

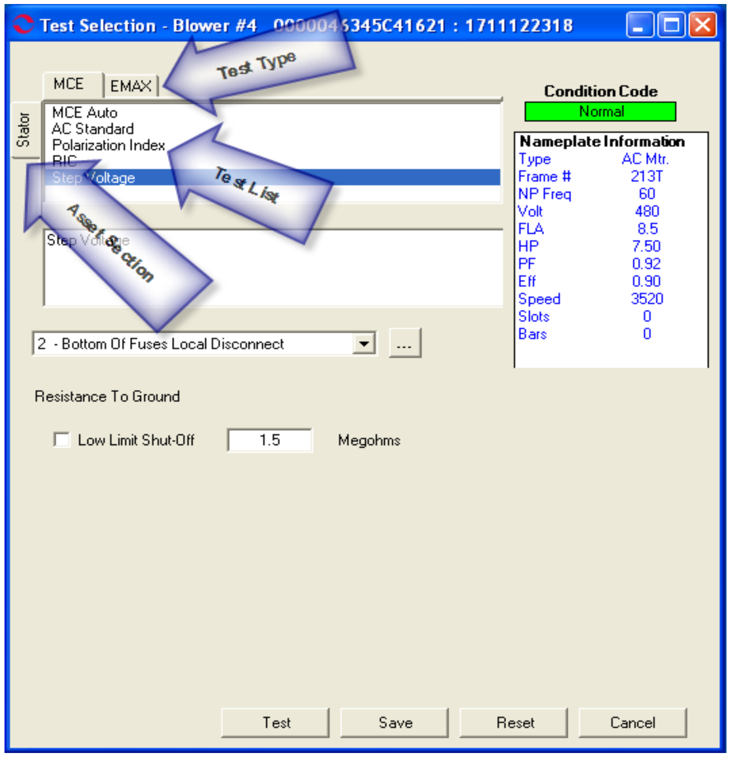


Figure 5-28: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Select Step Voltage from the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-29.

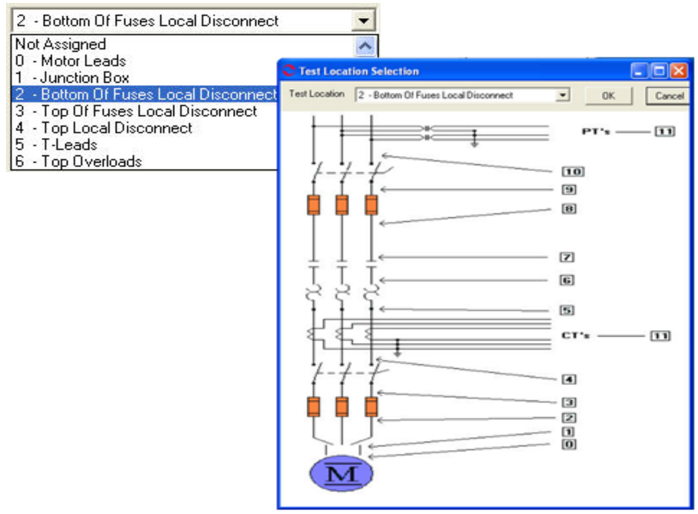


Figure 5-29: Test Locations

9. Verify the Low Limit Shut Off condition.

   Check the box to activate the low limit shut off and enter the desired Mohms.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the Step Voltage test window. See Figure 5-30.

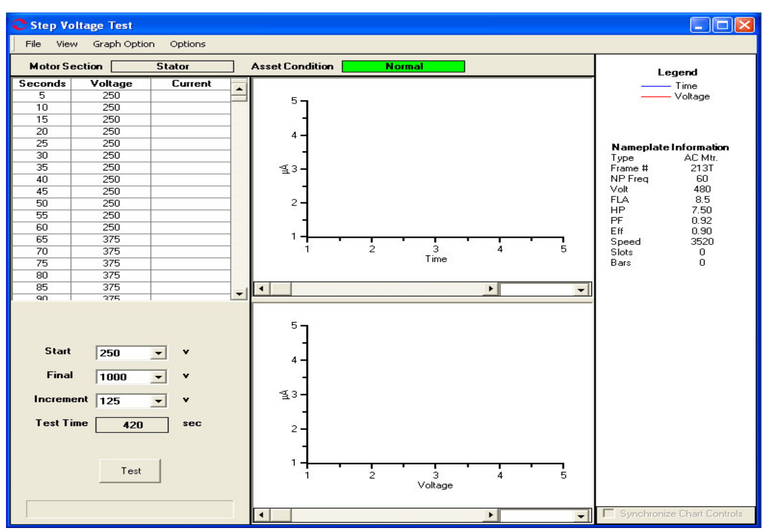


Figure 5-30: Step Voltage Test Window

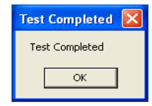
12. To begin the test click **Test**.

13. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

14. Test values are entered in the table on the left and are displayed in graph format on the right side of the window. The magnification of the graphs can be changed by using the down arrows below each graph area and selecting a new value from the drop down list. The default is Full. A progress bar at the bottom of the screen tracks the testing progress.

    Note: During the test the **Test** button changes to **Stop**, which allows you to interrupt the testing.

15. At the end of testing click **OK** in the Test Completed window.



16. Exit the Step Voltage Window by selecting File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

17. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The Step Voltage Test window closes.

    If you select **No**, the Step Voltage Test window closes. No test data is saved.

AC Synchronous Assets

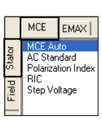
The MCE tests for an AC Synchronous asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage for the *Stator* section and MCE Auto, Synchronous, Polarization Index, and Step Voltage for the *Field* section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test
- Polarization Index (PI)/ Dielectric Absorption (DA). If a PI is performed, it is not necessary to perform a separate DA.

Synchronous assets are divided into two separate sections (Stator and Field Circuit). The asset Section of the Test Selection window defaults to Stator.

Some asset circuits may have surge capacitors and/or power factor correction capacitors installed. This is important since these components affect the values of the collected data, and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor or surge capacitors installed. However, a test should be taken with the surge capacitors removed for future comparison. If a asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.



Stator Section Test

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

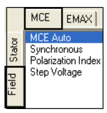
Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

RIC

RIC test is the same as for an AC Induction asset. See RIC on page 5-20.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.



Field Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Synchronous

The Synchronous test is reached by selecting the Field Tab and Synchronous from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Synchronous Test window opens. Figure 5-31.

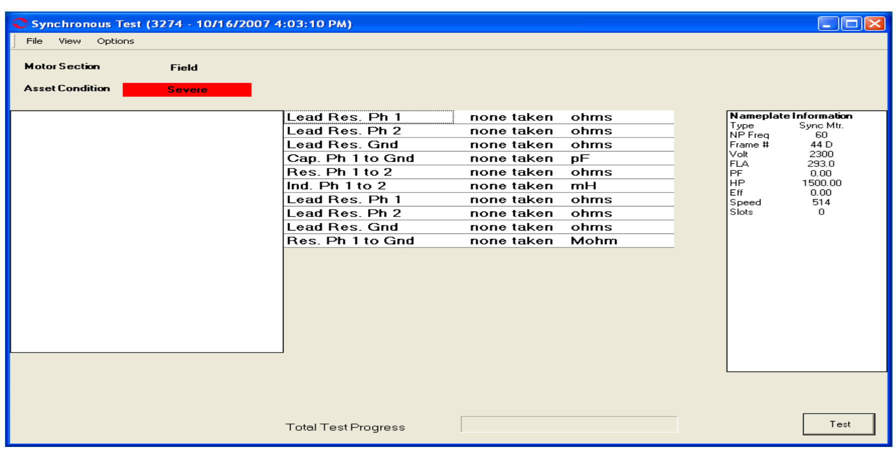


Figure 5-31: Synchronous Test Window

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Synchronous Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-32). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

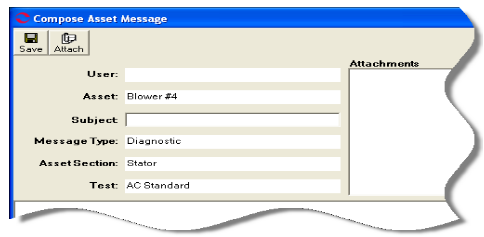


Figure 5-32: Compose Asset Message

Options Menu

Set Condition Code. Change the condition code, by selecting an option button, the Asset Condition box on the Synchronous Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

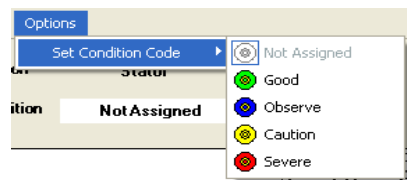


Figure 5-33: Set Condition Code Window

Step-by-Step Synchronous Testing

During the test the menu items are dimmed (not available).

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-5. This ensures that the test data is trendable/repeatable.

Table 5-5: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-34.

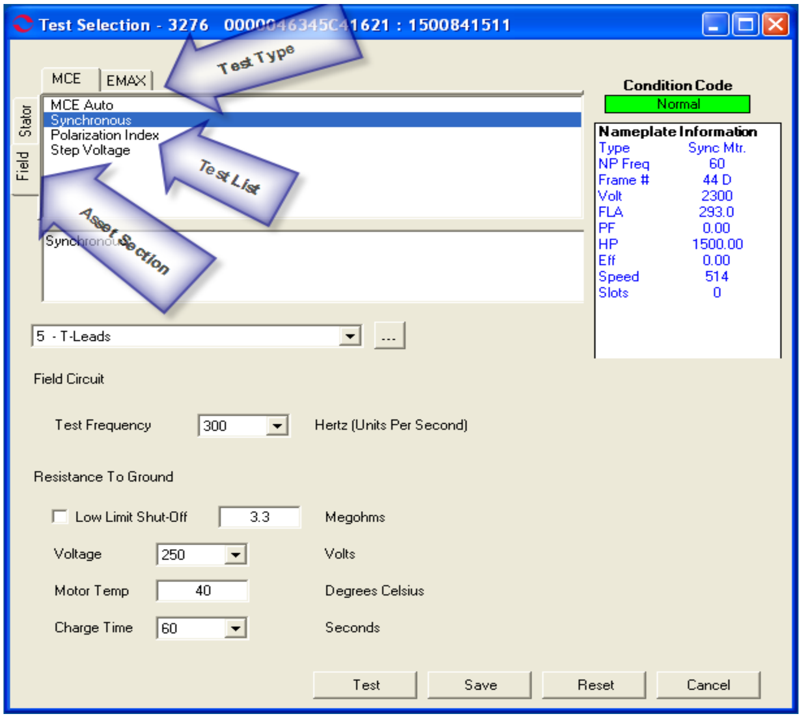


Figure 5-34: Test Selection Window

6. Verify that the MCE (Test Type) and Field (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Select Synchronous from the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-35.

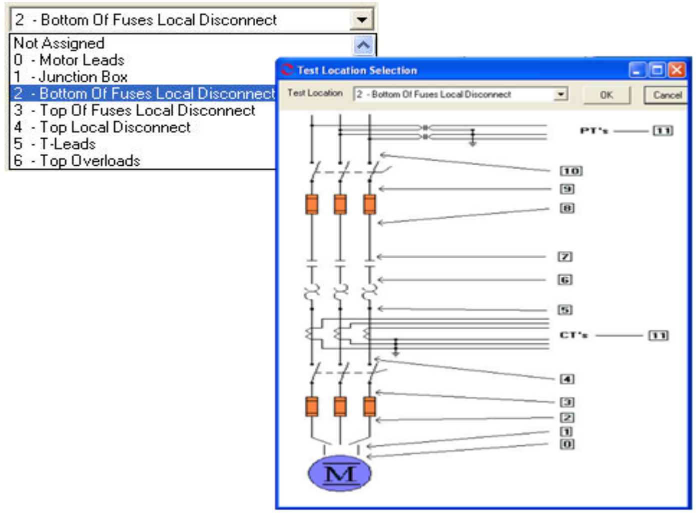


Figure 5-35: Test Locations

9. Verify the Test Frequency.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select the Charge Time Seconds.

    Click the down arrow and select the seconds from the drop-down list. The choices are from 30 to 180 seconds at 15 second increments.

14. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the Synchronous test window.

16. Verify that you are about to apply “X” volts to the circuit and click **Yes**.

17. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds.

18. At the end of testing the **Test** button changes to **Save,** Test Completed appears above the Nameplate Information section, and the progress bars disappear.

19. Re-test any individual point, if needed. If not go to step 20.

    If any portion of the test needs to be re-tested, click the tab which appears to the right of the individual test point. This retests only that test point in "manual mode." (Figure 5-36)

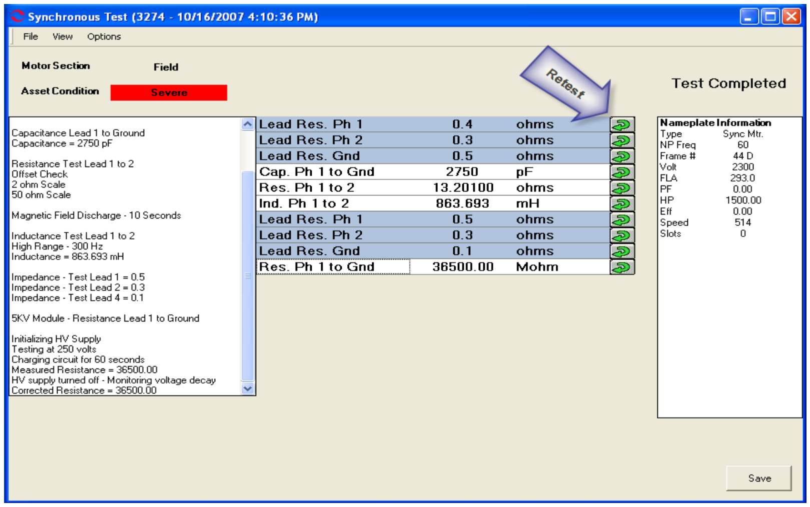


Figure 5-36: Completed Synchronous Test Window

20. When retesting is complete or if no re-testing is needed, click **Save** or File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

21. Click **OK** in the Save Completed window.

22. Click **Exit** to close the window.

AC Wound Rotor Assets

Wound rotor assets (WRMs) are divided into three separate sections (Stator, Rotor, and Resistor Bank). The asset Section box of the Test Selection window defaults to Stator.

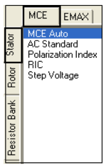
The MCE tests for an AC Wound Rotor asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage for the Stator section. MCE Auto, AC Standard, Polarization Index, and Step Voltage for the Rotor section. MCE Auto, Resistor Bank, Polarization Index, and Step Voltage for the Resistor Bank section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test

- Polarization Index (PI)/ Dielectric Absorption (DA). If a PI is performed, it is not necessary to perform a separate DA.

Some circuits may have surge capacitors and power factor correction capacitors installed. This is important since these components affect the values of the collected data, and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor capacitors installed. However, surge capacitors must be removed to ensure valid test data. If a asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.



Stator Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

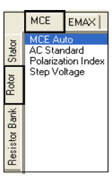
Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

RIC

RIC test is the same as for an AC Induction asset. See RIC on page 5-20.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5- 24.



Rotor Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

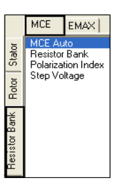
AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5- 24.



Resistor Bank Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Resistor Bank Test

The Resistor Bank test is reached by selecting the Resistor Bank tab and Resistor Bank from the test list on the Test Selection window. See page 1-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Resistor Bank Test window opens. Figure 5-37.

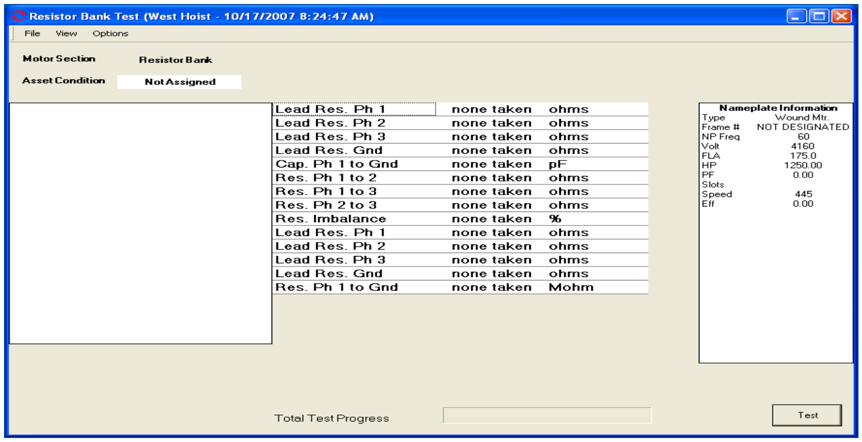


Figure 5-37: Resistor Bank Test Window

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Resistor Bank Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-38). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

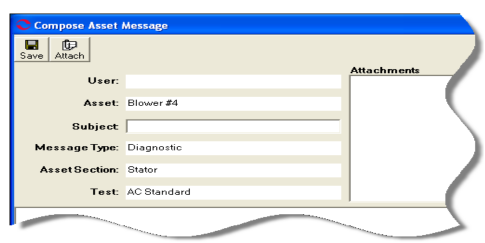


Figure 5-38: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting an option button (Figure 5-39). The Asset Condition box on the Resistor Bank Test window changes and a note is automatically generated by the software.

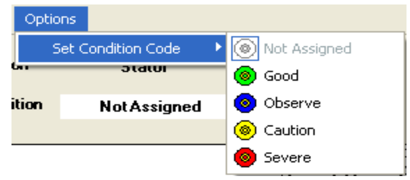


Figure 5-39: Set Condition Code Window

Step-by-Step Resistor Bank Testing

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Lift the brushes to isolate the resistor bank from the rotor field.

4. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-6. This ensures that the test data is trendable/repeatable.

Table 5-6: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
brushes	brushes over slip ring 1	brushes over slip ring 2	brushes over slip ring 3	gnd

5. Highlight the asset to be tested in the Site Navigator.

6. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-40.

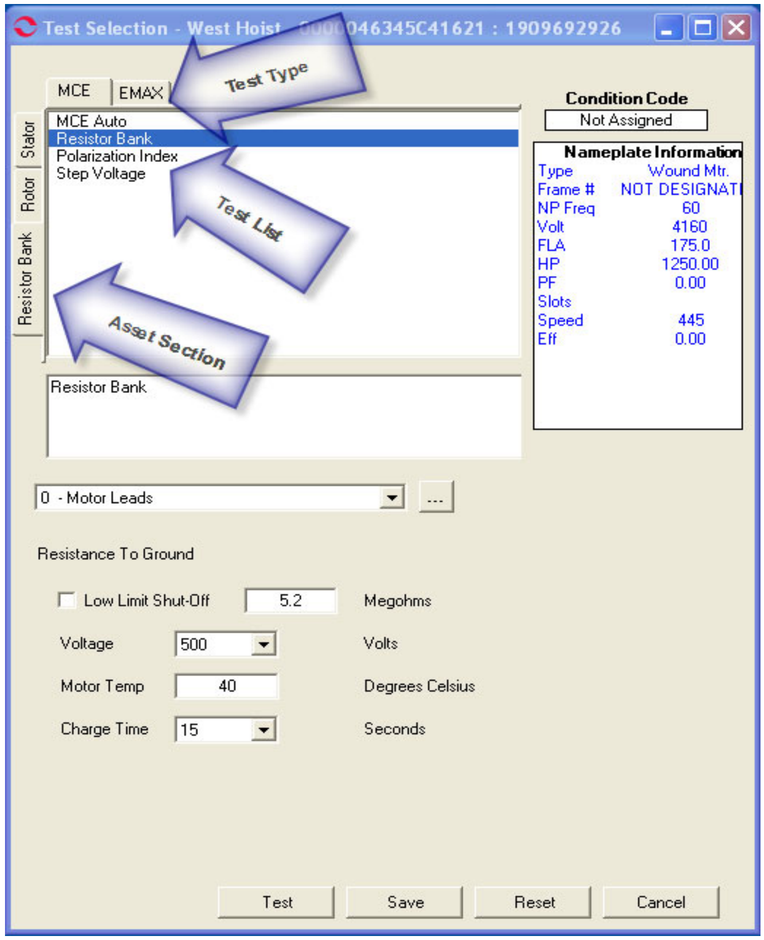


Figure 5-40: Test Selection Window

7. Verify that the MCE (Test Type) and Resistor Bank (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

8. Select Resistor Bank from the Test List box.

9. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-41.

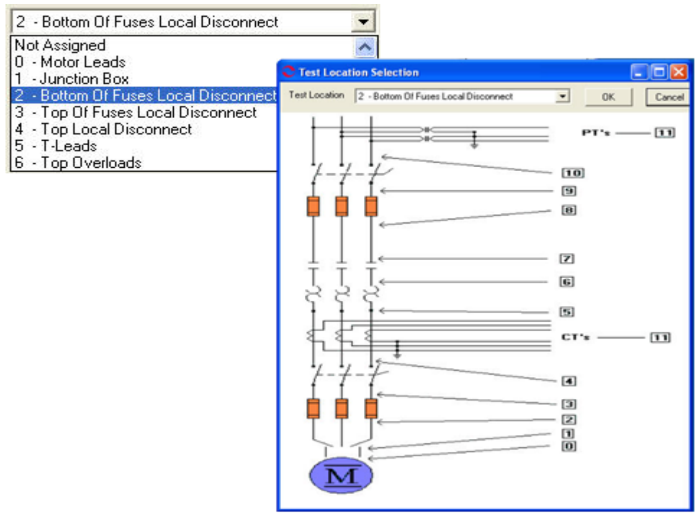


Figure 5-41: Test Locations

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

14. Click **Test** to go to the Resistor Bank Test window.

15. To begin the Resistor Bank Test, click **Test**.

16. Verify that you are about to apply “X” volts to the circuit and click **Yes**.

17. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area.

18. Re-test any individual point, if needed. If not go to step 19.

If any portion of the test needs to be re-tested, click the green arrow to the right of the point. This rechecks only that test point in “manual mode.” See Figure 5-42.

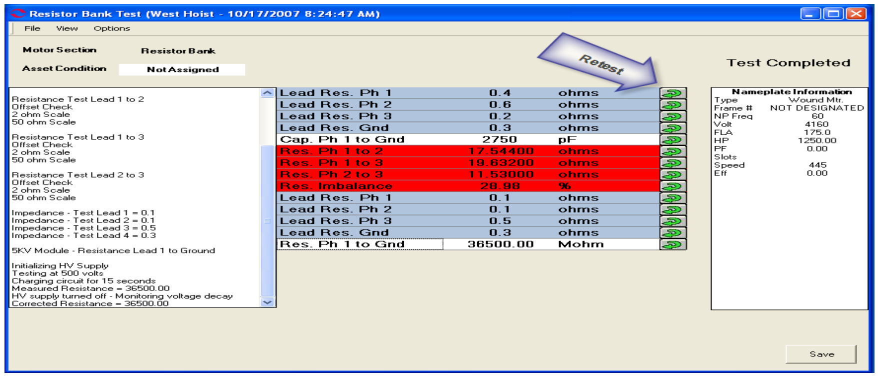


Figure 5-42: Resistor Bank Test Window - Retest Points

19. When retesting is complete or if no re-testing is needed, click **Save,** or File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

20. Click **OK** in the Save Completed window and the Resistor Bank Test window closes.

DC Assets

The MCE tests for a DC asset are MCE Auto, DC Standard, Polarization Index, Bar-to-Bar, and Step Voltage for the *Armature* section. MCE Auto, DC Standard, Polarization Index, and Step Voltage for the *Field* section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Standard Test
- Polarization Index (PI). If a PI is performed, it is not necessary to perform a separate DA.

DC assets are divided into two separate sections (Armature Circuit and Field Circuit). The Asset Section of the Test Selection window defaults to Armature Circuit.

Armature Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

DC Standard Test

The DC Standard Test is reached by selecting DC Standard from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The DC Standard Test Window (Figure 5-43) opens.

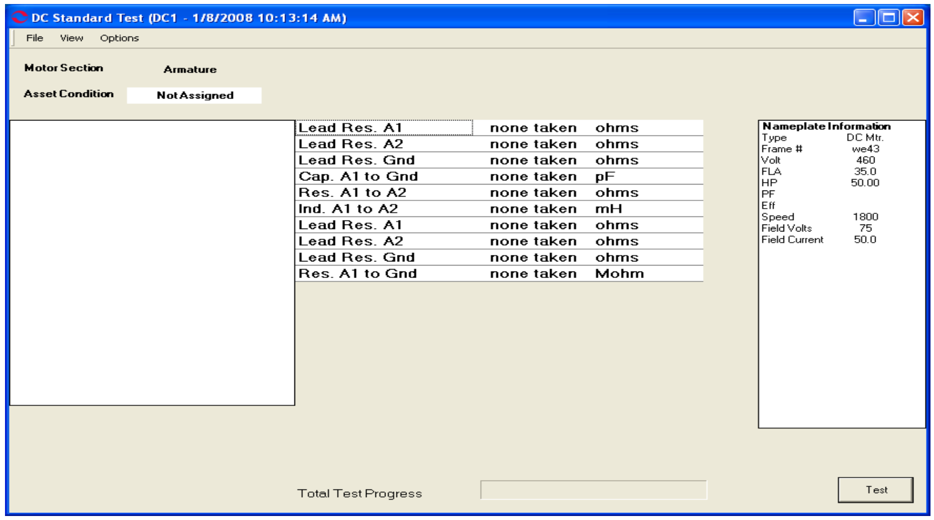


Figure 5-43: DC Standard Test Window

The DC Standard Test window menu consist of three options: File, View, and Options.

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the AC Standard test window and returns you to the MCEGold Home window.

View Menu

Create Message. Create Message opens the Compose Asset Message window (Figure 5-44). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

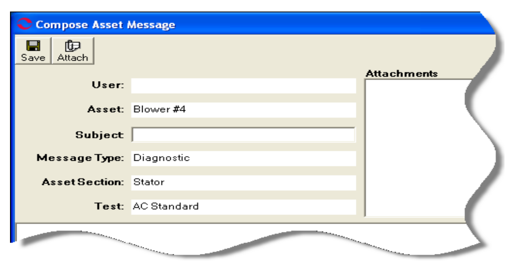


Figure 5-44: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting an option button (Figure 5-45). The Asset Condition box on the AC Standard Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43

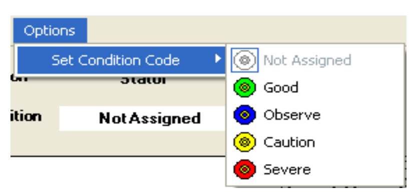


Figure 5-45: Options, Set Condition Code Menu

Step-by-Step DC Standard Testing

1. Deenergize and lock out the starter and asset.

2. Check for low level induced voltage using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit, in the same manner each time, as referenced in Table 5-7 and shown in Figure 5-46. This ensures that the test data is trendable/repeatable.

Table 5-7: Test Lead Connections

MCE test leads	Black	Blue	Green
motor leads	A1; A1 or S1	A2; S2 or A2	ground

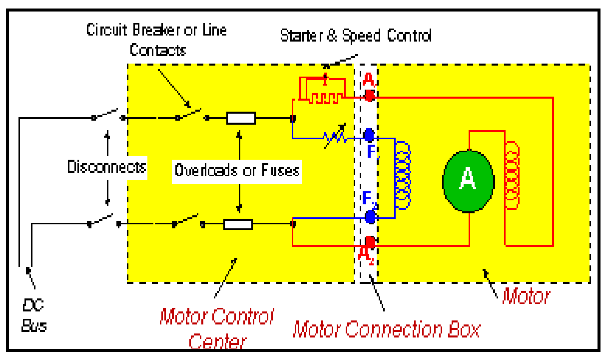
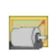


Figure 5-46: DC Asset Circuit Connections

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the tool bar to open the Test Selection window.

6. Verify that Armature Circuit is selected in the asset Section box.

7. Select DC Standard Test in the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-47.

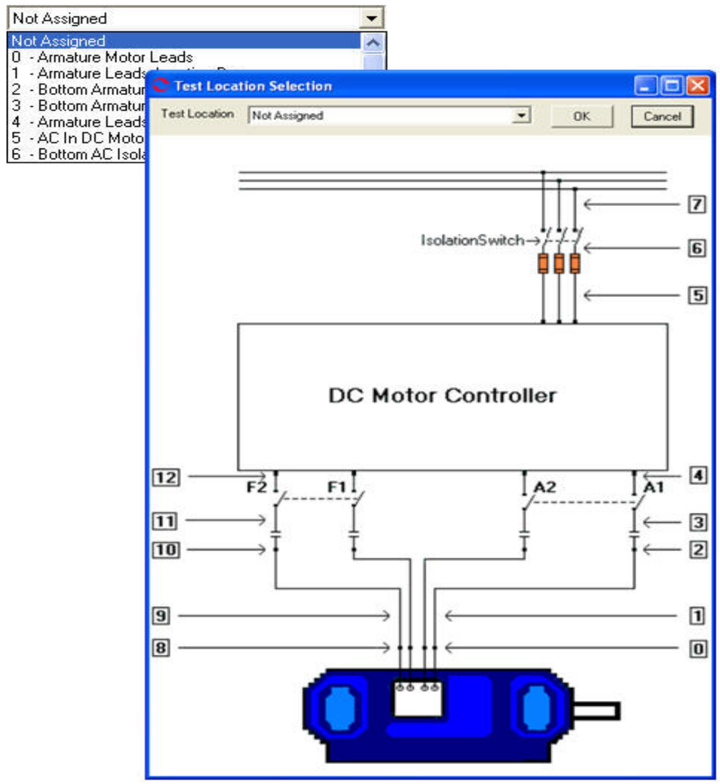


Figure 5-47: DC Asset Test Location

9. Select Test frequency for the Armature Circuit from the drop-down box.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Check the Low Limit Shut Off box and enter Mohms.

11. Select the test voltage for the resistance to ground measurement (500 for ≤ 2400 volts or 1000 for >2400 volts) based on asset nameplate voltage.

    Click the down arrow and select the voltage from the drop-down list.

12. Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select Charge Time seconds.

    Click the down arrow and select the charge time from the drop-down list. The choices are from 15 to 600 seconds.

14. Click **Save**, to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the DC Standard Test Window.

16. Click **Test** to begin testing.

17. Verify that you are about to apply "X" volts to the circuit by clicking **Yes**.

18. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area. See Figure 5-48.

    To stop the test at any time, click **Stop**. Click **Exit** to close the DC Standard test window and return to the Home window.

19. Re-test any individual point, if needed. If not go to step 20.

    If any portion of the test needs to be re-tested, double click the tab which appears to the right of the individual test point. This rechecks only that test point in "manual mode." See Figure 5-48.

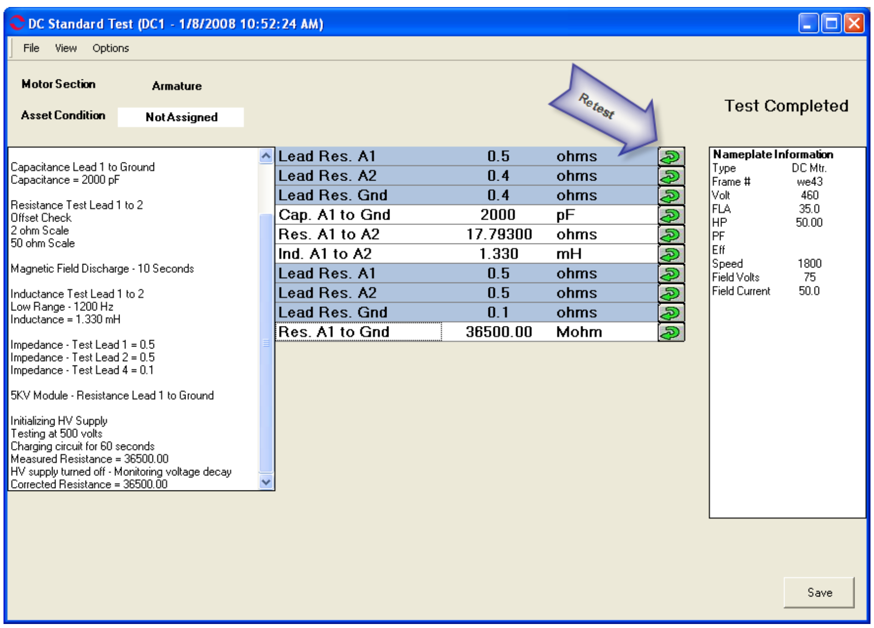


Figure 5-48: DC Standard Test Window

20. When retesting is complete or if no re-testing is needed, click **Save** or select File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

21. Click **OK** in the Save Complete window.

22. Click **Exit** in the DC Standard Test Window.

Step-by-Step Polarization Index Testing

1. Deenergize and lock out the starter asset.

2. Check for low level induced voltage using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground

3. Connect the MCE test leads to the circuit, in the same manner each time, as referenced in Table 5-8 and shown in Figure 5-49. This ensures that the test data is trendable/repeatable.

Table 5-8: Test Lead Connections

MCE test leads	Black	Blue	Green
motor leads	A1; A1 or S1	A2; S2 or A2	ground

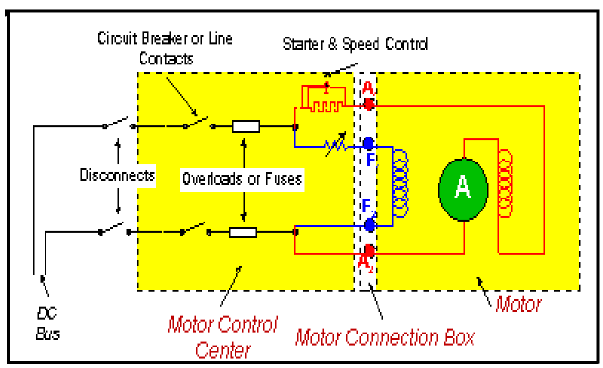
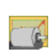


Figure 5-49: Asset Circuit Connections

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the tool bar to open the Test Selection window.

6. Verify that Armature is selected.

7. Select Polarization Index in the Test List Box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-50.

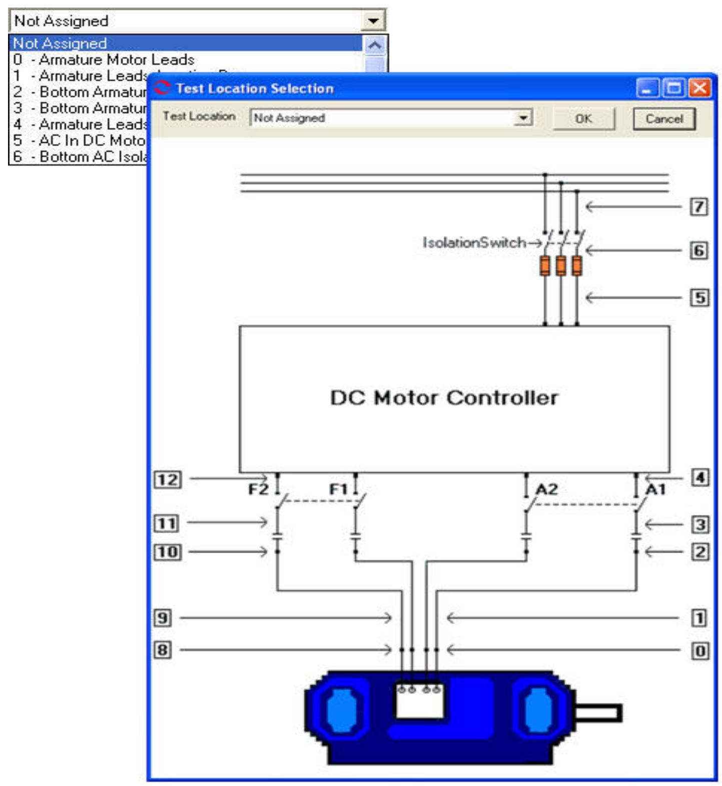


Figure 5-50: DC Asset Test Location

9. Check the Low Limit Shut Off box and enter Mohms.

10. Enter the test voltage for the resistance to ground measurement (500 for ≤ 2400 volts or 1000 for >2400 volts) based on asset nameplate voltage.

    Click the down arrow and select the voltage from the drop-down list.

11. Click **Save**, to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

12. Click **Test** to go to the PI Test Window. See Figure 5-51.

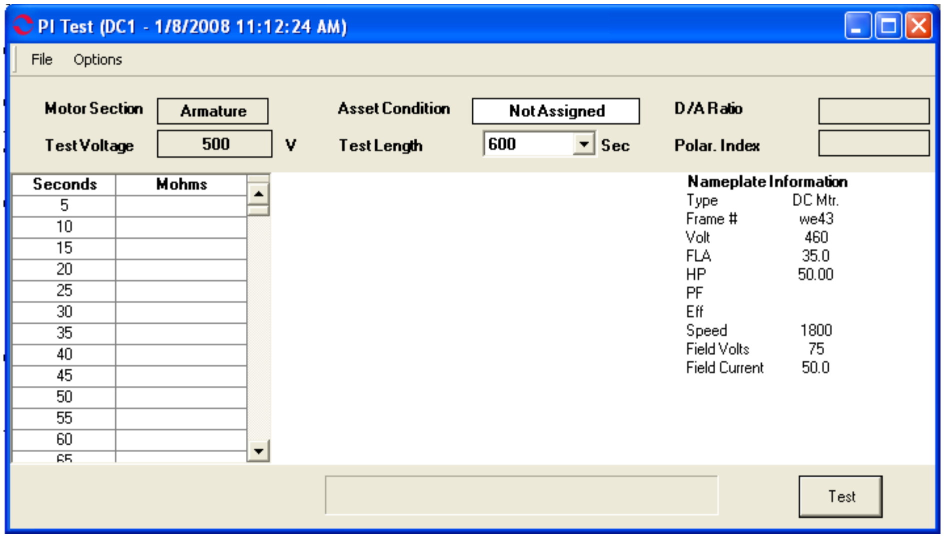


Figure 5-51: PI Test Window

13. Select the test length in seconds from the drop down list.

14. Click **Test** to begin testing.

    To stop the test at any time, click **Stop**. Click **Exit** to return to the Test Selection window.

15. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

16. During the testing the D/A ratio and the Polarization Index will be computed and entered in the appropriate text boxes on the window.

17. Click **OK** at the end of testing in the Test Complete window.

18. Close the PI Test window by selecting File, Exit, or Ctrl+X, or the close button (red X in the upper right corner).

19. Click **Yes** to save test data, in the Save Test Data window. Or **No** to exit without saving test data.

20. Click **OK** in the Save Completed window.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Bar-to-Bar

The Bar-to-Bar test is reached by selecting the Armature tab and Bar-to-Bar from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Bar-to-Bar Test window opens. Figure 5-52.

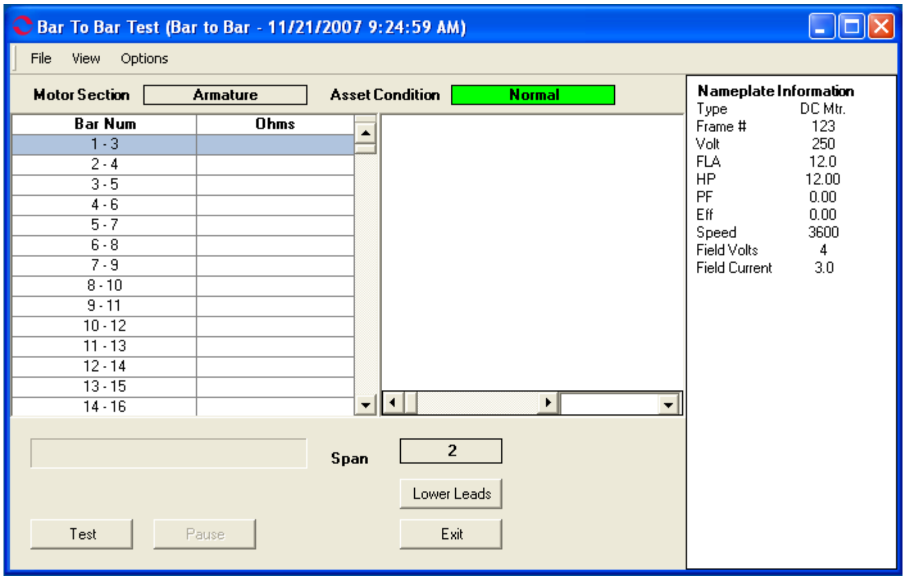


Figure 5-52: Bar-to-Bar Test Window

File Menu

Exit. Exit (Ctrl+X) closes the Bar-To-Bar Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-53). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

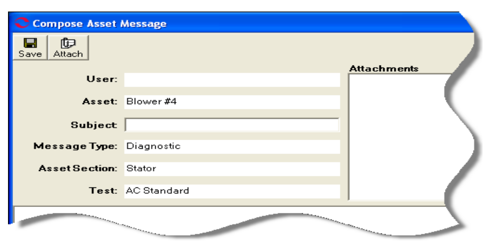


Figure 5-53: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting the desired condition code option button (Figure 5-54). The Asset Condition box on the Bar-To-Bar Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

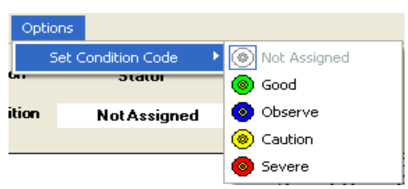


Figure 5-54: Set Condition Code Window

Raise Leads/Lower Leads Button

The Raise Leads/Lower Leads button toggles to signify the action to be taken with the test leads during testing.

Exit Button

The Exit Button is inactive (dimmed) during testing, but is active between moving the leads.

Pause Button

The Pause Button is inactive (dimmed) during testing, but is active between moving the leads.

Test

The lower left area of the Bar-to-Bar test window, Figure 5-55, informs you what action is required. The Test Dialog box displays the testing progress. The software checks for the leads and if no leads are found displays, “Waiting for Leads” in the text box. When the leads are in position, testing begins automatically. During testing the text box displays Read Resistance, Checking Leads, Test Completed, Waiting for Leads.

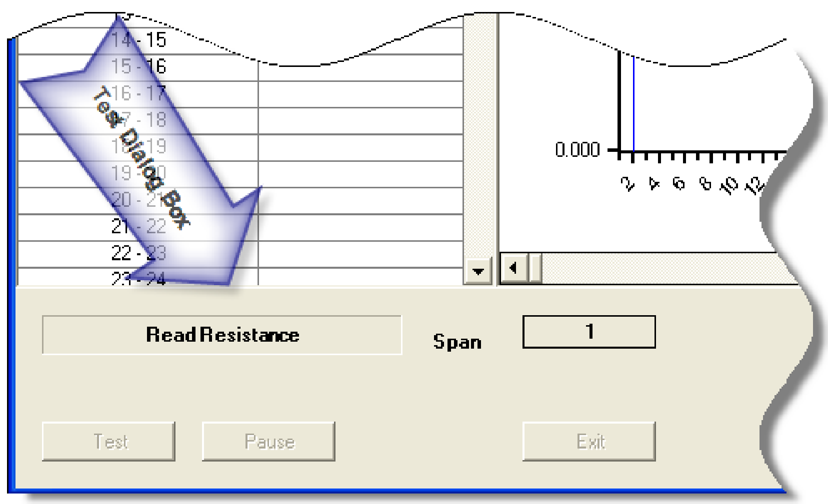


Figure 5-55:

Step-by-Step Bar-to-Bar Testing

1. Deenergize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the bar-to-bar test leads to the MCE and to the laptop parallel port.

4. Highlight the asset to be tested on the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-56.

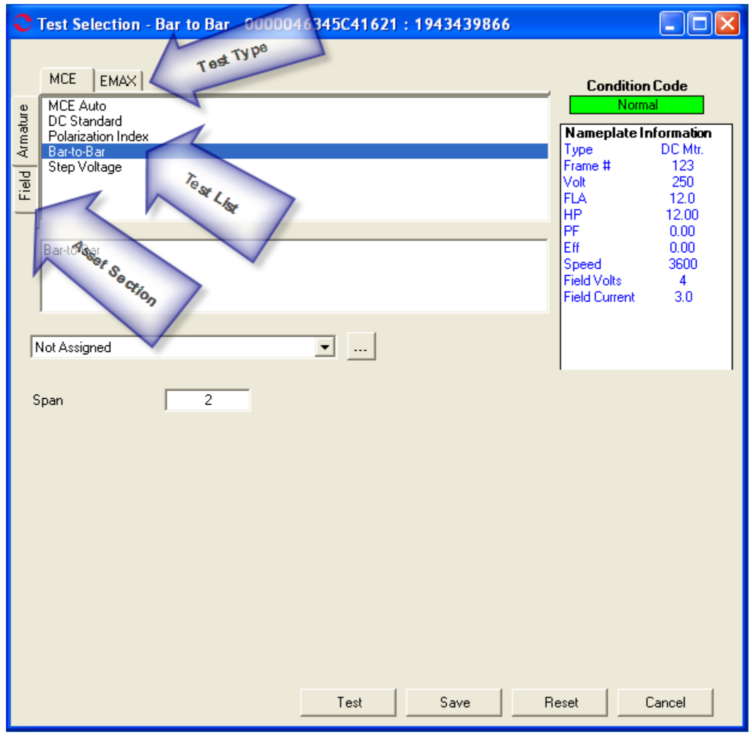


Figure 5-56: Test Selection Window

6. Verify that the MCE (Test Type) and Armature (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Click Bar-To-Bar from the Test List.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-57.

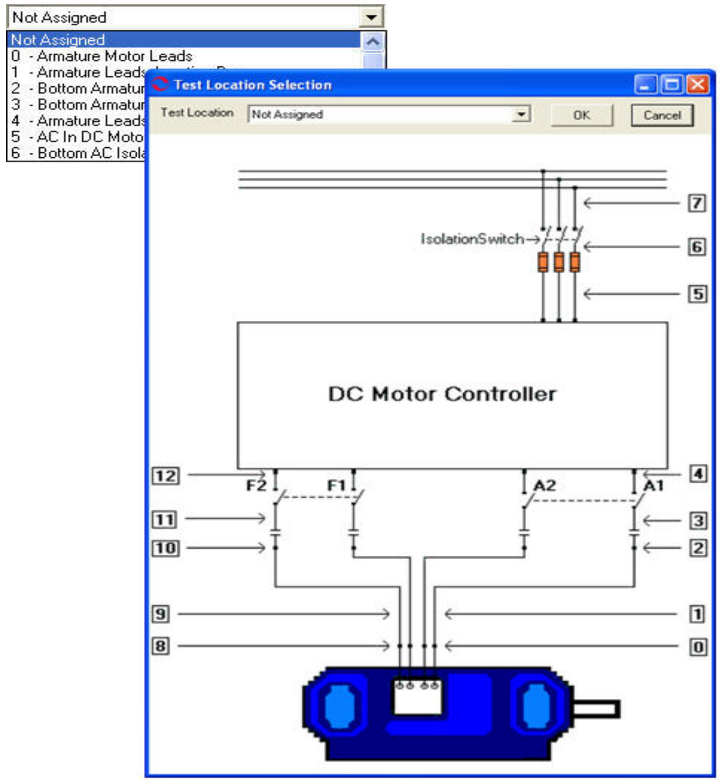


Figure 5-57: DC Asset Test Location

9. Verify the Span is correct.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the testing window

12. To begin the Bar-to-Bar Test, click **Test.**

13. When “Waiting for Leads” appears in the Test Dialog Box, position the leads. Testing will begin automatically. The dialog box will inform you of the testing progress beginning with Read Resistance, Checking Leads, and finally Test Complete. See Figure 5-58.

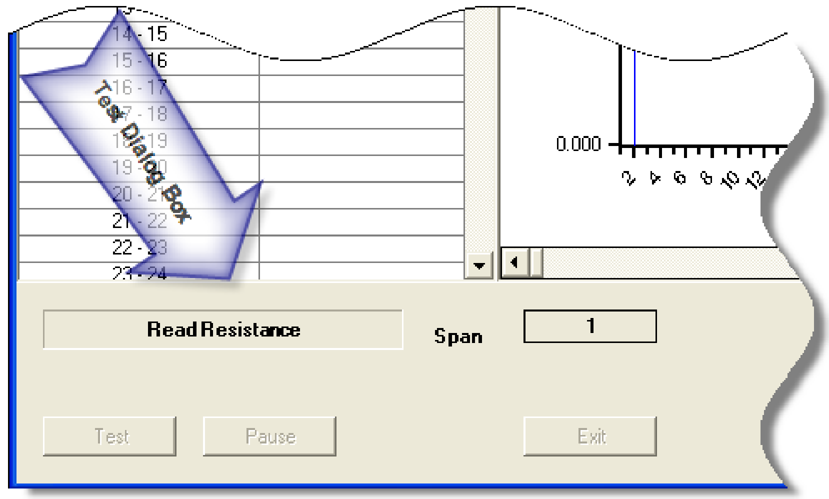


Figure 5-58: Test Dialog Box

14. During testing the test values are entered in the table on the left and are displayed in graph format in the center of the window. The magnification of the graph can be changed by using the down arrows below the graph area and selecting a new value from the drop down list. The default is Full.

15. When Test Complete appears in the Test Dialog box, reposition the leads. Testing will begin automatically.

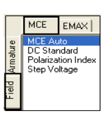
16. Repeat Step 14 until all bars have been tested.

17. At the end of testing, you will be asked if you want to continue testing. Click **Yes** to continue or **No** to end testing.

18. Click **Exit**. You will be asked if you want to save test data.

    Click **Yes** to save the test data. Click **OK** in the Save Completed window. The Bar-to-Bar test window closes.

    Or click **No** to exit the window without saving.



Field Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

DC Standard

DC Standard test for the Field section is the same as for the Armature section. See DC Standard on page 5-40.

Polarization Index

The Polarization Index test for the Field section is the same as for the Armature section. See Polarization Index on page 5-45.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

TEST DATA ANALYSIS INFORMATION

Standard Test

The standard test is similar for both AC and DC assets. In an AC asset, the following are either measured or calculated during a standard test:

Resistance-to-ground
Capacitance-to-ground
Resistance phase-to-phase
Inductance phase-to-phase
Resistive imbalance (calculated)
Inductive imbalance (calculated)
Power loss

In a DC asset, the following are either measured or calculated during the standard test:

Resistance-to-ground
Capacitance-to-ground
Armature and/or field resistance
Armature and/or field inductance

Resistance-to-Ground

What Does it Tell You?

The resistance-to-ground (RTG) measurement indicates the cleanliness and health of the insulation system. As the insulation ages, cracks and small holes develop. It also becomes brittle over time, as the wiring expands due to heating and contracts when it cools off. Aging and temperature variations also break down the molecular structure of the insulation.

These factors allow contaminants and moisture, which collect on the surface of the insulation, to penetrate to the conductor. Since current follows the path of least resistance, some of the total current is diverted from the circuit to these alternate paths, and ultimately to ground. As the RTG value decreases over time, capacitance-to-ground often increases, indicating the presence of many current leakage paths to ground and the accumulation of contaminants.

Why is This Important?

A low RTG value indicates that the insulation needs to be cleaned. If the condition causing the low RTG is not corrected and the RTG value continues to drop, the insulation could completely fail and the asset windings could be damaged. This could require a complete rewind of the stator. If the condition causing the low RTG is corrected, a less expensive clean, dip, and bake may suffice.

Setting Warning Levels

Minimum Value. IEEE (the Institute of Electrical and Electronics Engineers, Inc.) has established a standard for the minimum value of insulation resistance which can be applied to most AC windings, DC armature windings, and AC and DC field windings. The

standard is IEEE Std 43-2001. The equation for most windings made circa 1970 or before, all field windings, and others not noted in the exceptions listed below is IR_{1min}=kV+1.

In the formula:

IR_{1min} is the recommended minimum insulation resistance-to-ground, in megohms, at 40°C (104 °F) at the asset windings

kV is the rated terminal-to-terminal potential, in RMS kilovolts

Examples

A 480 volt asset has a minimum RTG value of 1.48 megohms (480 volts = .480 kilovolts; .48 + 1 = 1.48 megohms)

A 4160 volt asset has a minimum RTG value of 5.160 megohms (4160 volts = 4.160 kilovolts; 4.160 + 1 = 5.160 megohms)

MCEGold computes the minimum acceptable RTG value using this equation. This value is corrected to 40 °C. MCEGold provides both the temperature corrected RTG reading along with the actual measured RTG value. To make comparisons and trending valid, always enter actual asset winding temperature and trend the corrected measurement.

Exceptions to the equation are:

- Most DC armature and AC windings built circa or after 1970 (form wound coils). That standard is $IR_{1\ min}$ = 100.
- Most machines with random-wound stator coils and form-wound coils rated below 1 kV. That standard is IR_{1min}= 5.

Stator of AC Induction, Synchronous, and Wound Rotor Assets; Field and Armature of DC Assets

If the corrected RTG is between R_m and 2 times R_m, then the value is set at caution. The reading appears in yellow on the tester display or underlined on a printed copy of the Test History. If the reading is less than R_m, the value is set at alarm. The reading appears in red on the tester display or bolded on a printed copy.

Wound Rotors, Resistor Banks

Voltages in wound rotors and their three-phase resistor banks are typically too low to use the minimum resistance equation to figure minimum values. The warning levels should be set based on your experience. Establish a baseline test for new assets and assets tested for the first time, and watch the trends. Compare values on similar assets operating under similar conditions.

Exceptions

Some assets may show insulation resistance readings which are lower than the IEEE recommended minimum value and still have “good” insulation. These include:

- Windings with an extremely large surface area
- Large or slow-speed assets
- Assets with commutators

A DC armature with a low RTG value typically has multiple paths for leakage current, not just one. Because of this, finding the exact location of ground faults is almost impossible and repair is very difficult. This problem is much more complex than in AC assets. Therefore, lower minimum acceptable RTG values are generally tolerated. In these cases, the IEEE standard of IR_{1min}= kV + 1 is typically relaxed to IR_{1min}= kV.

Out-of-service assets, without installed heaters operating, may absorb enough moisture to lower insulation resistance to less than the recommended limits.

Interpreting Readings

There are two factors, which require user input, which affect the value of RTG measurements. They are temperature and charge time. In order to compare temperature-corrected RTG readings for similar assets operating under similar conditions, these factors MUST be taken into account.

Temperature

The Test Selection window uses the IEEE standard reference value of 40°C as the default value for the winding temperature. This can be changed. The corrected RTG reading shown at the end of the test and in the Test History is the value that would be expected at 40°C regardless of the *actual* temperature of the asset winding insulation when the test was performed. In other words, if the reading is always corrected to the same temperature, then temperature is removed as an influencing factor. This allows you to use the corrected RTG value from test to test as a valuable trending tool.

Temperature correction is necessary since the resistance of an insulation material decreases significantly as its temperature increases. The materials which make up insulation have a negative temperature coefficient (inversely proportional). In other words, as the temperature increases their ability to stop current flow decreases. This means it is necessary to know the temperature of the asset when determining the condition of the insulation system.

Therefore, as the temperature of the asset increases, the measured insulation resistance decreases. To compare the reading you got today with a reading you got last month, it is important that you compare like results. The way to do this is to calculate the corrected resistance to a given temperature. MCE resistance values are corrected to a standard temperature of 40°C. This temperature is selected because the normal operating temperature for an asset is typically approximately 40°C (104°F). When comparing the results of different tests note the temperature input for possible variations.

Table 5-9 shows the report results for the same insulation with resistance to ground measurements taken at a variety of temperatures and compensated to different temperatures.

Table 5-9: Temperature Compensation

Temperature	Actual Resistance	25 °C Compensated	40 °C Compensated
20 °C	20 Megaohm	14 Megaohm	5 Megaohm
25 °C	14 Megaohm	14 Megaohm	5 Megaohm
30 °C	10 Megaohm	14 Megaohm	5 Megaohm
35 °C	7 Megaohm	14 Megaohm	5 Megaohm
40 °C	5 Megaohm	14 Megaohm	5 Megaohm
45 °C	3.5 Megaohm	14 Megaohm	5 Megaohm
50 °C	2.5 Megaohm	14 Megaohm	5 Megaohm

It can be seen from the chart that if temperature compensation is not performed, the reported (actual) resistance to ground changes with temperature. When temperature compensation is performed, the reported resistance does not change when the test temperature changes. In order to compare results, all measurements MUST be compensated to the same temperature.

Test Voltage and Charge Time

The ground wall insulation in a asset has a conductor on either side. On one side of the insulation is the stator windings, the conductors that make up the individual coils in each pole group for each phase. On the other side is the stator core, formed by the stator laminations connected to the frame/casing of the asset. This design has the fundamental components which make up a capacitor. When a DC potential is applied, the insulation “charges” the way a capacitor does. This is important because if the resistance to ground reading is recorded as soon as the test potential is applied, it is lower than if it is recorded after the insulation is “charged.”

A rule of thumb for performing RTG measurements is to *apply the test potential for 1 minute or until the reading has stabilized*. This allows for different technicians to obtain values from test to test which can be compared. However, this is not very accurate. On the MCE, the duration of time the voltage is applied to the insulation system is selectable.

Test voltage potential can be from 250 to 5000 volts, based on asset nameplate voltage. Charge time can be set between 15 and 600 seconds, at 15 second intervals. Defaults are set at 500 volts and 60 seconds. Again, using the same values every time makes comparison and trending a valuable tool.

Data Interpretation

If the RTG value is low, isolate the problem to either the power circuit or the asset. Assuming the first test was made at the MCC, perform another test at the asset connection box. Disconnect the asset leads and test the asset. If the RTG value is higher testing the asset, the fault is in the cables between the MCC and the asset. Check the connections in the asset connection box, look for moisture in the conduit, and examine the cables. The cables may require cleaning, drying, or replacement.

If the RTG value at the asset connection box is still low, the fault is in the asset. If the value is in caution, the asset may need to be dried, cleaned in place, or removed for a clean, dip, and bake. If the value is in alarm, the asset may need to be rewound. If the RTG value is less than the IEEE minimum, look for a ground fault and clear this condition before starting the asset.

Examples

A conveyor asset was tested and had <.1 Megohm RTG. When the technician removed the terminal box cover, he found that one of the taped connections had arced to ground. The leads were repaired and the asset was retested. RTG increased to 263 Megohms.

A compressor asset was tested and had <.1 Megohm RTG. When the technician removed the terminal box cover, he saw that the box was half full of water. The leads were dried and the asset was retested. RTG increased to 21.5 Megohms

Capacitance-to-Ground

What Does it Tell You?

The capacitance-to-ground (CTG) measurement is indicative of the cleanliness of the windings and cables. As dirt and contaminants build up on windings and cables, CTG values increase. An increasing trend showing rising CTG values indicates that the asset needs to be cleaned.

Why is This Important?

A capacitor is formed by any two conducting materials, called plates, separated from each other by a dielectric material. Dielectric material is anything that is “unable to conduct direct electric current.” A cable or winding surrounded by insulation provides one conductor and the dielectric material. The second plate is formed by the stator core and casing iron.

Normally, when the outside of the insulation is clean and dry, it is not a good conductor. When dirt, moisture, and other contaminates begin to cover the stator windings inside the asset, they cause the outer insulation surface areas to become conductive. Since this surface is in contact with the ground, it allows an AC current path to ground. Cables in the power circuit are also subjected to the same affect, when moisture penetrates the outer casing. The cleanliness of the windings and cables can be determined by looking at the CTG value.

With a buildup of material on them, dirty windings and cables produce higher capacitance values than clean ones do. Over time, CTG values steadily increasing indicate an accumulation of dirt and that cleaning is necessary. This can be correlated with decreasing RTG values.

Dirt and contamination also reduce a asset’s ability to dissipate the heat generated by its operation, resulting in premature aging. A general rule of thumb is that insulation life decreases by 50% for every 10 °C (50 °F) increase in operating temperature above the design temperature of the insulation system. This holds true with the asset operating at or above a 75% load. Heat raises the resistance of conductor materials and breaks down the insulation. These factors accelerate the development of cracks in the insulation, providing paths for unwanted current to flow to ground. If capacitance is higher than normal, a low RTG reading is an indication that such a path already exists.

Setting Warning Levels

Preset warning levels for CTG values in MCEGold are based on a percent change from the baseline measurement. This is merely a comparison warning. A 100% increase from baseline produces a caution (yellow on the computer display or underlined on the printed copy). A 200% increase from baseline produces an alarm (red on the computer display or bold on the printed copy). These values are guidelines. As you gather data on a single

asset or on similar assets operating in the same environment, reset the warning levels to reflect your specific conditions.

Data Interpretation

Capacitance-to-ground is a function of many factors. Therefore, comparison of CTG values is more revealing of a asset's condition than is the analysis of a single snapshot CTG value. For example, capacitance to ground is influenced by the design of each individual asset, the length of the cable between the MCE and asset, the type of insulation on the cables and asset windings, and the number and type of connectors in the circuit.

A new or recently refurbished asset may have a very low CTG reading. A "normal" capacitance value can vary from asset to asset and is NOT an absolute value. CTG must be analyzed by trending readings on the same asset or by comparing values taken on similar assets, with similar histories, operating under the same conditions. If CTG increases over time, dirt, moisture, and/or contaminants are building up on the windings, cables, or both.

Surge capacitors are used in some circuits and will affect CTG readings. Whenever possible, CTG tests should be performed with the capacitors in the circuit as well as disconnected, to indicate the health of the capacitors. This allows for trending the condition of the capacitors as well as the CTG of the asset.

Examples

Capacitors and surge caps were left in the circuit for tests of two chillers used to cool vital computers. Table 5-10 shows how several values were affected. Notice the difference in the readings when the power factor capacitors were removed.

Table 5-10: Effects of Power Correction Capacitors

	With Power Factor Capacitors Installed		With Power Factor Capacitors Removed	
	Chiller #1	Chiller #2	Chiller #1	Chiller #2
Balance of Resistance	1.74%	2.164%	0.050%	2.000%
Balance of Inductance	16.0%	0.520%	2.560%	0.500%
CTG	999,999 pF	999,999 pF	38,750 pF	37,250 pF
RTG	0 Megohms	0 Megohms	>2,000 Megohms	> 2,000 Megohms

A conveyor asset was tested and had <.1 Megohm RTG and 999,999 pF CTG. When the technician removed the terminal box cover, he found that one of the taped connections had arced to ground. The leads were repaired and the asset was retested. RTG increased to 263 Megohms and CTG decreased to 67,750 pF.

A compressor asset was tested and had <.1 Megohm RTG and 83,000 pF. When the technician removed the terminal box cover, he saw that the box was half full of water. The leads were dried and the asset was retested. RTG increased to 21.5 Megohms and CTG decreased to 8,000 pF.

Phase-To-Phase Resistance

What Does it Tell You?

Phase-to-phase resistance is the measured DC resistance between phases of the stator in an AC asset and between polarities of the armature and field coils in a DC asset.

In AC induction assets, use the phase-to-phase resistance values and resistive imbalances for trending, troubleshooting, and quality control. In DC assets, use trending and relative comparison to determine the condition of the phases in the asset and power circuits. This includes comparing readings taken from identical assets operating in similar conditions and comparing current readings against past readings for the same asset.

An increasing resistive imbalance or a changing resistance over time can indicate one or more of the following:

- High resistance connections
- Coil-to-coil, phase-to-phase, or turn-to-turn current leakage paths
- Corroded terminals or connections
- Loose cable terminals or bus bar connections
- Open windings
- Poor crimps or bad solder joints
- Loose, dirty, or corroded fuse clips or manual disconnect switches
- Loose, pitted, worn, or poorly adjusted contacts in asset controllers or circuit breakers
- Mismatched components (incompatible materials, wrong sizes, etc.)
- Undersized conductors (misassembled or improperly engineered)

Why is This Important?

Circuit resistance is determined by the length, size, width, composition, condition, type and temperature of the conductors and connectors. When two different conductors are connected, dirt, corrosion, or an improper connection increases the circuit resistance. Also, inadequate connections cause heating of the conductor, which increases resistance even more. This could be caused if only a few strands of a conductor or portions of a soldered joint are improperly connected to a terminal or if undersized connectors are used.

In a three-phase asset circuit, the resistance in the conductor paths should be balanced. A "resistive imbalance" occurs when the phases have unequal resistances. The formula below shows that a very small resistive imbalance results in a high voltage imbalance. This produces uneven current flow and excessive heat.

$$Vimb = \frac{\frac{2}{3} \times (Rmax - Rmin) \times FLA}{Vl - \left(\left(\frac{2}{3}\right) \times (Rmax - Rmin) \times FLA\right)} x100$$

In the formula:

Vimb = voltage imbalance
Rmax = maximum winding resistance value
Rmin = minimum winding resistance value

FLA = full load amp rating of asset
Vl = line voltage
100 = converts number to percentage

When voltage applied across three-phase asset leads is unbalanced, circulating currents, called "negative sequence currents", are induced. When these negative sequence currents are present, they cause heating in the windings. EPRI's (the Electric Power Research Institute) Handbook to Assess the Insulation Condition of Large Rotating Machines states "a 3.5% voltage imbalance can raise winding temperature 25% in the winding(s) affected by such currents." EASA (the Electrical Apparatus Service Association) says a 1% voltage imbalance results in a 6-7% current imbalance.

The most extreme case of resistive imbalance occurs when a asset "single phases." This "single phasing" quickly causes the asset to fail because the remaining two phases compensate by increasing current by 200% to 300% of normal. Rapid heating of the windings which are still connected destroys the insulation surrounding them.

Resistance to the flow of current in a circuit is of concern from the standpoints of safety, energy conservation, and insulation life. High resistance points in conductors generate heat both at the point where the resistance is located and in the three-phase assets being supplied.

Regardless of the source, some of the effects of increased heat production in the asset include:

- Higher resistance due to heat in conductor materials adjacent to the fault
- Deterioration (accelerated aging) of the surrounding and supporting insulating materials
- Imbalance in multi-phase circuits, which adversely affects equipment performance and life
- Increased power consumption in all cases
- Fire or failure in extreme situations

Setting Warning Levels

The preset warning levels in MCEGold are based on both actual values and on a % change from the baseline value.

Data Interpretation

Resistive imbalance above the setpoint indicates that a problem exists in either the power circuit or in the stator windings. First, isolate the problem to the asset or the circuit. Looking at individual resistance readings can help isolate the problem to a phase. Also, look for the following characteristics which indicate faulty connections.

- Aluminum cables connected to lugs marked for copper wire only
- Discoloration of insulation or contacts
- Damaged insulation having small cracks, bare conductors, or metal components
- Mismatched cables in common circuits
- Poor lug crimps on T-Leads
- Oxidation of conductor metals
- Presence of contaminants such as dirt

Example

The following information is from a 7,000 HP vertical reactor coolant pump asset at a nuclear power plant. A high resistance solder joint between phases 1 and 3 produced a resistive imbalance of 37.15%. The cost associated with the power loss was calculated to be $58,517.84 per year. Multiple tests, shown in Table 5-11, were performed to verify the problem.

Table 5-11: MCE Tests Used in Troubleshooting Efforts

Test Date	5/31/96	5/31/96	5/31/96
Test ID:	331	332	333
Frequency	1200	1200	1200
	BASELINE		
Mohm Ph 1 to Gnd			
Charge Time	30	30	30
Voltage	1000	1000	1000
Motor Temp	40	40	40
Measured Mohm	>2000	>2000	>2000
Corrected Mohm	OVR	OVR	OVR
pF Ph 1 to Gnd	116250	116250	116250
ohm Ph 1 to 2	0.27450	0.26800	0.27400
ohm Ph 1 to 3	0.43750	0.43700	0.44100
ohm Ph 2 to 3	0.24500	0.24300	0.24200
mH Ph 1 to 2	6.750	6.750	6.750
mH Ph 1 to 3	6.755	6.750	6.750
mH Ph 2 to 3	6.745	6.745	6.745
% Res. Imbalance	37.15	38.29	38.24
% Ind. Imbalance	0.07	0.05	0.05
$ Power Loss	58517.84	58973.83	60493.78

Phase-to-Phase Inductance

What Does it Tell You?

In AC assets, phase-to-phase inductance readings can:

- Indicate the condition of the stator windings
- Detect phase-to-phase and coil-to-coil current leakage paths
- Reveal poor or incorrect rework

These readings can also be used to detect faults in power cables. A Rotor Influence Check (RIC) can be performed to further troubleshoot the asset to reveal faults such as:

- Broken/cracked rotor bars or end rings
- Porosity and lamination damage
- Eccentricity problems

In DC assets, inductance changes within the field or armature can indicate current leakage paths in the windings.

Inductance changes when leakage paths develop. These paths can be either within the winding coils, or directly to ground. Leakage paths result from mechanical, thermal, environmental, or electrical damage to the insulation system of the windings. Additionally phase-to-phase and turn-to-turn shorts can occur. In either case, current flow bypasses some coils, thereby reducing inductive reactance and increasing current in other phases of the stator. Temperature rises in the remaining conductors and in the surrounding insulation. This accelerates the deterioration, which can cause an avalanche effect, as heat produces more insulation failures, resulting in more leakage paths and more coils removed from the circuit, further increasing temperature.

As there are fewer winding turns in a given phase actively creating the magnetic field upon which the asset is functioning, the windings in the other phases compensate to meet the requirements of the load on the asset. These windings in turn draw more current than is normally supplied by a balanced asset.

Why is This Important?

A large inductive imbalance causes torque-induced vibration at two-times line frequency ($2F_L$). This vibration can be linked to mechanical degradation. Also, inductive imbalance can contribute to other problems, among which are:

- Bearing damage
- Coupling damage
- Loosened rotor bars
- Insulation failure at winding end turns or at exit of stator slots

Setting Warning Levels

The preset warning levels in MCEGold are based on both actual values and on a change from the baseline value.

Data Interpretation

Many factors affect inductance readings, including asset winding coils, the stator iron, the rotor, and the number of rotor bars. The power circuit has little or no effect on the inductance readings unless there are power factor or surge capacitors in the circuit.

Power correction and surge capacitors are used in some circuits and will affect phase-to-phase inductance readings. Whenever possible, phase-to-phase inductance tests should be performed with the capacitors in the circuit as well as disconnected, to indicate the health of the capacitors. This allows for trending the condition of the capacitors as well as the phase-to-phase inductance of the asset.

If both inductive and resistive imbalance are high, look for a leakage path in a coil or an open coil. If resistive imbalance is low, the fault may be in the rotor.

A rotor bar/cage anomaly may not produce a large inductive imbalance on one single test. If inductive imbalance has increased or is high, perform a RIC to further define the problem. Excessive vibration can also be an indicator of inductive imbalance. If you notice high vibration readings, perform a RIC to collaborate the data.

Example

A new asset with a cast aluminum rotor was load-tested prior to installation. The asset failed to reach rated HP. A RIC was conducted and indicated the presence of broken rotor bars.

When the rotor bars were cast, high resistance connections were formed. Operating the asset during the load-test produced excessive heat at those points. The melted paint on the rotor identified the high resistance connections beneath them.

Test Lead Check

The MCE verifies the resistance of the test leads before and after each test. This ensures test lead continuity and proper connection prior to running the test. If any test lead resistance exceeds a predetermined value, the MCE stops the test. That lead must then be reconnected and retested successfully to continue. This ensures maximum accuracy and repeatability of the collected data.

Resistive Imbalance

Resistive imbalance is calculated from the three individual phase-to-phase resistance readings taken during the standard test. It is displayed as a percentage and will be put into a caution or alarm state if it exceeds a specific limit. This limit can be changed in the MCEGold software. Because this value is calculated from *three* phase-to-phase readings, there is no resistive imbalance value for DC assets.

In AC assets, resistive imbalance is an indication of one or more high-resistance connections in the circuit or shorted turns. Assuming the original test was performed at the MCC, isolate the problem to the asset or to the power circuit by retesting the asset at the connection box. If the resistive imbalance remains, the problem is in the asset. If the resistive imbalance goes away, the problem is in the cables or power circuit. Look at the individual resistance readings to determine the faulty phase.

Inductive Imbalance

Inductive imbalance is calculated from the three individual phase-to-phase inductance readings taken during the standard test. It is displayed as a percentage and will be put into a caution or alarm state if it exceeds a specific limit. This limit can be changed in the MCEGold software. Due to the fact that this value is calculated from *three* phase-to-phase readings, there is no inductive imbalance value for DC assets.

In AC assets, this calculated value can indicate the condition of the stator and rotor/stator relationship. Turn-to-turn or phase-to-phase shorts in the stator causes a high inductive imbalance. Rotor/stator eccentricity causes a varying value of inductive imbalance, as seen on subsequent standard tests. To isolate a problem to the rotor or the stator, perform a Rotor Influence Check.

Power factor capacitors, line reactors, and other power correction devices can impact inductance values. Separation of these devices from the circuit may be required when troubleshooting the asset.

Average Inductance

Average inductance is calculated from the three individual phase-to-phase inductance readings taken during the standard test. Due to the fact that this value is calculated from *three* phase-to-phase readings, there is no inductance imbalance value for DC assets. In AC assets, this calculated value can indicate the condition of the rotor and rotor/stator relationship. Rotor defects will cause an increase in the average inductance. To isolate a problem to the rotor or the stator, perform a Rotor Influence Check.

Polarization Index Test

What Does it Tell You?

The Polarization Index (PI) and Dielectric Absorption (DA) ratios indicate the condition of the insulation system of the asset and power circuit. Both of these tests use ratios of measurements of insulation resistance taken at two different times. The PI is the ratio of the reading taken at 10 minutes and divided by the reading taken at 1 minute. The DA is the ratio of the reading taken at 60 seconds divided by the reading taken at 30 seconds.

There are three different currents that flow through an insulator when a voltage potential is applied. Since the RTG test measures the voltage and current to calculate insulation resistance, all of these currents must be taken into account.

- First, the “capacitive current” starts out high and drops to nearly zero after the insulation has been charged to full test voltage. This is normally negligible after the first few seconds of the test.
- Second, the “absorption current” also starts out high and drops off. The majority of this current dissipates after one minute, but continues to decay for up to 5 to 10 minutes.
- Finally, the “conduction” or “leakage current” is a small, mostly steady current which becomes a factor after the absorption current drops to a negligible value. This current should remain steady for the remainder of the test.

The relationship between all these currents is shown in Figure 5-59.

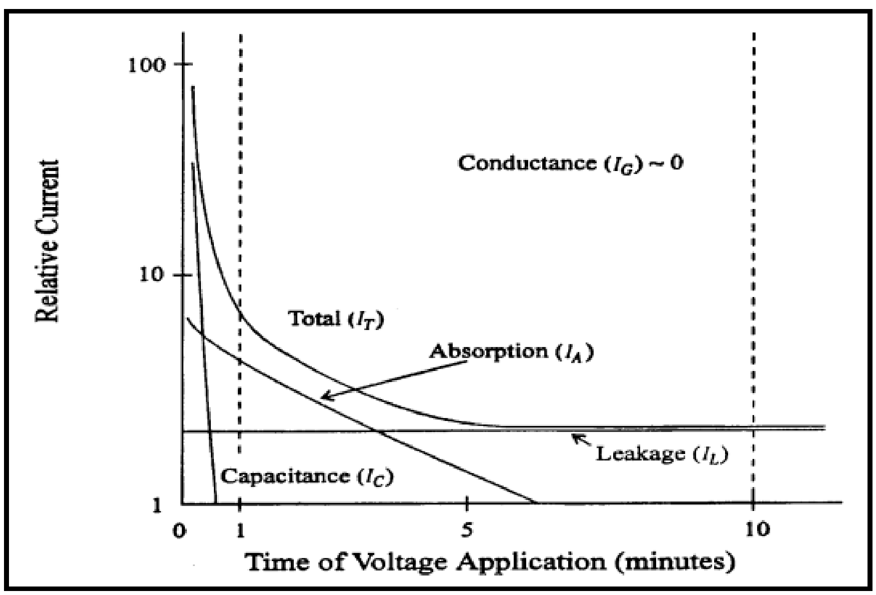


Figure 5-59: Current Relationships

As the asset accumulates dirt and as the insulation ages and cracks, the PI and DA ratios decrease. Dirt accumulates based on the operation and environment of the asset. The insulation cracks as a function of heat and aging of the asset.

Because of the effects of each of these varying currents, the resistance to ground measured by any insulation tester varies with the amount of time the voltage is applied to the insulation. In order to trend or compare insulation RTG values, the charge time for all tests

MUST be the same. If the charge time is not the same, the trend or comparison may not be valid.

Finally, the charging developed by these three different currents does not dissipate immediately when the voltage is removed at the end of the test. The insulation system must be allowed to discharge sufficiently between resistance to ground tests in order to obtain accurate results. A rule of thumb states that insulation takes four times the amount of charge time to discharge.

Why Is This Important?

Resistance-to-ground readings involve three different current components: capacitive, absorption, and leakage. The PI test allows the charging and absorption currents to decay so that only actual leakage current is measured. As a voltage is continuously applied, healthy insulation slowly polarizes and the absorption current diminishes. This causes a steady rise in resistance until the majority of the current is from the small amount leaking to ground. In poor insulation, leakage current is high enough to overshadow the lowering absorption current and provide little increase in the resistance over time.

Setting Warning Levels

In Managing Motors, Richard Nailen, P.E., offers the following guidelines for interpreting PI and DA ratios. If the PI ratio is less than 2 or the DA ratio is less than 1.5, look for insulation degradation.

	Unacceptable	Acceptable
PI	1 to 1.5	2 to 4
DA	≤1.25	>1.50

IEEE recommends the following values for PI. Machines rated at 10,000 kVA and less should have values at least as large as the acceptable values listed below before operation or hi-pot testing.

	PI
Class A	1.5
Class B, F, H	2.0

Data Interpretation

Because the PI and DA values are ratios, temperature correction is unnecessary. PI and DA can be used for both on-the-spot, one-time checks and for trending over time. Individual readings can be compared to the recommended setpoints.

A good PI Profile (PIP) shows a sharp rise followed by a steady, but slowly increasing trend. A downward trend suggests deteriorating conditions. A flat or ragged trace indicates short-term current transients. Such traces indicate insulation breakdown, possibly due to contamination or moisture in the power circuit or asset. Observing the readings over time permits scheduling of cleaning or reconditioning before failure occurs.

If the PI or DA ratio is low, isolate the problem to the circuit or the asset. Assuming the first test was made at the MCC, run another test from the MCC with the “T” leads disconnected.

If the low value is gone, the problem is in the power circuit. If the low value still exists, test the asset at the asset connection box with the leads to the MCC disconnected. If the

low value is gone, the problem is in the cables between the asset and the MCC. If the low value still exists, the problem is in the asset.

Examine the cables in the asset connection box. They could require cleaning, drying, or replacement. Also, check for water in the conduit.

If the PI or DA ratio is < 1.0, look for a ground fault. Clear this fault before starting the asset.

Some exceptions to be aware of include:

- Moisture or contamination on the windings decreases the PI
- The PI can be lowered by certain semiconducting materials which are used for corona elimination on the end windings of some high-potential AC machines
- Performing PI testing in ambient temperatures less than the dew point may significantly impact the PI values

Examples

The following pictures show the response of the insulation in both a good (Figure 5-60) and a bad (Figure 5-61) asset, with a constant voltage applied for a 10 minute period. The increase in the RTG value is due to the decrease in current through the insulation.

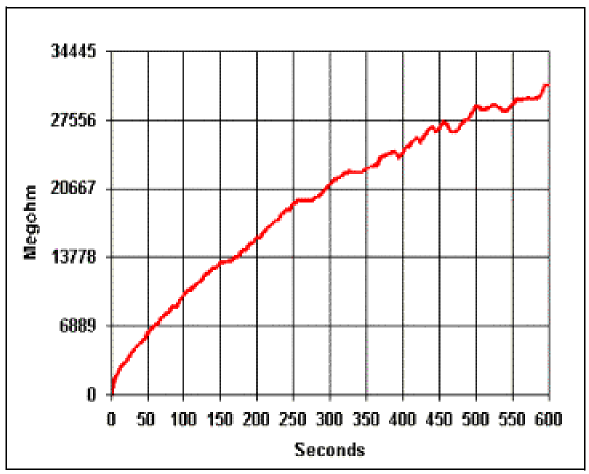


Figure 5-60: Asset with a Good PI

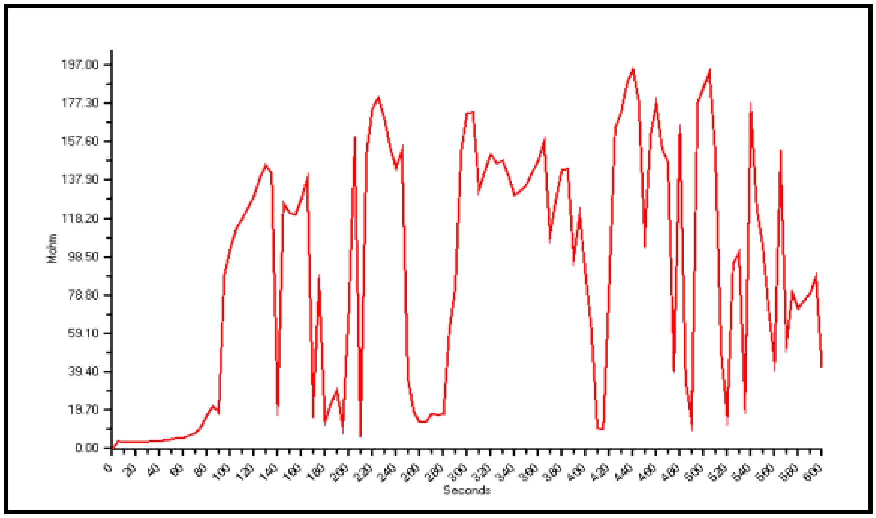


Figure 5-61: Asset With a Bad PI

The unstable RTG readings in the bad PI are a result of low level discharges occurring in faults in the insulation.

ROTOR INFLUENCE CHECK (RIC)

What Does It Tell You?

The Rotor Influence Check (RIC) is a graphical representation of the rotor/stator relationship. By analyzing variations in the magnetic flux while rotating the rotor, eccentricity and rotor defects are identified. The RIC can also be used to confirm stator faults. Figure 5-62 shows a RIC graph for a motor with no defects.

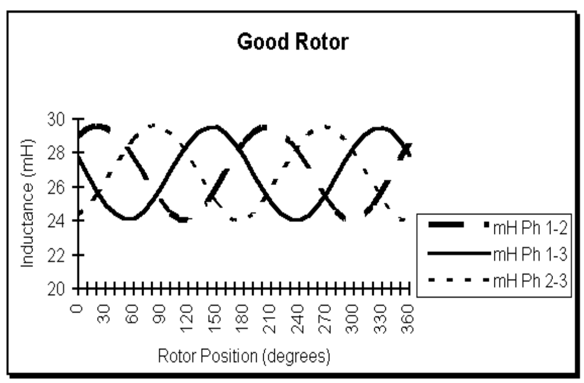


Figure 5-62: RIC from a Good Asset

A motor acts similar to an electromagnet. The rotor acts like the "core" and the stator acts like the windings of the electromagnet. A RIC shows how the rotor's residual magnetism influences the stator inductance in different positions. As the magnetic field of the rotor interacts with more of the coils in each stator winding, the inductance of that winding changes. This influence causes repeatable patterns of change in the graph of the stator inductance, shown above as sinusoidal waveforms.

Why Is This Important?

Broken rotor bars can cause extreme heat and vibration, which can result in winding failure, bearing failure, and loss of torque in a motor. Eccentricity, a non-uniformity of the air gap between the rotor and stator, can cause excessive vibration, which can result in winding and bearing failure.

Rotor Position And Aliasing

Each RIC consists of a series of inductance measurements taken at predetermined positions of the rotor. The amount by which the rotor is moved for each measurement and the total rotation of the rotor for the test are determined by the number of poles in the asset. The increment and total rotation are calculated to show the RIC pattern for one complete pole group. If additional readings are taken beyond the total and at the same increments, the pattern should repeat itself. Table 5-12 shows the recommended increments and total rotation to cover one pole face for a asset with a given number of poles.

Table 5-12: RIC Degree Increments vs. Number of Poles

Poles	Increment	Total
2	10.0°	180°
4	5.0°	90°
6	3.3°	60°
8+	2.5°	45°

The number of increments and total rotation are automatically calculated by MCEGold, based on the entered nameplate data. You may reduce the increment and perform more tests to cover the recommended total rotation. Increasing the increments and performing fewer measurements than the default values is not recommended because doing this results in “aliasing.” Because not enough points are taken to reveal a true picture of the curve, aliasing produces an inaccurate and incomplete graph.

The following example shows how to determine the number of poles a asset has, the number of total degrees to turn the rotor, and the increments by which to turn it. Start with the basic equation:

$$F = \frac{NP}{120}$$

In the formula:

F = line frequency (60 Hertz in the US)
N = synchronous asset speed
P = number of poles in the asset
120 = 120 degrees of electrical spacing between poles

For a asset whose synchronous speed is 1800 rpm, use a variation of this equation to find the number of poles:

P = 120F/N
P = (120)x(60)/1800
P = 4 poles

Next, determine the number of degrees per pole face. To find this, divide 360 by the number of poles.

360/4 = 90 degrees per pole face.

Next, determine the increments, in degrees, by which to position the rotor to generate an accurate RIC pattern. To find this, divide the number of degrees per pole face by 18.

90/18 = 5 degrees.

Thus, the following would apply for a asset whose synchronous speed is 1800 rpm:

4 poles
90 degrees per pole face
5 degree increments per rotation to develop an accurate RIC

The increments were chosen since the RIC pattern typically repeats itself by the same number of poles in the asset through a complete 360° rotation of the rotor. Using these increments is recommended to increase consistency and reduce aliasing. Also, use the same increments and total rotation each time you perform a RIC. This ensures that the RIC is started and run the same way for each test. Doing this enables you to reliably compare the data and graph to subsequent tests for trending.

When the RIC is started, the MCE measures the resistance of each phase winding. At each increment the inductance of each winding pair is measured and recorded. Between measurements you are prompted to move the rotor to the next position.

Data Interpretation

Aliasing

Aliasing occurs when too few measurements are taken too far apart to show the true shape of the curve. The following figures show RICs which exhibit aliasing.

Figure 5-63 shows two waveforms of a good rotor in a 6-pole asset. The waveform with the connected circles was generated with measurements taken at the recommended interval of 3.3°. The waveform with the dashed lines was generated with measurements taken at 15° intervals. The waveform from measurements taken at 15° intervals shows a lack of definition.

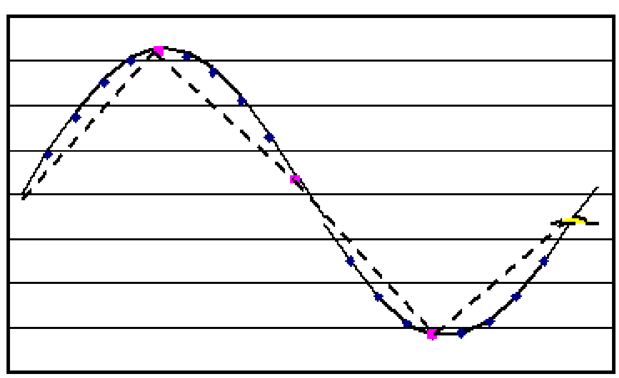


Figure 5-63: Aliasing

Figure 5-64 shows two waveforms taken on a asset which has known rotor faults. The presence of the fault is hidden when the measurements are taken at 15° increments (dashed waveform). When they were made at the recommended 3.3° increments (circles), the presence of the rotor fault is indicated by the flattened peaks. Note that the dashed waveforms shown in Figure 5-63 and 5-64 appear identical masking the true rotor conditions.

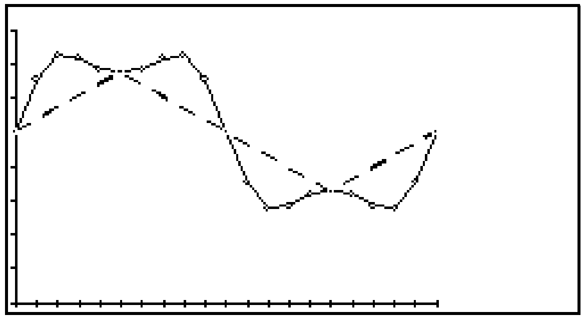


Figure 5-64: Aliasing

Good Asset

Figure 5-65 shows a RIC test for a typical AC induction asset with a good rotor. The three graphs resemble sine waves which are 120° out of phase with each other. The sinusoidal pattern is smooth and repeatable. The amplitude of the sine waves varies from asset to asset, due to factors specific to each asset, such as winding configuration, air gap, core steel quality, and rotor construction and design.

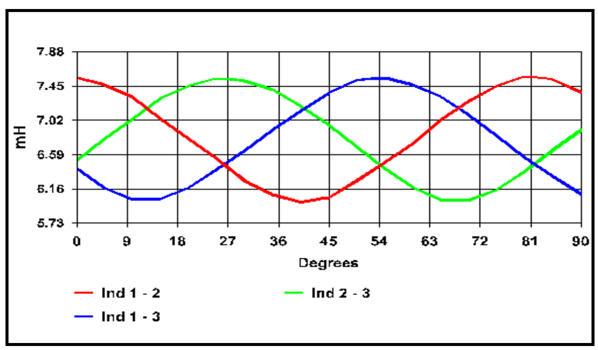


Figure 5-65: RIC from Good Asset

In some assets, the amplitude changes of the graphs are very small and may appear erratic. This erratic appearance may be due to measurement resolution steps, and not due to actual changes in inductance. This condition may indicate a low influence rotor with no rotor defects. One such low influence rotor is shown in the RIC graph in Figure 5-66.

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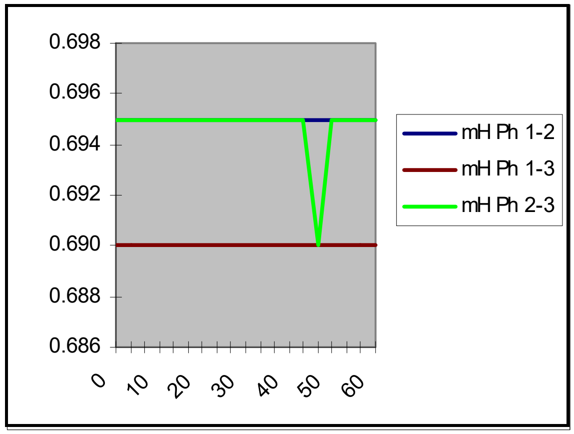


Figure 5-66: RIC from Asset with Low Influence Rotor

Eccentricity

Eccentricity is defined as the condition of the air gap between the rotor and stator, all the way around 360° of the asset. This gap should be the same width all the way around. If the rotor is bowed, the bearing clearances improperly set, or the end bell not aligned properly, the air gap will not be equal. An unequal air gap produces a phase-to-phase inductance graph that is markedly higher at one end of the graph than at the other. This is shown in Figure 5-67.

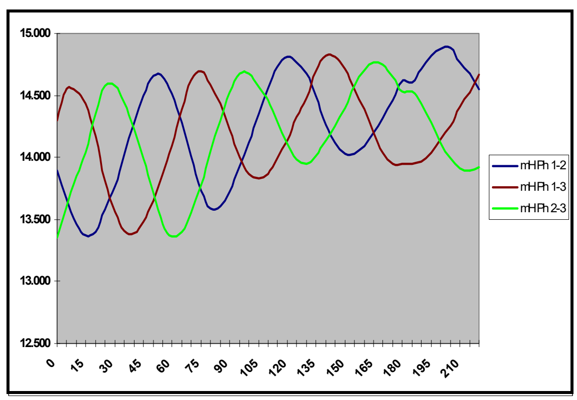


Figure 5-67: RIC from Asset with Eccentricity

If an eccentricity problem is suspected, continue performing the RIC to include at least two pole faces beyond the default increment setting. An exception to be aware of is when sleeve bearings are used in the asset. Due to their oil film, they can falsely indicate eccentricity problems since the rotor "settles" when the asset is not running.

Broken Rotor Bars

A rotor with broken bars produces graphs with anomalies in their wave shapes, such as flattened and staggered peaks.

Figure 5-68 shows a motor with ten broken rotor bars. These were found following a RIC. The flattening of the peaks in the phase-to-phase inductance graphs results from the influence of the broken bars. The irregularities in these traces are repeatable in each phase.

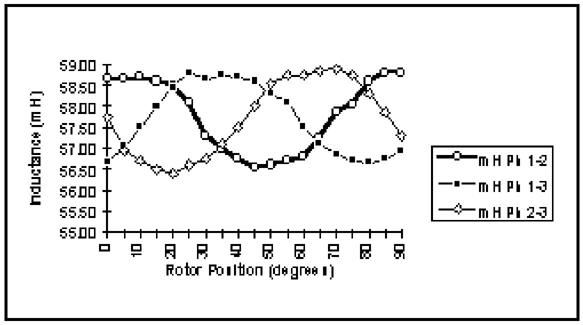


Figure 5-68: RIC from Motor with Broken Rotor Bars

Figure 5-69 shows a motor with cracked welded joints at the shorting rings. The cracked welded joints were found in 14 out of 122 rotor bars after a RIC was taken. The erratic pattern of flattened and staggered peaks points to the presence of the broken bars.

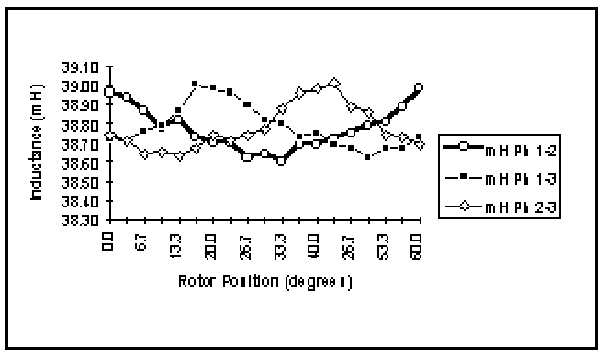


Figure 5-69: RIC from Motor with Broken Rotor Bars

Figure 5-70 shows the RIC test of a 480 volt 60 HP AC induction motor with broken rotor bars and a slight air gap problem. Note the flattened peaks in each phase-to-phase graph.

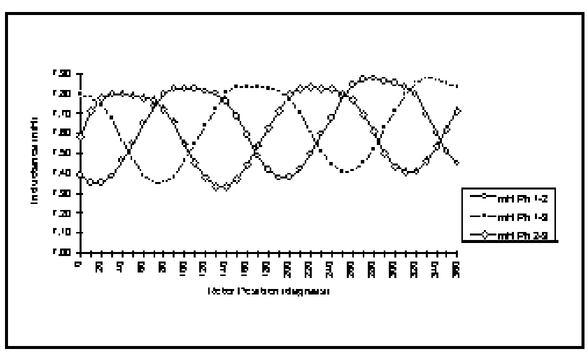


Figure 5-70: RIC from Motor with Broken Rotor Bars

Figure 5-71 shows the staggered peaks in a RIC for a 480 volt 5 HP motor. A rotor anomaly was determined to be the cause for these peaks. This was the result of a maintenance supervisor drilling a hole in one rotor bar as a demonstration.

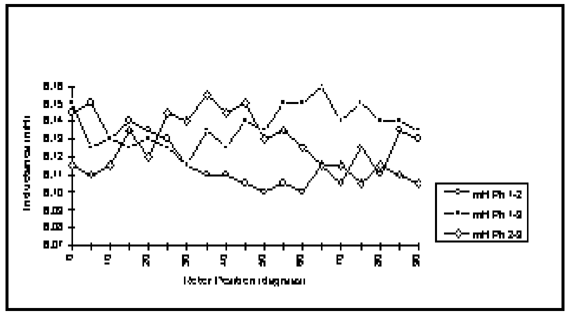


Figure 5-71: RIC from Motor with Broken Rotor Bars

One-Up/Two-Down and Two-Up/One-Down

Phase-to-phase or turn-to-turn stator winding shorts can result in either a one-up/two-down or two-up/one-down RIC pattern. This is shown in the graphs in Figure 5-72.

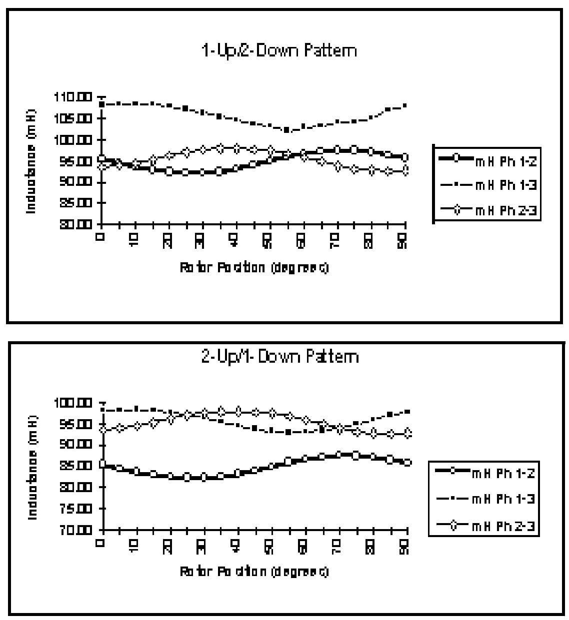


Figure 5-72: RIC from Motor with Phase-to-Phase or Turn-to-Turn Shorts

To assist in the analysis, compare the RIC with the phase-to-phase resistance readings on the standard test. If the same phases are affected resistively and inductively, this further confirms a winding defect. If resistance readings do not confirm this condition, evaluate the asset for eccentricity/air gap problems.

DC Bar-to-Bar Test

What Does It Tell You?

Testing the resistance between commutator bars gives an indication of the comparative value of resistance that exists between all like electrical circuits in an armature.

Why Is This Important?

The commutator consists of insulated segments assembled into a cylinder and held together by insulated rings. Electric current is transferred to the armature windings by “brushes” made mainly of carbon and graphite. Brush wear creates carbon dust, a conductive contaminant, which penetrates into crevices, cracks and openings of the armature. Copper particles add to the contaminant accumulation when the wrong brushes are installed or the brushes are improperly installed, or when maintenance is inadequate. If the insulating material on the commutator bars or their risers has cracked, these contaminants can short entire windings.

Also, high resistance connections can develop at the risers causing open or high-resistance armature coils. Equalizing connections can break and cause an imbalance due to the loss of equalization.

Data Interpretation

The resistance readings between bars are in the microhm range for medium to large machines. Most DC assets of this size have armatures constructed with equalizing jumpers or compensating shorting connections. The effect of these connections on the Bar-to-Bar test results shows as a regular pattern of change from bar to bar. Good bars have 1 or 2 different values. If a bar differs greatly from either of these 2 values then look for faults.

Armatures with 50% compensation have every other bar equalized; with 33% compensation have every 3rd bar equalized; with 25% compensation have every 4th bar equalized.

MCE ANALYSIS

AC Induction Assets

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - repeatable erratic inductance throughout the peaks of the waveforms
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity sometimes causes a consistent separation in the three sine waves, coupled with a low inductive imbalance.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase) or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA in Caution or Alarm indicates changing or excessive surface contamination.
- Breakdown of insulation system.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

AC Synchronous Assets

Stator

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - appears like a normal sine wave but has a larger than normal inductive imbalance
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity can sometimes cause a consistent separation in the three sine waves.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.

- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase), circuit defect (cable short or power factor correction capacitor failure), or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information on the rotor condition.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio- PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Field Circuit

Synchronous Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - Resistance in Caution or Alarm indicates a high or low resistance of the field windings.

  NOTE: The Caution and Alarm limits are set based on nameplate field voltage and current values at normal operating temperature of the asset. Testing on a cold asset may indicate values outside the Caution and Alarm settings.

- Low Inductance - Low Inductance in Caution or Alarm indicates turn-to-turn faults in the field coils.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

AC Wound Rotor Assets

Stator

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - appears like a normal sine wave but has a larger than normal inductive imbalance
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity can sometimes cause a consistent separation in the three sine waves, coupled with a low inductive imbalance.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase) or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Rotor

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red for recommended actions.

- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection on the slip ring or winding connections. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase). Refer to the individual phase-to-phase inductance readings to assist in locating the fault.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Resistor Bank

Resistor Bank

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection between the resistors or a faulty resistor. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

DC Assets

Armature Circuit

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - values in Caution or Alarm indicate high resistance connection in the switchgear, disconnect, or asset connection box. This can also indicate improper brush wear/seating or a poor commutator film.
- High/Low Inductance - values in Caution or Alarm indicate a winding defect (turn-to-turn or coil-to-coil).

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Bar-to-Bar

- High/Low Resistance - values significantly above or below the average resistance reading indicate an open or a short in the armature winding or commutator segments.

Field Circuit

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - values in Caution or Alarm indicate a high resistance connection in the switchgear, disconnect, or asset connection box.
- High/Low Inductance - values in Caution or Alarm indicate a winding defect (turn-to-turn or coil-to-coil).

Polarization Index/Dielectric Absorption

- Low PI or DA Ratio - PI or DA Ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

CHAPTER 5: MCE

TESTING QUICK START

MCE testing may be started by selecting either the Test Selection  or the MCE Auto 

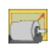
icons on the toolbar.

Selecting the MCE Auto icon automatically runs the Standard Test followed by the Polarization Index test. It uses the existing testing setup values. MCE Auto is discussed in detail on page 5-7.

Selecting the Test Selection icon allows you to verify and/or change the testing setup values and select which test you want to run. Test Selection is discussed in detail on page 5-3.

1. Start MCEGold.

2. On the Site Navigator or WatchList highlight the asset to be tested.

3. Select the Test Selection icon  on the tool bar to open the Test Selection window.

4. In the Test Selection window the default is set to MCE testing. For EMAX testing click the EMAX tab at the top and see Chapters 6 & 7. The asset section tabs along the left side will vary depending on the type of asset being tested. Nameplate Information is automatically filled in by MCEGold from the nameplate data.

5. Select the asset section tab along the left side corresponding to the section to be tested.

6. Select the test to be performed from the list of tests. The available selections are driven by the type of asset and the asset section selected for testing. The Notes section provides instructions that are relevant for the selected test.

7. Select the asset test location by using the drop-down list or using the search button to open the Test Location Selection window.

8. Select the Test Frequency from the drop-down list. The Test Frequency default is driven by the type of asset selected for testing.

9. Select the Resistance-to-Ground by entering in the Mohms if they are different from the default. Check the Low Limit check box if you want the unit to shut down automatically upon measuring a specified low resistance to ground value.

10. Select the Voltage from the drop-down list box. The choices are: 250, 500, 1000, 2500, and 5000.

11. Set the asset Temperature if different from the default value of 40.

12. Select the charge time from the drop-down list box. The choices are in 15 second increments, beginning at 15 and ending at 600 seconds.

13. Click **Save** to save the MCE Test Setup values selected for this particular asset or click **Reset** to restore the original values. Note: Original values may only be reset if new values have not been saved. If you have clicked the Save button it will be necessary to manually change them back to the originals and save them.

14. Click **Test** to go the test window.

15. Click **Test** on the Test window. From this point the process will differ depending on the test being performed. Each test is covered in detail later in this chapter.

INTRODUCTION

The MCE tester measures natural characteristics of a deenergized asset and its circuit to determine its condition. These characteristics are resistance-to-ground, capacitance-to-ground, winding resistance, and winding inductance. MCE testing can identify faults in the power circuit, insulation, stator, rotor, and the air gap between the rotor and stator.

The tests that can be run on a asset vary, depending on the asset type. For AC assets (Induction, Synchronous, and Wound Rotor) the tests are AC Standard Test, Polarization Index (PI) which includes a Dielectric Absorption Ratio, Rotor Influence Check (RIC), and Step Voltage. For DC assets the tests are DC Standard Test, Polarization Index (PI) which includes a Dielectric Absorption Ratio, Bar-to-Bar (Armature Circuit only), and Step Voltage.

Both AC and DC assets have an MCE Auto test which runs the Standard test followed by the Polarization Index test, automatically saves the test results, and displays the Fault Zone Report at the end of testing.

The frequency and type of asset testing you perform is based on your experience with the tester, the condition of each individual asset, and the criticality/application of each asset. Since it may be impossible to test each and every asset in your facility, ask yourself the following questions when deciding which assets to test.

- Is the asset easily replaceable and if so, is a replacement readily available?
- Would buying a new asset cost less than repairing the old asset?
- Is the asset redundant or non-critical?

If you answered yes to all three of these questions, you may not want to consider this asset for your monitoring program.

If you are unfamiliar with an asset, review its maintenance history of test results, problems, and repairs before testing it. Talk with the operators who run it and anyone who may have information about its repair history. This will give you a more complete picture of the condition of the asset.

MCE test results give you a comprehensive picture of the electrical condition of the asset. MCE results can be utilized, along with results obtained from other technologies, to get a complete picture of the health of the asset. Some examples of other technologies include vibration, oil analysis, and infrared thermography.

Some of the MCE tests give you enough information to call an asset good or bad, based on results from one test. Other MCE tests give you data which is best used for trending and comparison.

Trending means comparing sequential test results for the same asset over time. This tracks what the particular asset is doing, how it is holding up, when it may need to be cleaned, when it needs more detailed maintenance, or when a fault develops.

Test frequency depends on the asset's criticality and the condition of the asset when it is first tested. As the asset ages, you may decide to test it more frequently to better track its condition.

When you first start testing with the MCE, the initial test is automatically designated as the baseline test. After maintenance is performed on an asset and it is returned to optimal condition, measure subsequent tests against that condition by designating the first test after the maintenance as the new baseline.

Comparison means comparing individual test results on one asset with test results from an identical asset operating in a similar environment. By identical asset we mean the same manufacturer, voltage and horsepower rating, cable length for MCC, etc. For example, if there are four like assets operating side by side performing the same task, all running at approximately the same load, each running about the same amount of time, the test data should be very close for all of them. If all four assets are tested, and three are basically the same, but the fourth is very different from the other three, look for potential problems with the fourth asset.

MCE testing is performed on a deenergized asset. However, there may be energized circuitry in the same cabinet in which you connect the tester.

FOLLOW ALL ELECTRICAL SAFETY PRECAUTIONS AND PROCEDURES FOR WORKING IN THE VICINITY OF ENERGIZED EQUIPMENT. READ THE ELECTRICAL SAFETY PRECAUTIONS IN CHAPTER ONE BEFORE PERFORMING ANY TESTS.

For AC assets, test lead colors of black, blue, and red connect to phases 1, 2, and 3 (left to right, top to bottom); green connects to ground. For DC assets, test lead colors of black and blue connect to F1/A1 and F2/A2; the red lead is not used; green connects to ground. The DC Bar-to-Bar pistol grip or pencil probe test leads connect to commutator bars.

Some asset circuits may have surge capacitors and/or power factor correction capacitors installed. It is important to know about them since these components affect the values of the collected data and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power or surge capacitors installed, however, surge capacitors must be removed for the accurate measurement of the asset's insulation resistance-to-ground. If an asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.

Test Selection Window

In this chapter, the MCE aspects of asset testing are discussed. EMAX testing is discussed in the Power and Current Analysis chapters. The Test Selection window discussion is followed by the Step-by-step testing procedures, Test Data Analysis on page 5-53, and finally MCE Analysis on page 5-74.

Note: Selecting the MCE Auto test icon  on the tool bar bypasses the Test Selection window and automatically runs the Standard Test followed by the Polarization Index test using either the default or previously saved test settings, at the end of testing the test results are saved, and the Fault Zone Report opens.

To open the Test Selection Window click the Test Selection icon  on the tool bar.

The Test Selection window is shown in Figure 5-1. The asset name is located on the title bar to the right of the window name. The Test Selection window is used for both MCE and EMAX testing by selecting the desired test type tab.

The asset section tabs are found along the left side of the test selection area and are dependent on the asset type. Possible sections are Armature Circuit, Field Circuit, Resistor Bank, Rotor, and Stator.

- For AC Induction assets, the only option is Stator.
- For AC Synchronous assets, options are Field Circuit and Stator.
- For Wound Rotor assets, options are Stator, Rotor, and Resistor Bank.
- For DC assets, options are Armature and Field Circuit.

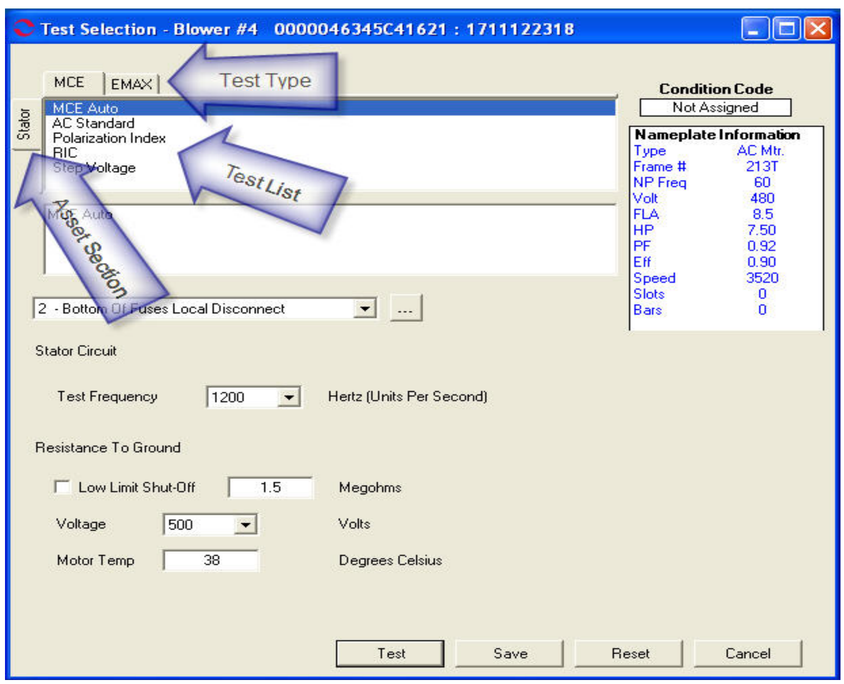


Figure 5-1: Test Selection Window

Test List

The top left section of the window contains a list of test selections for either MCE or EMAX, depending on asset type, test type and asset section tabs selected. The test lists section displays the various tests which may be performed based on the asset type and asset section chosen. When a test is selected, the name of the test is highlighted blue and

the test set up area changes to values appropriate for the test selected. The test list possibilities for MCE testing are:

- MCE Auto
- Standard (AC asset)
- Standard (DC asset)
- Polarization Index
- Rotor Influence Check (RIC)
- Step Voltage
- Synchronous (Synchronous, Field section)
- Resistor Bank (Wound Rotor, Resistor Bank section)
- Commutator Bar-to-Bar (DC asset)

Asset Information

Asset Information is located on the right side. This area displays the Condition Code and nameplate information of the asset being tested. The information comes from the nameplate data that was entered when the asset was set up and cannot be edited on this window. Information displayed, depending on asset type, may include: Type, Frame #, NP Frequency, Voltage, FLA, HP, PF, Eff, Speed, Slots, and Bars. Also, Field Volts and Field Current are listed for DC assets.

MCE Test Setup

The lower half of the Test Selection window is devoted to test set-up selections. The set-up options depend on the asset type and test selected.

Asset Test Location

The Asset Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. See Figure 5-2. Use the graph to determine the location, then click the down arrow in the Test Location text box, select the location from the list, and click **OK.**

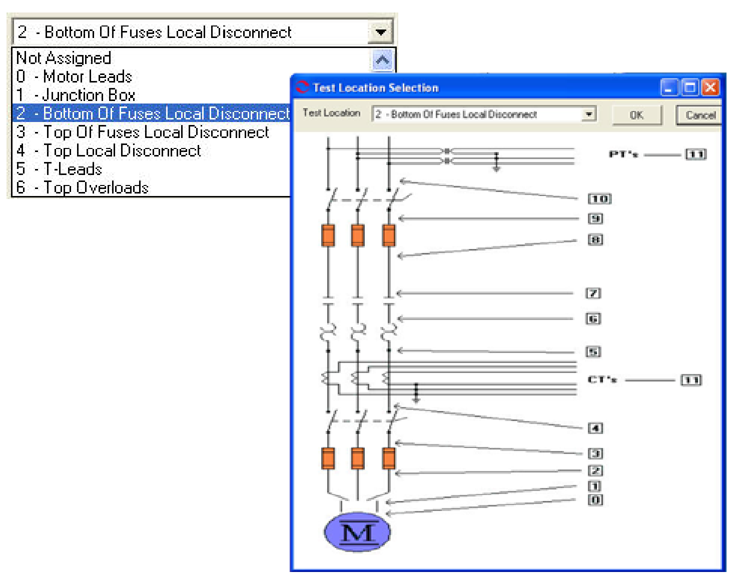


Figure 5-2: AC Asset Test Location

Test Frequency

Test Frequency is selected from a drop-down box. Click the down arrow and select from the list to change the frequency. The choices are 300 or 1200 Hz depending on the section being tested. Test Frequency is not available for the resistor bank section of a wound rotor asset.

Resistance-to-Ground

Resistance-to-Ground provides the option to check (turn on) the Low Limit Shut Off and enter a shut off voltage.

Voltage

Voltage is selected from a drop-down list. Click the down arrow and select from the list to change the voltage. The voltage choices are from 250, 500, 1,000, 2,500, and 5,000.

Select a voltage of 500 or 1000 volts, based on the asset's voltage. EASA (Electrical Apparatus Service Association), in their booklet How to Get the Most From Your Electric Motors, suggests 500 volts for assets rated ≤2400 volts and 1000 volts for assets rated at >2400 volts.

Asset Temperature

The default value is 40° C. The value may be changed by typing in a new value.

Span

Span selection is only available for Bar-to-Bar testing of the armature section of DC assets.

Charge Time

Charge time is available for the Standard test of an AC Induction, Wound Rotor, Synchronous, and DC assets. The default value is 60 seconds. To change the charge time, click the down arrow and select from the list of between 15 and 600 seconds.

Test Button

Click **Test** to advance to the test window.

Save Button

Click **Save** when the test set-up selections are complete. This saves the settings as default values for that asset for subsequent tests, but is not required. If you forget to save and click Test, you will be asked if you want to save your changes.

Reset Button

Click **Reset** to set values back to the pre-changed value. Note: If you have clicked the Save button they will not reset and it will be necessary to manually change them back.

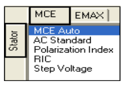
Cancel Button

Click **Cancel** to close the Test Selection window without saving setup changes or proceeding to the test window. You will be asked if you want to save test setup settings.

TEST WINDOW

Once the asset section and setup parameters are selected, you are ready to run the test. This section explains each test by asset type and asset section. The test window is discussed followed by step-by-step testing procedures. Test analysis information begins on page 5-53.

AC Induction Assets



The MCE tests for an AC Induction asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage. They are discussed in detail in this section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test
- Polarization Index (PI)/Dielectric Absorption (DA) If a PI is performed, it is not necessary to perform a separate DA.

Some circuits may have surge capacitors and power factor correction capacitors installed. This is important since these components affect the values of the collected data and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor capacitors installed. However, a test should be taken with surge capacitors removed for future comparison. If an asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.

MCE Auto Test

MCE Auto test performs a standard test followed by a Polarization Index test, then saves the data and produces a Fault Zone Report.

MCE Auto test can be started by clicking the MCE Auto icon

on the toolbar or selecting MCE Auto from the test list in the Test Selection Window. If you select the MCE Auto icon, the MCE Auto test window opens bypassing the Test Selection window.

If you need to change the test setup settings, select the Test Selection icon 

. The Test Selection window opens, make your changes, and then select MCE Auto from the test list and click **Test**. The MCE Auto Test window, Figure 5-3, opens. The MCE Auto Test window menu consist of three options: File, View, and Options.

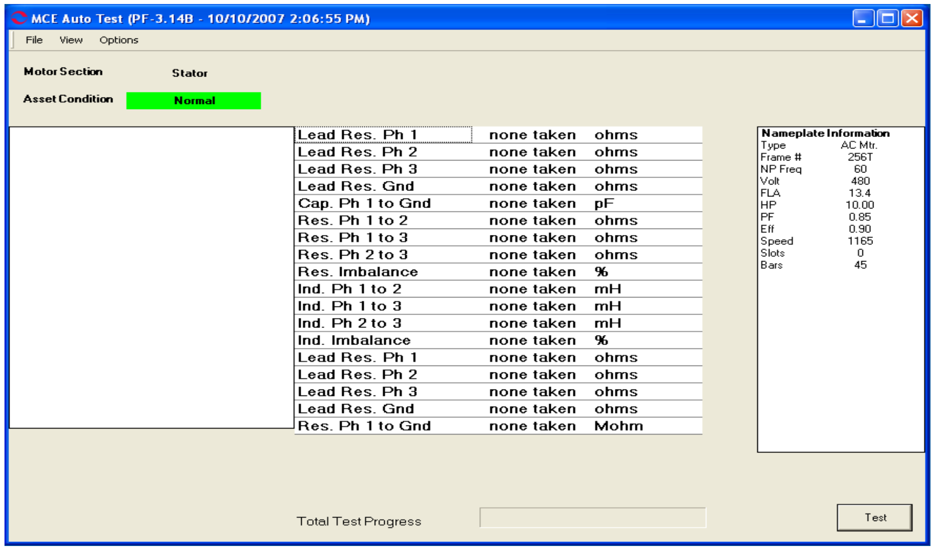


Figure 5-3: MCE Auto Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the MCE Auto Test and Test Selection windows and returns you to the Home window.

View Menu

Create Message . Create Message opens the Compose Asset Message window (Figure 5-4). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

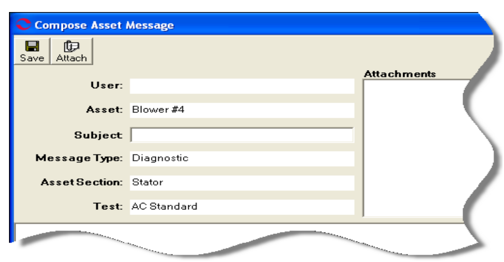


Figure 5-4: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-5). The Asset Condition box on the MCE Auto Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

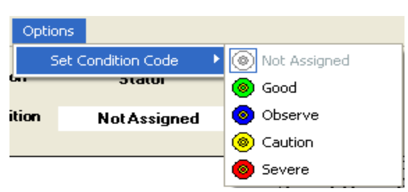


Figure 5-5: Set Condition Code Window

Test Button

To begin testing click **Test**. During testing the menu items are dimmed (not available) and the Test button changes to Stop. The test takes approximately 11 minutes.

The tester automatically proceeds from the Standard test to the Polarization Index (PI) test. A status bar displays the testing progress. During the Standard test there is one Total Test Progress bar. When the PI test is performed there is a PI progress bar, a Total Progress bar, and a graph in the lower left displaying the test results. See Figure 5-6.

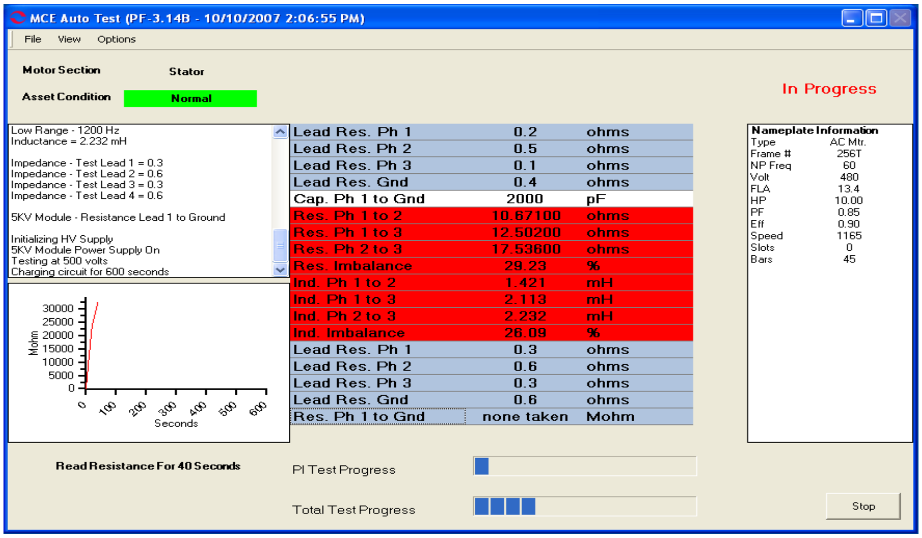


Figure 5-6: MCE Auto Test Window - PI Test

At the end of the PI test, the test results are automatically saved and the Fault Zone Report is generated and displayed. See Figure 5-7.

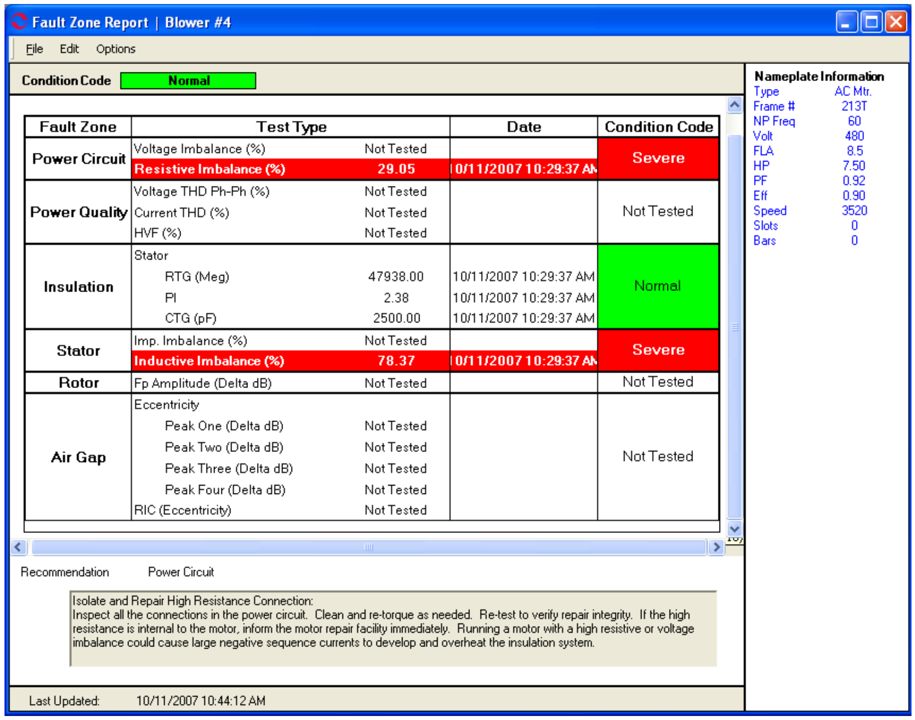


Figure 5-7: MCE Auto Test Fault Zone Report

Fault Zone Report

NOTE: The information for the Fault Zone Report, beginning with File Menu and ending with To View Test History on page 5-12, has been replaced with a new and improved ocular format. A description of the ocular fault zone can be found on page 3-52 in Chapter 3-MCEGold3.

File Menu

Print Preview. Print Preview, shown in Figure 5-8, displays the Fault Zone Report as it will be printed. Using the File menu on the Print Preview window, you can export the report to PDF or HTML or add comments before printing.

To *create a PDF file*, select File, Export to PDF, select the location you wish to save the file in, enter a file name, and click **Save**.

To *create a HTML file*, select File, Export to HTML, select the location you wish to save the file in, enter a file name and click **Save**.

To *add comments*, select File, Add Comments. In the Add Remarks window type your comments and click **Add**. The comments appear in the Comments section at the bottom of the report. They will appear on the printed report, but are not saved for the future. Permanent comments should be entered in the Message Center using Edit, Create Message, which is discussed on page 5-11.

To *print the report* click the **Print** icon on the Print Preview toolbar.

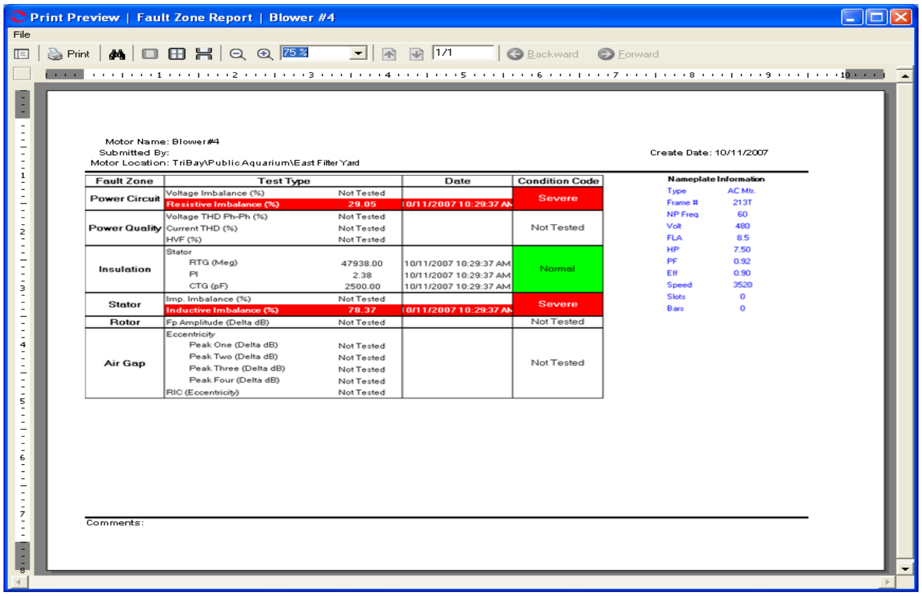


Figure 5-8: Print Preview

Print. Print prints the report to your default printer.

Exit (Ctrl+Q). Exit the report by using File, Exit (Ctrl+Q) or clicking the Close button (red X in the upper right corner).

Edit Menu

Create Message (Ctrl+M). You may enter permanent notes by selecting Create Message (Ctrl+M). This opens the Compose Asset Message window shown in Figure 5-4 on page 5-8. The note is viewed from the Message Center. See the section on Message Center in Chapter 3, page 3-41.

Options Menu

Refresh (Ctrl+R). The Refresh function is used to update the Fault Zone Report when changes have been made to the warning settings.

Set Condition Code. Change the condition code, by selecting an option button, the Condition Code box changes, and a note is automatically generated by the software. The note is viewed from the Message Center. See the section on Message Center, in Chapter 3, page 3-43.

Description/Recommendation

The blank area at the bottom of the report is designed to provide additional information, such as descriptions of the Fault Zones and Test Types or recommended actions for the Condition Code. It is for on screen viewing only and does not appear on the printed report.

To **view a description** of the Fault Zone or Test Type, click on the name in the Fault Zone report. The description will appear in the text box at the bottom of the window.

To **view the recommended course of action** for a condition code, click the condition code name. The recommended course of action will appear in the text box at the bottom of the window. Figure 5-7 shows how the window would appear if severe condition code of the power circuit was selected.

To View Test History

To **open the Test History** click on the test type result value or the date. The Test History window opens.

AC Standard Test

The AC Standard test is reach by selecting AC Standard from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The AC Standard Test Window (Figure 5-9) opens.

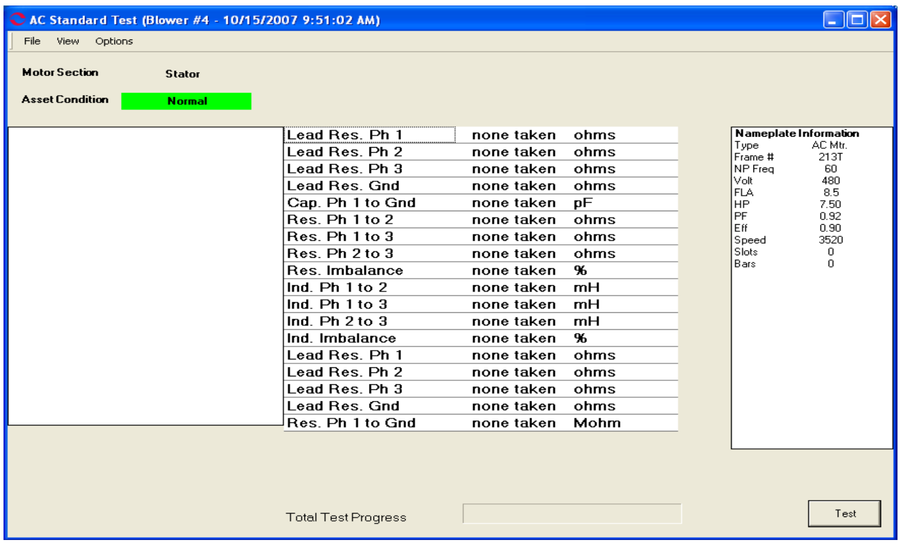


Figure 5-9: AC Standard Test Window

The AC Standard Test window menu consist of three options: File, View, and Options.

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the AC Standard test window and returns you to the MCEGold Home window.

View Menu

Create Message. Create Message opens the Compose Asset Message window (Figure 5-10). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

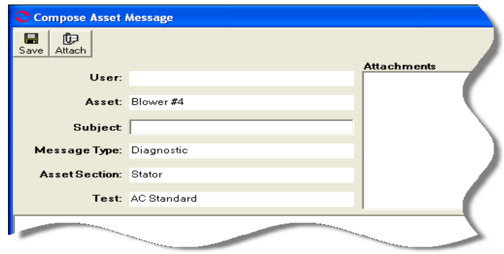


Figure 5-10: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting an option button (Figure 5-11). The Asset Condition box on the AC Standard Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43

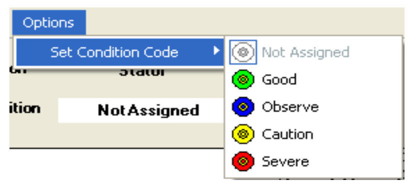


Figure 5-11: Options, Set Condition Code Menu

Step-by-Step AC Standard Testing

1. De-energize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE to the circuit, in the same manner each time, as referenced in Table 5-1. This ensures that the test data is trendable/repeatable.

Table 5-1: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested on the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-12.

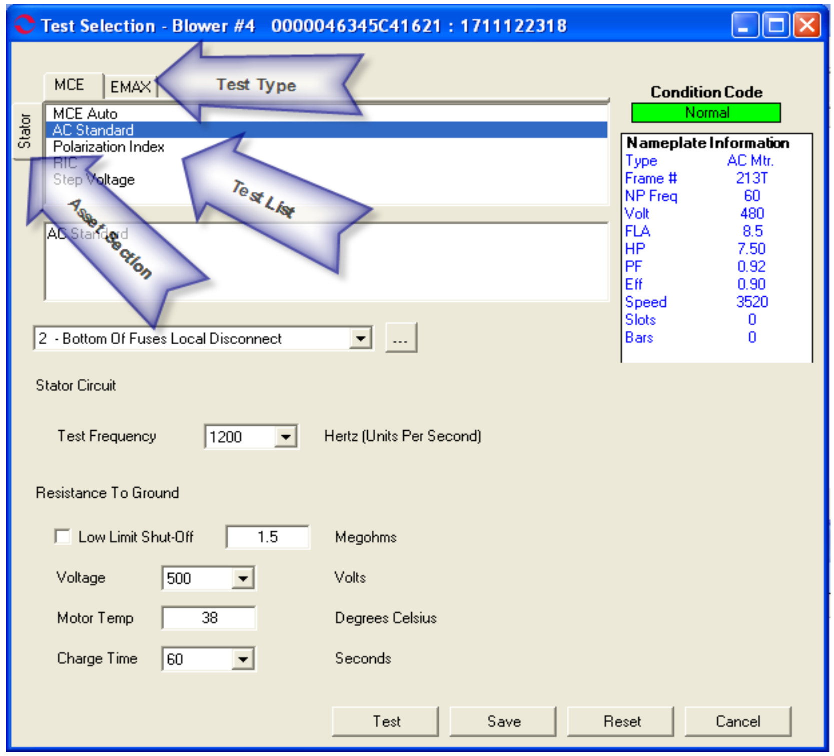


Figure 5-12: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Click AC Standard from the Test List.

   If all of the settings in the MCE Test Setup are correct, click **Test** to go directly to the test. Go to step 16.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-13.

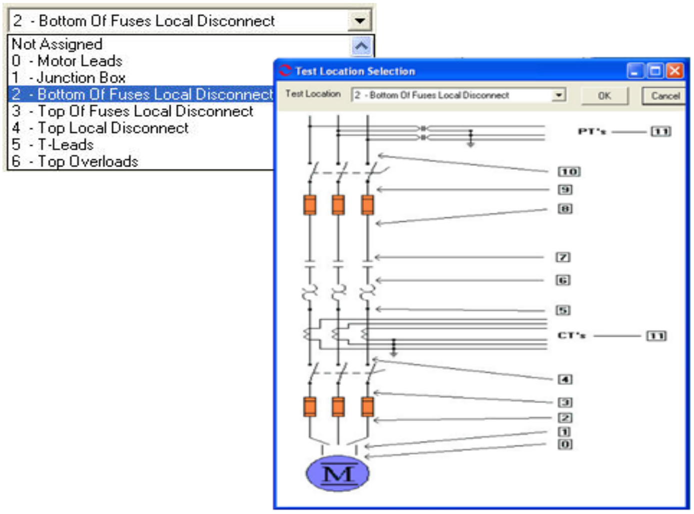


Figure 5-13: Asset Test Location

9. Verify the Test Frequency.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select the Charge Time Seconds.

    Click the down arrow and select the seconds from the drop-down list. The choices are from 30 to 180 seconds at 15 second increments.

14. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the testing window.

16. Click **Test** in the AC Standard Test Window.

17. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

18. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area. See Figure 5-14.

    To stop the test at any time, click **Stop**. Click **Exit** to close the AC Standard test window and return to the Home window.

19. Click **OK** when the test is complete.

20. Re-test any individual point, if needed. If not go to step 21.

    If any portion of the test needs to be re-tested, double click the tab which appears to the right of the individual test point. This rechecks only that test point in “manual mode.” See Figure 5-14.

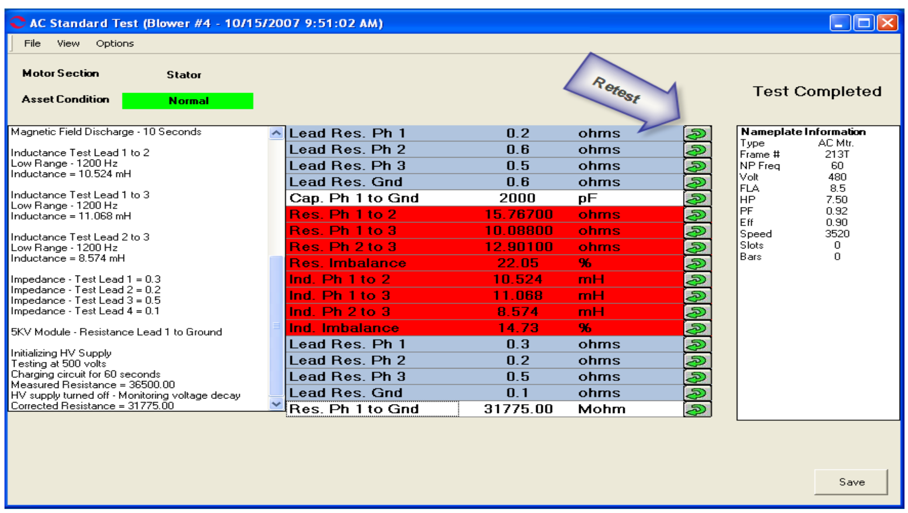


Figure 5-14: AC Standard Test Window

21. When retesting is complete or if no re-testing is needed, click **Save** or select File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

22. Click **OK** in the Save Complete window.

23. Click **Exit** in the AC Standard Test Window.

Polarization Index

The Polarization Index (PI) test is reached by selecting Polarization Index from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information.

Verify that the test set-up settings are correct and click **Test**. The PI test window opens. See Figure 5-15.

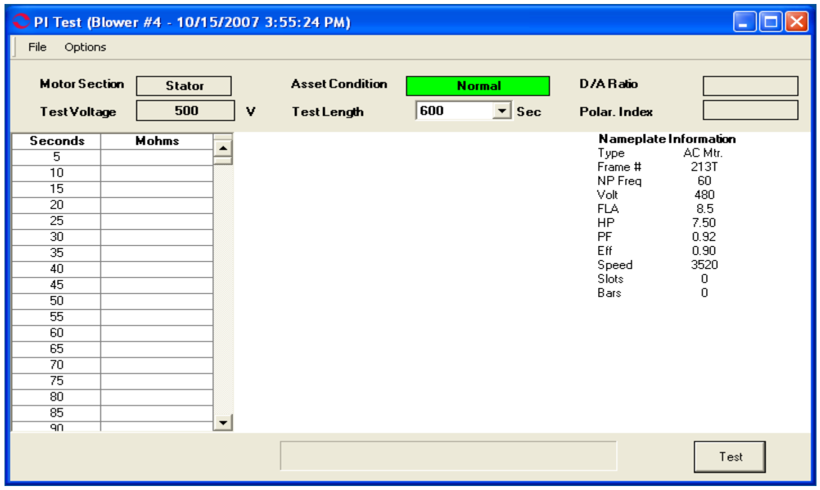


Figure 5-15: PI Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the PI Test window and returns you to the Home window.

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-16). The Asset Condition box on the PI Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

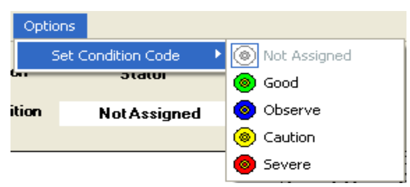


Figure 5-16: Set Condition Code Window

Step-by-Step Polarization Index Testing

The PI test takes ten minutes. During the test the menu items are dimmed (not available) and the **Test** button changes to **Stop**.

1. Deenergize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE to the circuit, in the same manner each time, as referenced in Table 5-2. This ensures that the test data is trendable/repeatable.

Table 5-2: : Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
“T” lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-17.

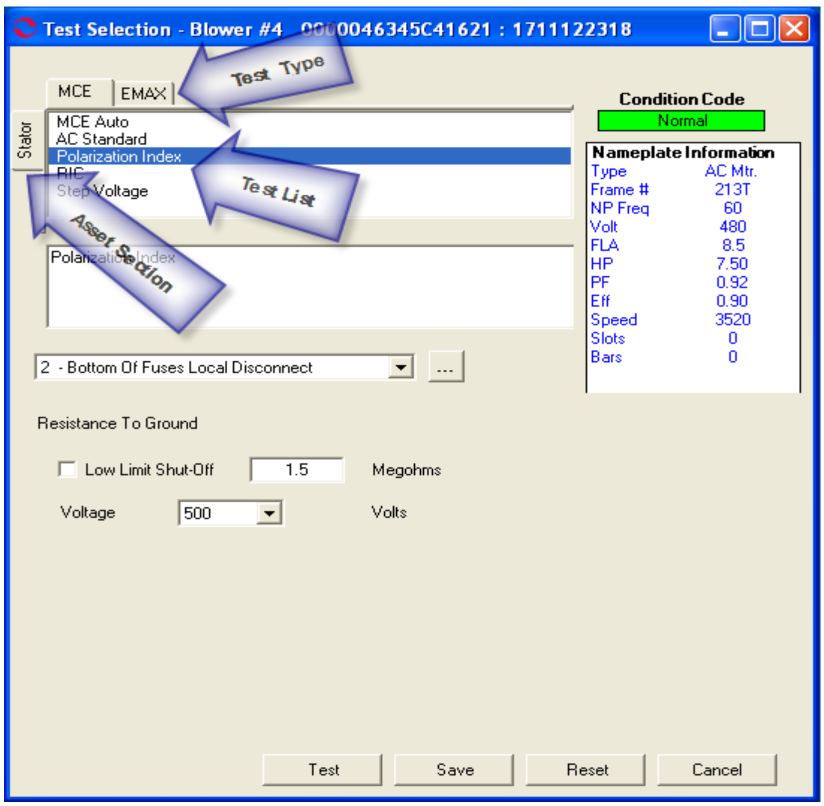


Figure 5-17: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-18.

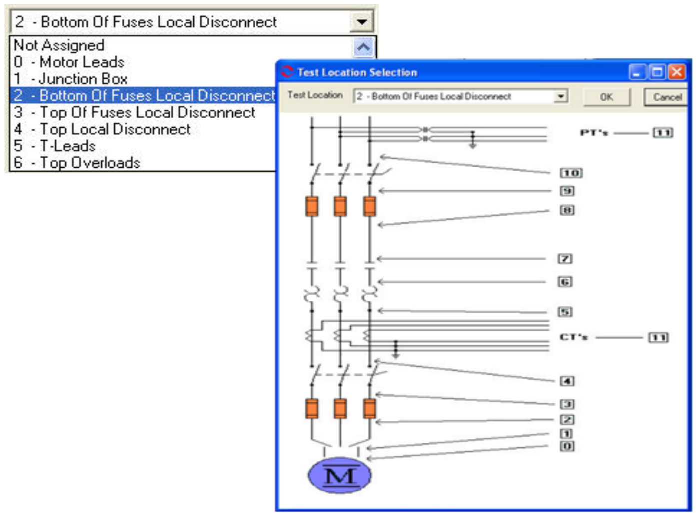


Figure 5-18: Asset Test Location

8. Verify the Low Limit Shut Off condition.

   Check the box to activate the low limit shut off and enter the desired Mohms.

9. Verify the Voltage.

   Click the down arrow and select the voltage from the drop-down list. Select the test voltage based on asset nameplate voltage.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the testing window.

12. Click **Test** in the PI Test window.

13. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

14. As the test proceeds, the test result values are displayed in the table and plotted on the graph. At the end of one minute the D/A ratio is computed and displayed in the D/A Ratio text box. The progress bar displays the progress of the testing.

    Note: To stop the test, click **Stop.**

15. Click **OK** in the Test Completed window. The menu item become active and the **Stop** button is inactive.

16. Exit the PI Test window by selecting File, Exit, or Ctrl+X, or the close button (Red X in the upper right corner).

17. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The PI Test window closes

    If you select **No**, the PI Test window closes. No test data is saved.

RIC

The RIC test is reached by selecting RIC from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The RIC test window opens. See Figure 5-19.

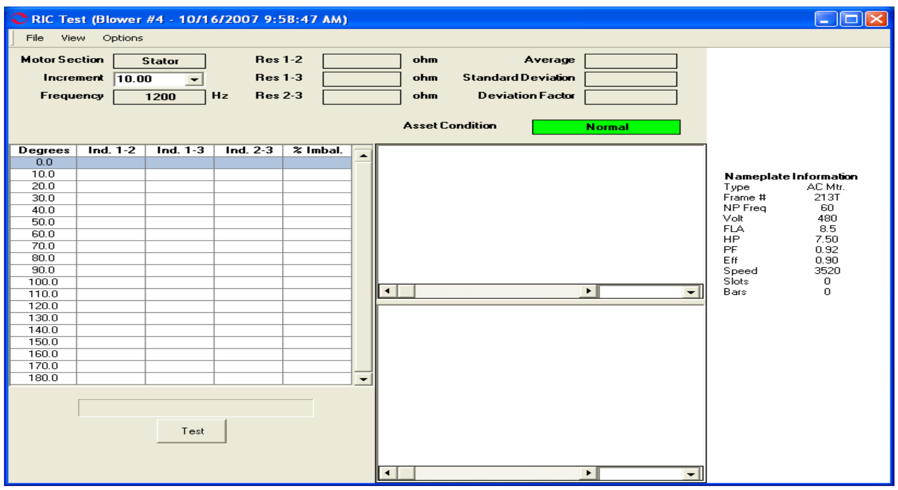


Figure 5-19: RIC Test Window

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the RIC Test window and returns you to the Home window.

View Menu

Create Message . Create Message opens the Compose Asset Message window (Figure 5-20). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

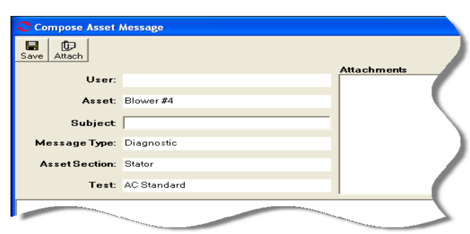


Figure 5-20: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code, by selecting the option button corresponding to the condition (Figure 5-21). The Asset Condition box on the RIC Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

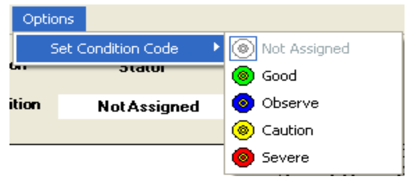


Figure 5-21: Set Condition Code Window

Step-by-Step RIC Testing

During the test the menu items are dimmed (not available). To stop testing, use File, Exit which becomes active after each test point.

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Place the shaft key way in the up position. This ensures a common starting point for all subsequent tests.

4. Ensure that the field is disconnected from the control circuit.

   This is accomplished by isolating/removing the brushes from the slip rings or by disconnecting the field leads from the diode pack in a self-exited asset. This allows the natural magnetic field on the rotor to expand, enhancing the detection of rotor problems.

5. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-3. This ensures that the test data is trendable/repeatable.

Table 5-3: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

6. Highlight the asset to be tested in the Site Navigator.

7. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-22.

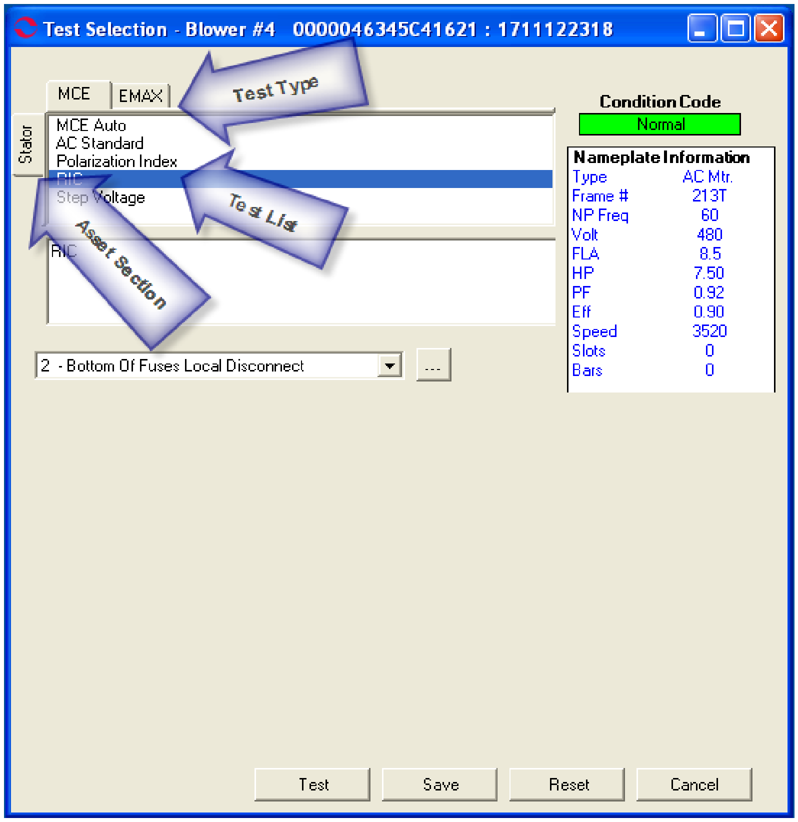


Figure 5-22: Test Selection Window

8. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset section is available.

9. Select RIC from the Test List box.

10. Verify the Test Location in the Test Setup section.

    To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-23.

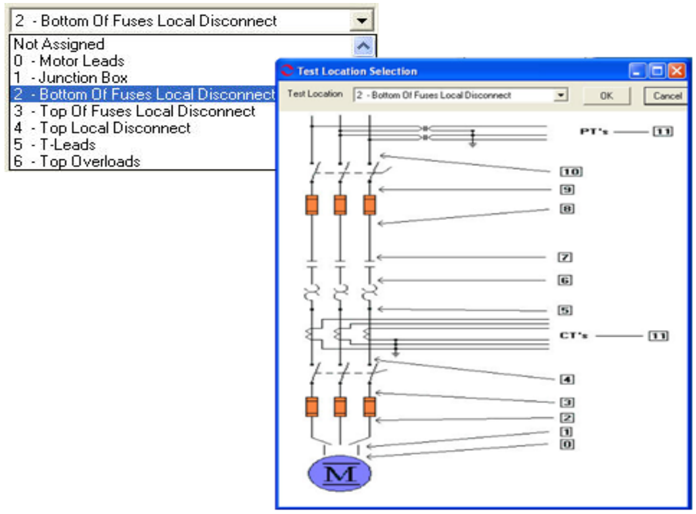


Figure 5-23: Test Locations

11. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

12. Click **Test** to go to the test. The RIC test window, Figure 5-24, opens.

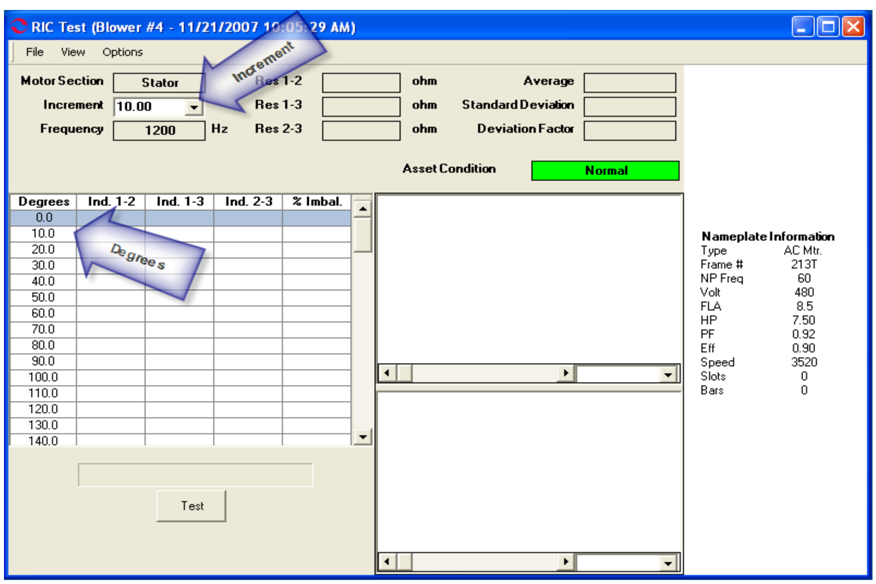


Figure 5-24: RIC Test Window

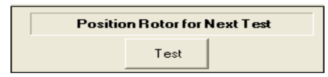
13. Verify that increments to be used during testing are correct. This information is located at the top of the RIC Test window.

    To change the Increments, which automatically computes the appropriate Degrees, click the down arrow and select the increment from the drop-down list.

    The new increments are displayed and the degrees on the test data table is updated.

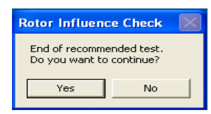
14. Position the rotor to the first position and click **Test** to begin testing.

15. At the end of each test point, you will be reminded to position the rotor for the next test point. Move the rotor and click **Test**. Repeat until the end of the recommended test.



    As the test progresses, the values will be inserted into the table and displayed in the graph areas. The magnification of the graphs can be changed by using the down arrows below each graph area and selecting a new value from the drop down list. The default is Full.

16. At the end of the recommended test you will be asked if you want to continue. Select **Yes** to continue testing or **No** to end testing.

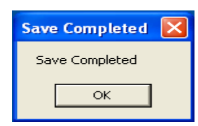


17. Exit the RIC Test window by selecting File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

18. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The RIC Test window closes.

    If you select **No**, the RIC Test window closes. No test data is saved.



Step Voltage

The Step Voltage test is reached by selecting Step Voltage from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Step Voltage Test window opens. Figure 5-25.

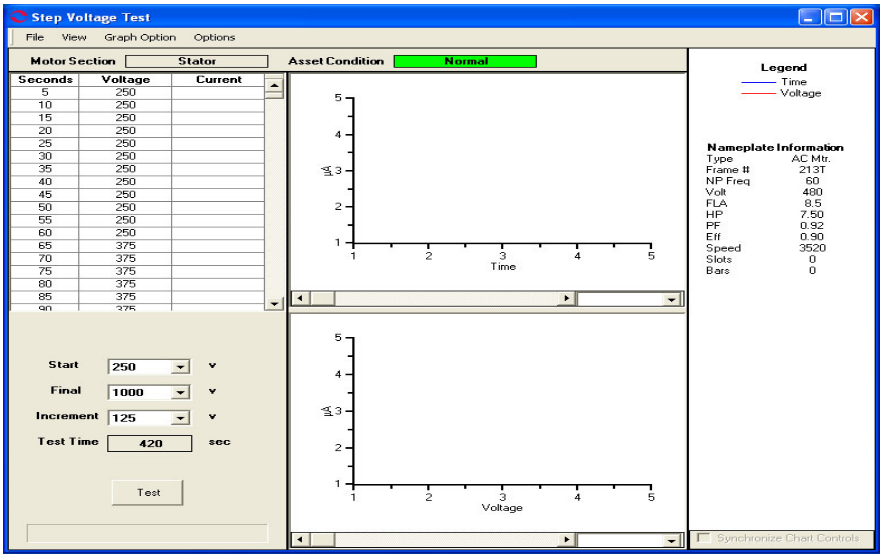


Figure 5-25: Step Voltage Test

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Step Voltage window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-26). Messages created here are viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

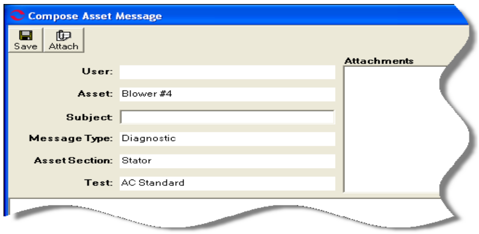


Figure 5-26: Compose Asset Message

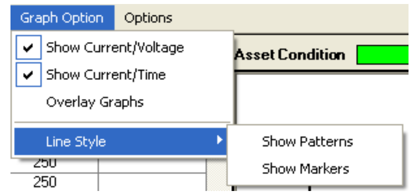
Graph Option Menu

Show Current/Voltage. Show Current/Voltage controls the graph display area. If just Current/Voltage is selected one graph displays on the window. If Show Current/Voltage and Show Current/Time are both selected then two graphs will display.

Show Current/Time. Show Current/Time controls the graph display area. If just Current/Time is selected one graph displays on the window. If Show Current/Time and Show Current/Voltage are both selected then two graphs will display.

Overlay Graphs. Overlay Graphs controls the graph display area. When Overlay Graphs is selected test results are graphed on one graph.

Line Style. Line Style controls the appearance of the line on the graph.



Show Patterns changes the graph line style from a solid to a pattern. When a change is made to the line style it is reflected in the Legend area of the window, which is located just above the Nameplate Information.

Show Markers inserts markers on the graph line. When a change is made to the line style it is reflected in the Legend area of the window, which is located just above the Nameplate Information.

Options Menu

Set Condition Code. Change the condition code, by selecting an option button (Figure 5-27). The Asset Condition box on the Step Voltage Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

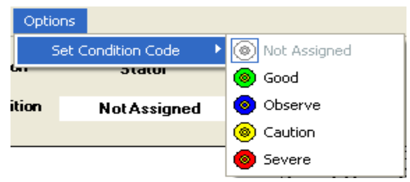


Figure 5-27: Set Condition Code Window

Step-by-Step Step Voltage Testing

During the test the menu items are dimmed (not available).

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-4. This ensures that the test data is trendable/repeatable.

Table 5-4: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-28.

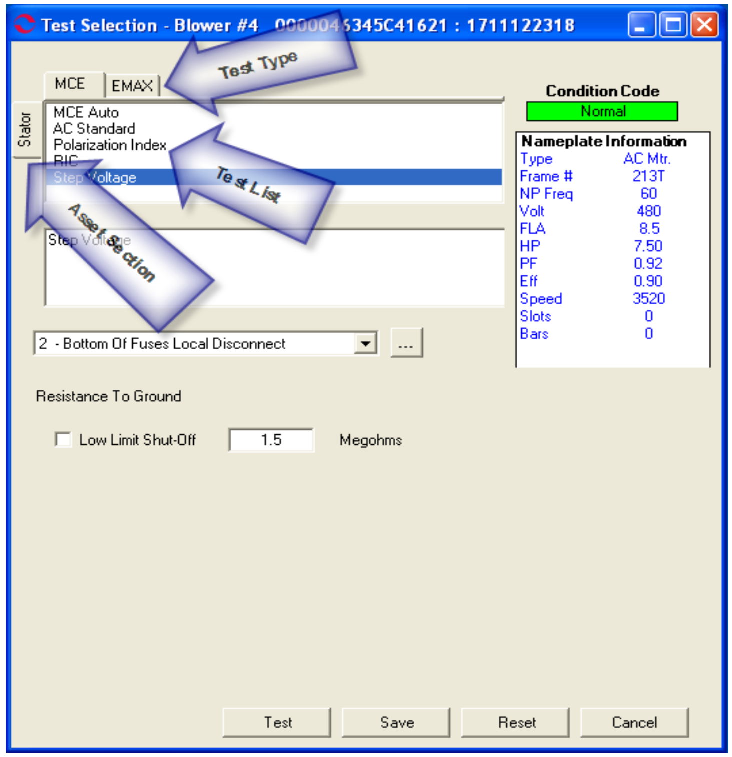


Figure 5-28: Test Selection Window

6. Verify that the MCE (Test Type) and Stator (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Select Step Voltage from the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-29.

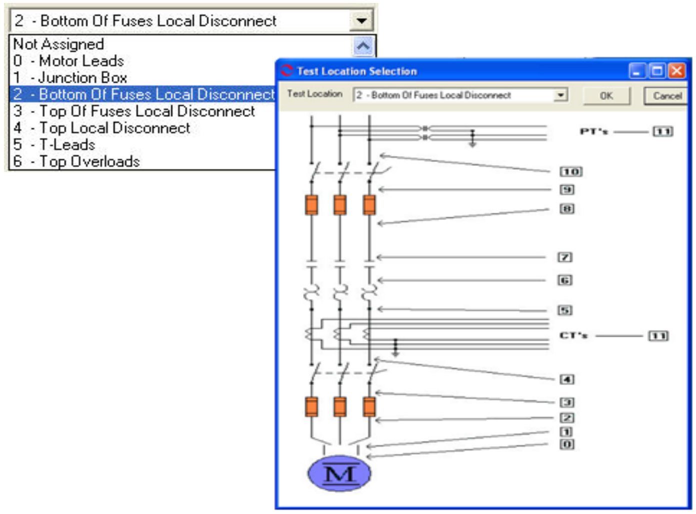


Figure 5-29: Test Locations

9. Verify the Low Limit Shut Off condition.

   Check the box to activate the low limit shut off and enter the desired Mohms.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the Step Voltage test window. See Figure 5-30.

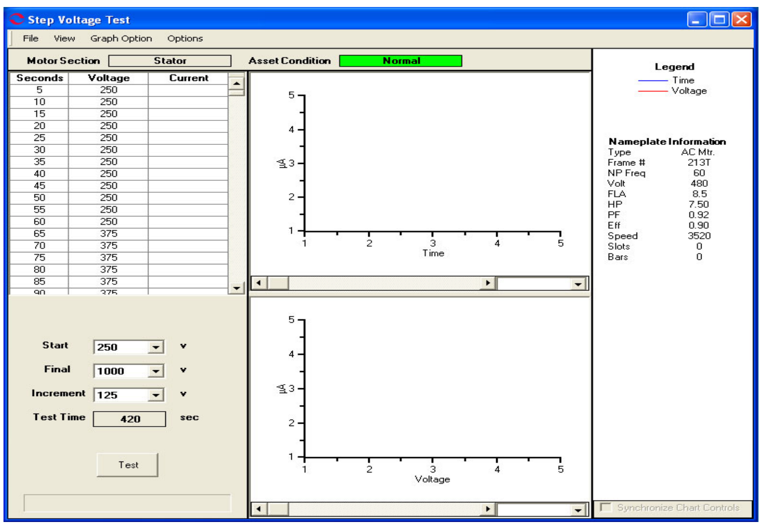


Figure 5-30: Step Voltage Test Window

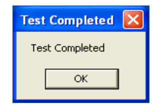
12. To begin the test click **Test**.

13. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

14. Test values are entered in the table on the left and are displayed in graph format on the right side of the window. The magnification of the graphs can be changed by using the down arrows below each graph area and selecting a new value from the drop down list. The default is Full. A progress bar at the bottom of the screen tracks the testing progress.

    Note: During the test the **Test** button changes to **Stop**, which allows you to interrupt the testing.

15. At the end of testing click **OK** in the Test Completed window.



16. Exit the Step Voltage Window by selecting File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

17. You will be asked if you want to save test data. Click **Yes** or **No**.

    If you select **Yes**, click **OK** in the Save Completed widow. The Step Voltage Test window closes.

    If you select **No**, the Step Voltage Test window closes. No test data is saved.

AC Synchronous Assets

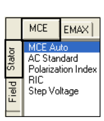
The MCE tests for an AC Synchronous asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage for the *Stator* section and MCE Auto, Synchronous, Polarization Index, and Step Voltage for the *Field* section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test
- Polarization Index (PI)/ Dielectric Absorption (DA). If a PI is performed, it is not necessary to perform a separate DA.

Synchronous assets are divided into two separate sections (Stator and Field Circuit). The asset Section of the Test Selection window defaults to Stator.

Some asset circuits may have surge capacitors and/or power factor correction capacitors installed. This is important since these components affect the values of the collected data, and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor or surge capacitors installed. However, a test should be taken with the surge capacitors removed for future comparison. If a asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.



Stator Section Test

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

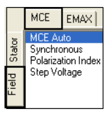
Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

RIC

RIC test is the same as for an AC Induction asset. See RIC on page 5-20.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.



Field Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Synchronous

The Synchronous test is reached by selecting the Field Tab and Synchronous from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Synchronous Test window opens. Figure 5-31.

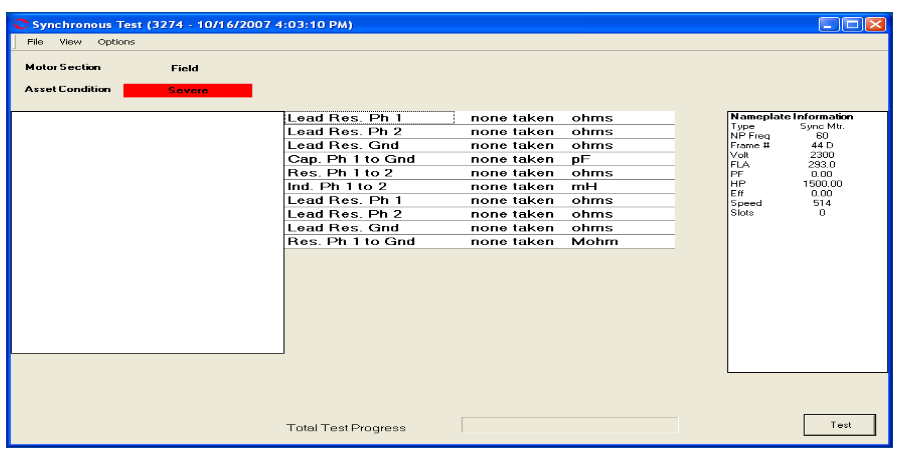


Figure 5-31: Synchronous Test Window

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Synchronous Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-32). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

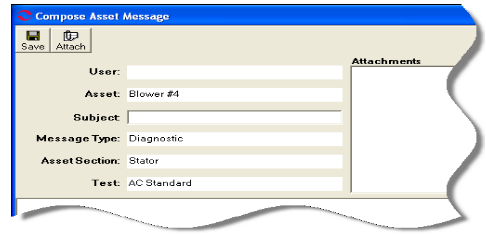


Figure 5-32: Compose Asset Message

Options Menu

Set Condition Code. Change the condition code, by selecting an option button, the Asset Condition box on the Synchronous Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

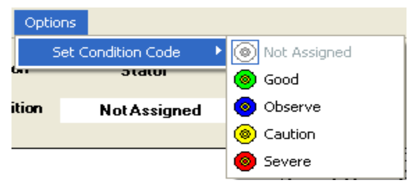


Figure 5-33: Set Condition Code Window

Step-by-Step Synchronous Testing

During the test the menu items are dimmed (not available).

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-5. This ensures that the test data is trendable/repeatable.

Table 5-5: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
motor phase	A	B	C	gnd
"T" lead	T1	T2	T3	gnd
vertical	top	mid	bot	gnd
horizontal	left	mid	right	gnd

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-34.

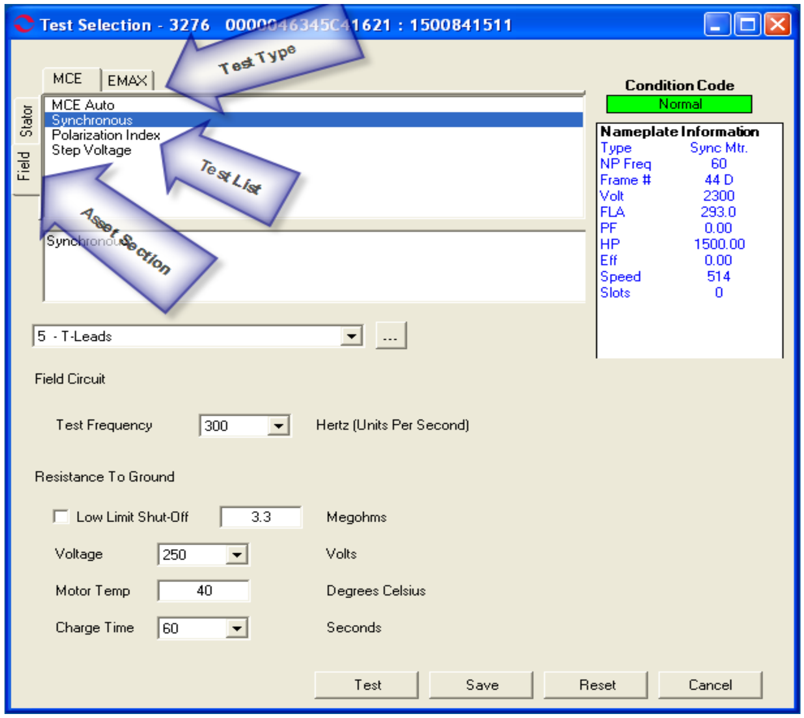


Figure 5-34: Test Selection Window

6. Verify that the MCE (Test Type) and Field (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Select Synchronous from the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-35.

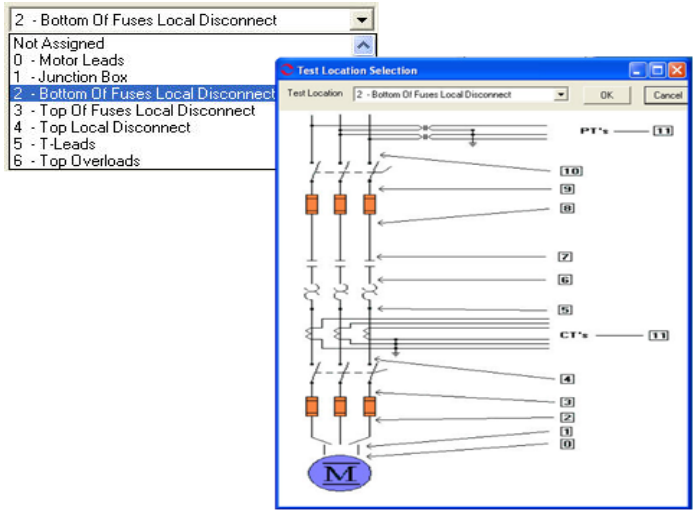


Figure 5-35: Test Locations

9. Verify the Test Frequency.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select the Charge Time Seconds.

    Click the down arrow and select the seconds from the drop-down list. The choices are from 30 to 180 seconds at 15 second increments.

14. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the Synchronous test window.

16. Verify that you are about to apply “X” volts to the circuit and click **Yes**.

17. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds.

18. At the end of testing the **Test** button changes to **Save,** Test Completed appears above the Nameplate Information section, and the progress bars disappear.

19. Re-test any individual point, if needed. If not go to step 20.

    If any portion of the test needs to be re-tested, click the tab which appears to the right of the individual test point. This retests only that test point in "manual mode." (Figure 5-36)

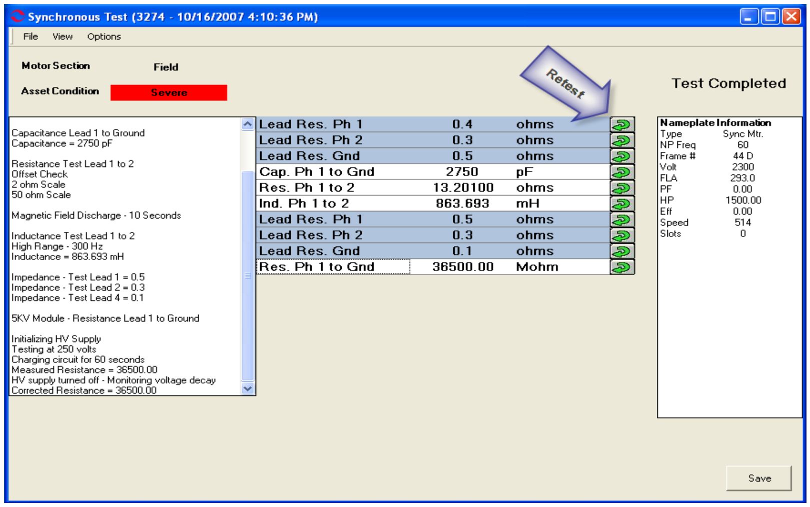


Figure 5-36: Completed Synchronous Test Window

20. When retesting is complete or if no re-testing is needed, click **Save** or File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

21. Click **OK** in the Save Completed window.

22. Click **Exit** to close the window.

AC Wound Rotor Assets

Wound rotor assets (WRMs) are divided into three separate sections (Stator, Rotor, and Resistor Bank). The asset Section box of the Test Selection window defaults to Stator.

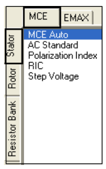
The MCE tests for an AC Wound Rotor asset are MCE Auto, AC Standard, Polarization Index, RIC, and Step Voltage for the Stator section. MCE Auto, AC Standard, Polarization Index, and Step Voltage for the Rotor section. MCE Auto, Resistor Bank, Polarization Index, and Step Voltage for the Resistor Bank section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Rotor Influence Check (RIC)
- Standard Test

- Polarization Index (PI)/ Dielectric Absorption (DA). If a PI is performed, it is not necessary to perform a separate DA.

Some circuits may have surge capacitors and power factor correction capacitors installed. This is important since these components affect the values of the collected data, and increase the time and number of steps involved in troubleshooting. Testing can be performed with the power factor capacitors installed. However, surge capacitors must be removed to ensure valid test data. If a asset appears faulty with the power factor capacitors installed, disconnect them and perform the testing again to isolate the fault.



Stator Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

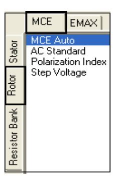
Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

RIC

RIC test is the same as for an AC Induction asset. See RIC on page 5-20.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5- 24.



Rotor Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

AC Standard

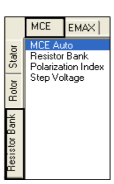
AC Standard is the same as for an AC Induction asset. See AC Standard on page 5-12.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5- 24.



Resistor Bank Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

Polarization Index

Polarization Index test is the same as for an AC Induction asset. See Polarization Index on page 5-16.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Resistor Bank Test

The Resistor Bank test is reached by selecting the Resistor Bank tab and Resistor Bank from the test list on the Test Selection window. See page 1-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Resistor Bank Test window opens. Figure 5-37.

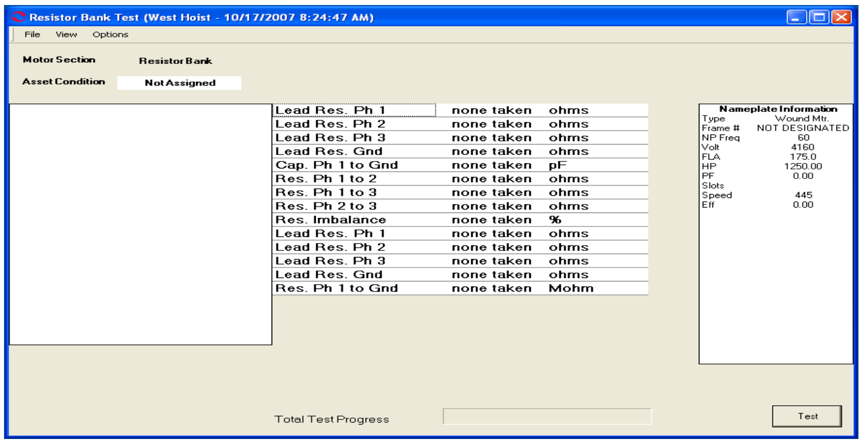


Figure 5-37: Resistor Bank Test Window

File Menu

Save. Save Data is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the Resistor Bank Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-38). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

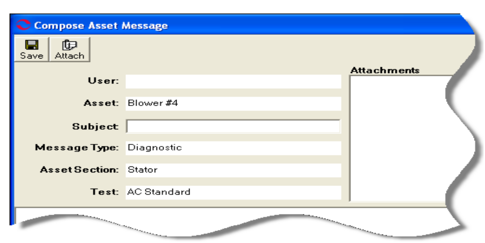


Figure 5-38: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting an option button (Figure 5-39). The Asset Condition box on the Resistor Bank Test window changes and a note is automatically generated by the software.

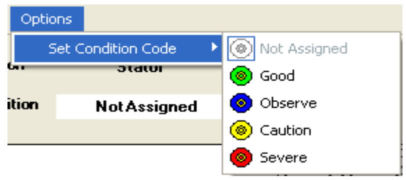


Figure 5-39: Set Condition Code Window

Step-by-Step Resistor Bank Testing

1. Deenergize and lock out the starter, disconnect, and the asset. Follow your company's electrical safety procedures for tagouts.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the voltage does not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Lift the brushes to isolate the resistor bank from the rotor field.

4. Connect the MCE test leads to the circuit/asset, in the same manner each time, as referenced in Table 5-6. This ensures that the test data is trendable/repeatable.

Table 5-6: Test Lead Connections

MCE test leads	Black	Blue	Red	Green
brushes	brushes over slip ring 1	brushes over slip ring 2	brushes over slip ring 3	gnd

5. Highlight the asset to be tested in the Site Navigator.

6. Select the Test Selection icon  on the toolbar. The Test Selection window opens, Figure 5-40.

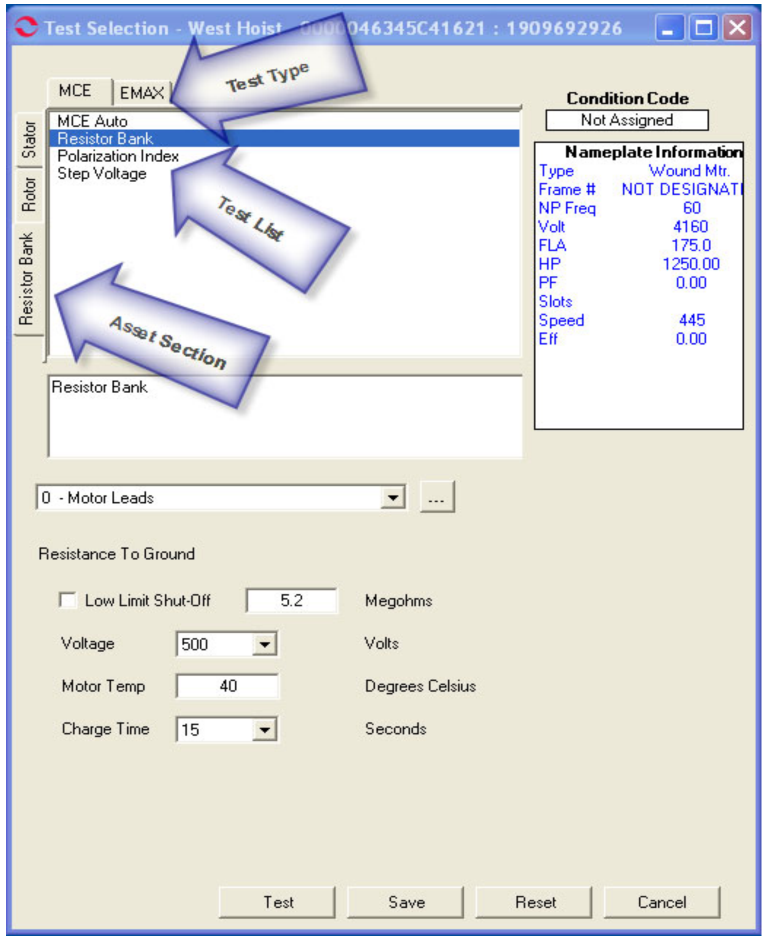


Figure 5-40: Test Selection Window

7. Verify that the MCE (Test Type) and Resistor Bank (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

8. Select Resistor Bank from the Test List box.

9. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button ... . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-41.

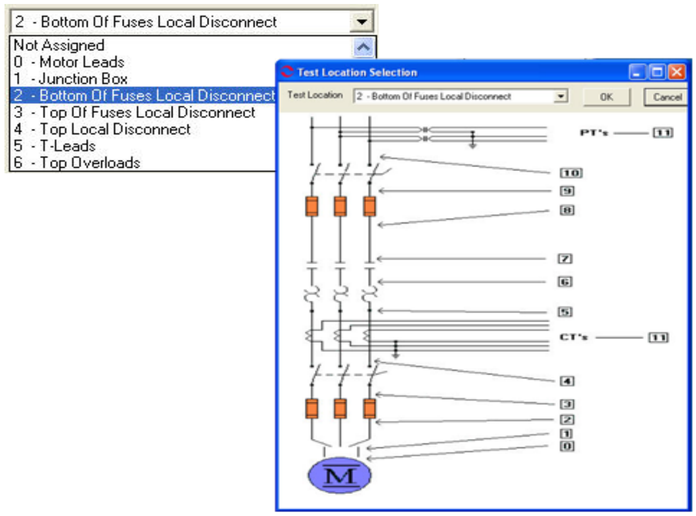


Figure 5-41: Test Locations

10. Verify the Low Limit Shut Off condition.

    Check the box to activate the low limit shut off and enter the desired Mohms.

11. Verify the Voltage.

    Click the down arrow and select the voltage from the drop-down list. Select test voltage based on asset nameplate voltage.

12. Enter the temperature.

    Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

14. Click **Test** to go to the Resistor Bank Test window.

15. To begin the Resistor Bank Test, click **Test**.

16. Verify that you are about to apply “X” volts to the circuit and click **Yes**.

17. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area.

18. Re-test any individual point, if needed. If not go to step 19.

If any portion of the test needs to be re-tested, click the green arrow to the right of the point. This rechecks only that test point in “manual mode.” See Figure 5-42.

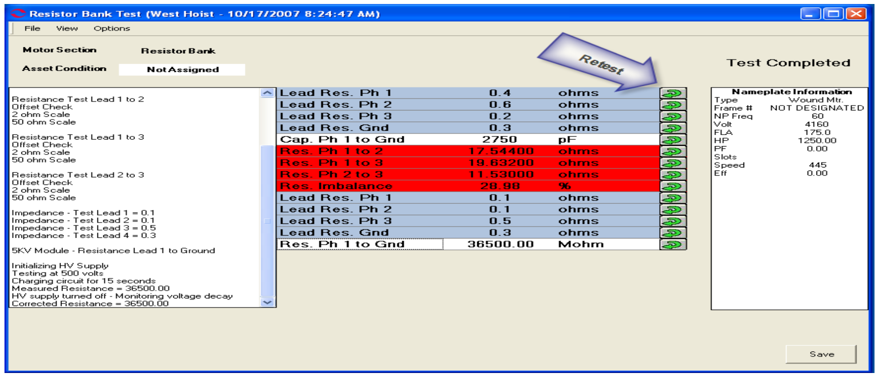


Figure 5-42: Resistor Bank Test Window - Retest Points

19. When retesting is complete or if no re-testing is needed, click **Save,** or File, Exit, or Ctrl+X, or the close button (X in the upper right corner).

20. Click **OK** in the Save Completed window and the Resistor Bank Test window closes.

DC Assets

The MCE tests for a DC asset are MCE Auto, DC Standard, Polarization Index, Bar-to-Bar, and Step Voltage for the *Armature* section. MCE Auto, DC Standard, Polarization Index, and Step Voltage for the *Field* section.

Note: To minimize the influence of stored energy on test results, perform the tests in the following order. If a test is not to be performed, skip to the next test.

- Standard Test
- Polarization Index (PI). If a PI is performed, it is not necessary to perform a separate DA.

DC assets are divided into two separate sections (Armature Circuit and Field Circuit). The Asset Section of the Test Selection window defaults to Armature Circuit.

Armature Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

DC Standard Test

The DC Standard Test is reached by selecting DC Standard from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The DC Standard Test Window (Figure 5-43) opens.

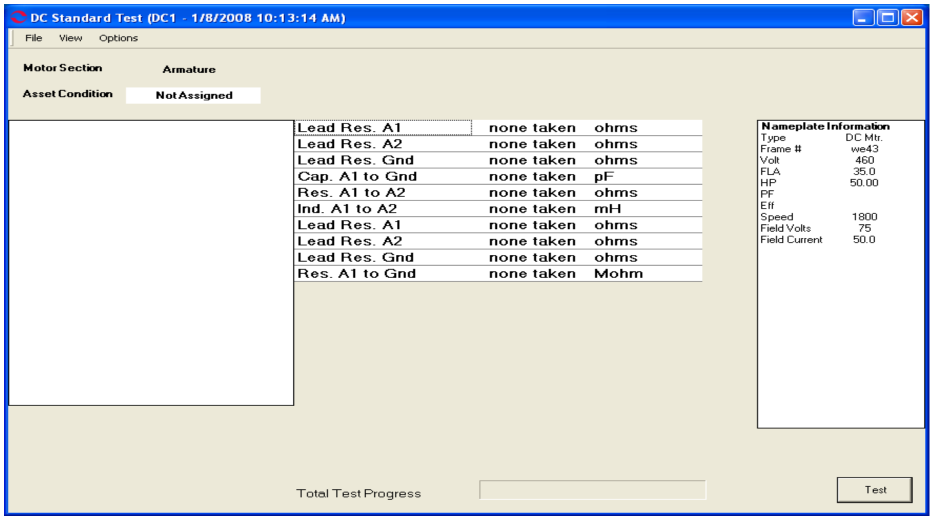


Figure 5-43: DC Standard Test Window

The DC Standard Test window menu consist of three options: File, View, and Options.

File Menu

Save. Save (Ctrl+S) is not active, it appears dimmed, until after testing is complete.

Exit. Exit (Ctrl+X) closes the AC Standard test window and returns you to the MCEGold Home window.

View Menu

Create Message. Create Message opens the Compose Asset Message window (Figure 5-44). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

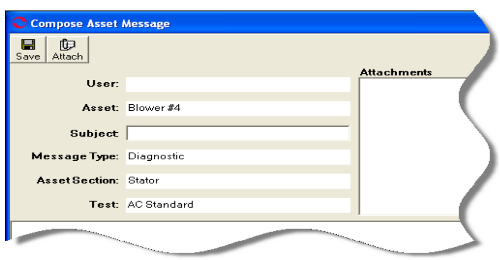


Figure 5-44: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting an option button (Figure 5-45). The Asset Condition box on the AC Standard Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43

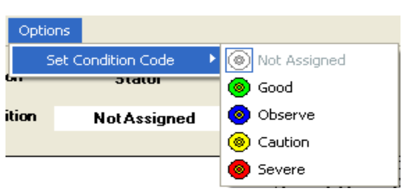


Figure 5-45: Options, Set Condition Code Menu

Step-by-Step DC Standard Testing

1. Deenergize and lock out the starter and asset.

2. Check for low level induced voltage using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the MCE test leads to the circuit, in the same manner each time, as referenced in Table 5-7 and shown in Figure 5-46. This ensures that the test data is trendable/repeatable.

Table 5-7: Test Lead Connections

MCE test leads	Black	Blue	Green
motor leads	A1; A1 or S1	A2; S2 or A2	ground

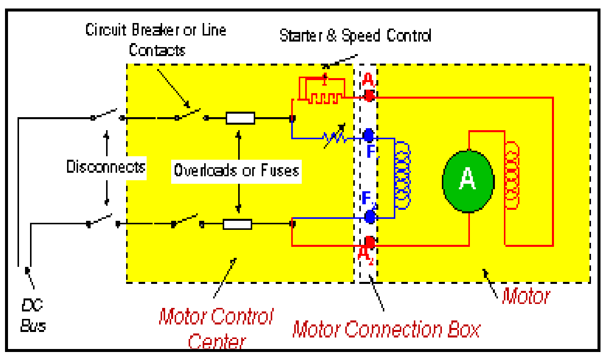


Figure 5-46: DC Asset Circuit Connections

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the tool bar to open the Test Selection window.

6. Verify that Armature Circuit is selected in the asset Section box.

7. Select DC Standard Test in the Test List box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button [...]. The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-47.

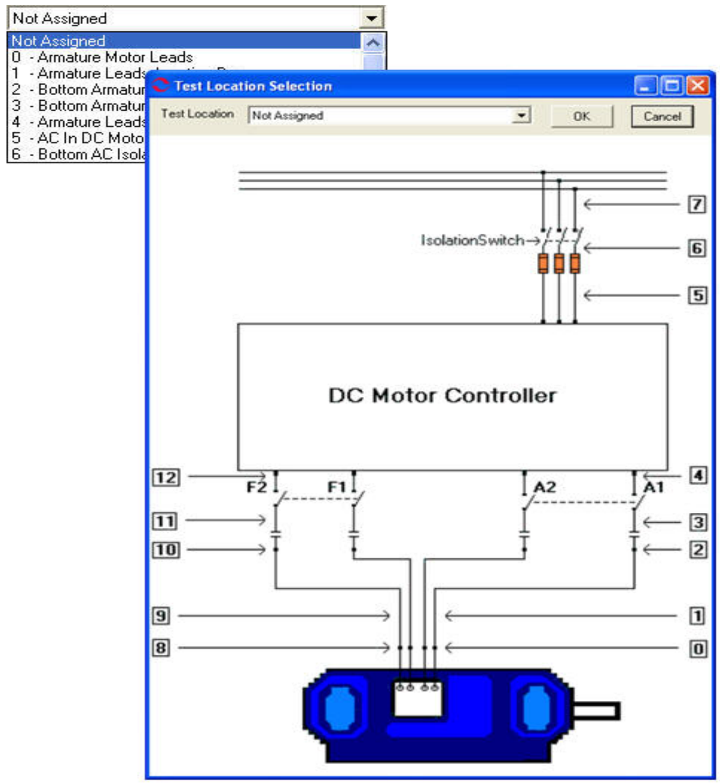


Figure 5-47: DC Asset Test Location

9. Select Test frequency for the Armature Circuit from the drop-down box.

   Click the down arrow and select the frequency from the drop-down list. The values are 300 or 1200.

10. Check the Low Limit Shut Off box and enter Mohms.

11. Select the test voltage for the resistance to ground measurement (500 for ≤ 2400 volts or 1000 for >2400 volts) based on asset nameplate voltage.

    Click the down arrow and select the voltage from the drop-down list.

12. Adjust the Temperature ° C to stator core temperature at the time of testing.

13. Select Charge Time seconds.

    Click the down arrow and select the charge time from the drop-down list. The choices are from 15 to 600 seconds.

14. Click **Save**, to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

15. Click **Test** to go to the DC Standard Test Window.

16. Click **Test** to begin testing.

17. Verify that you are about to apply "X" volts to the circuit by clicking **Yes**.

18. Testing begins, progress bars are displayed for Total Test Progress and Discharge Progress at various times. The test values are filled in as testing proceeds. At the end of testing Test Completed appears above the Nameplate Information area. See Figure 5-48.

    To stop the test at any time, click **Stop**. Click **Exit** to close the DC Standard test window and return to the Home window.

19. Re-test any individual point, if needed. If not go to step 20.

    If any portion of the test needs to be re-tested, double click the tab which appears to the right of the individual test point. This rechecks only that test point in "manual mode." See Figure 5-48.

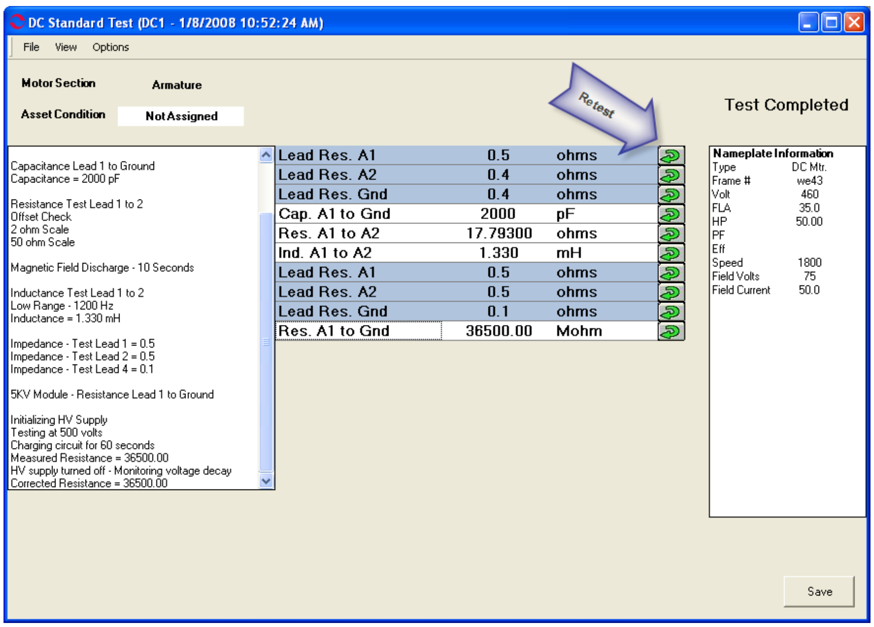


Figure 5-48: DC Standard Test Window

20. When retesting is complete or if no re-testing is needed, click **Save** or select File, Exit, or Ctrl+X, or use the close button (X in the upper right corner).

21. Click **OK** in the Save Complete window.

22. Click **Exit** in the DC Standard Test Window.

Step-by-Step Polarization Index Testing

1. Deenergize and lock out the starter asset.

2. Check for low level induced voltage using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground

3. Connect the MCE test leads to the circuit, in the same manner each time, as referenced in Table 5-8 and shown in Figure 5-49. This ensures that the test data is trendable/repeatable.

Table 5-8: Test Lead Connections

MCE test leads	Black	Blue	Green
motor leads	A1; A1 or S1	A2; S2 or A2	ground

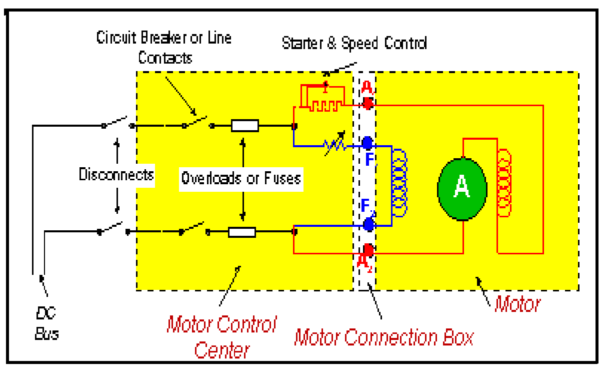


Figure 5-49: Asset Circuit Connections

4. Highlight the asset to be tested in the Site Navigator.

5. Select the Test Selection icon  on the tool bar to open the Test Selection window.

6. Verify that Armature is selected.

7. Select Polarization Index in the Test List Box.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-50.

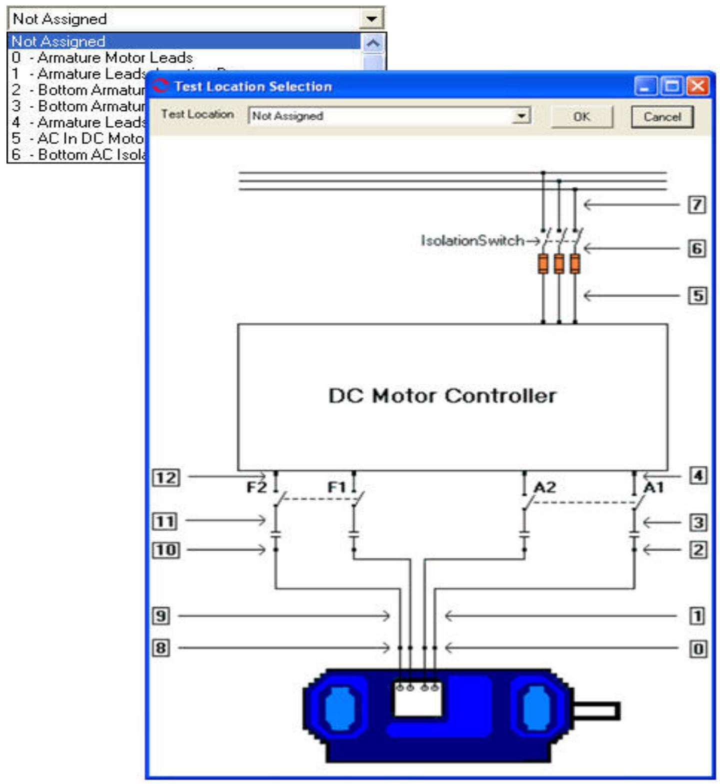


Figure 5-50: DC Asset Test Location

9. Check the Low Limit Shut Off box and enter Mohms.

10. Enter the test voltage for the resistance to ground measurement (500 for $\leq$ 2400 volts or 1000 for >2400 volts) based on asset nameplate voltage.

    Click the down arrow and select the voltage from the drop-down list.

11. Click **Save**, to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

12. Click **Test** to go to the PI Test Window. See Figure 5-51.

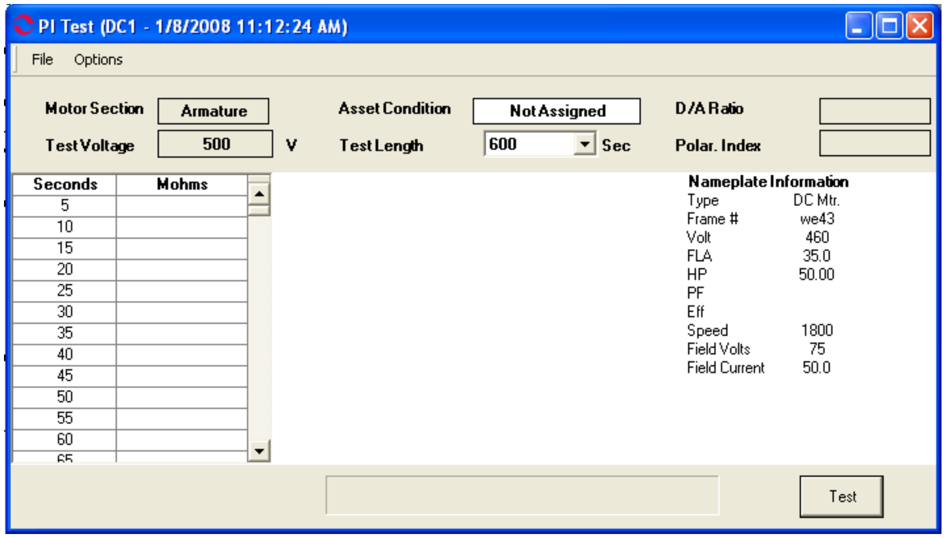


Figure 5-51: PI Test Window

13. Select the test length in seconds from the drop down list.

14. Click **Test** to begin testing.

    To stop the test at any time, click **Stop**. Click **Exit** to return to the Test Selection window.

15. Verify that you are about to apply “X” volts to the circuit by clicking **Yes**.

16. During the testing the D/A ratio and the Polarization Index will be computed and entered in the appropriate text boxes on the window.

17. Click **OK** at the end of testing in the Test Complete window.

18. Close the PI Test window by selecting File, Exit, or Ctrl+X, or the close button (red X in the upper right corner).

19. Click **Yes** to save test data, in the Save Test Data window. Or **No** to exit without saving test data.

20. Click **OK** in the Save Completed window.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

Bar-to-Bar

The Bar-to-Bar test is reached by selecting the Armature tab and Bar-to-Bar from the test list on the Test Selection window. See page 5-3, Test Selection Window for more information. Verify that the test set-up settings are correct and click **Test**. The Bar-to-Bar Test window opens. Figure 5-52.

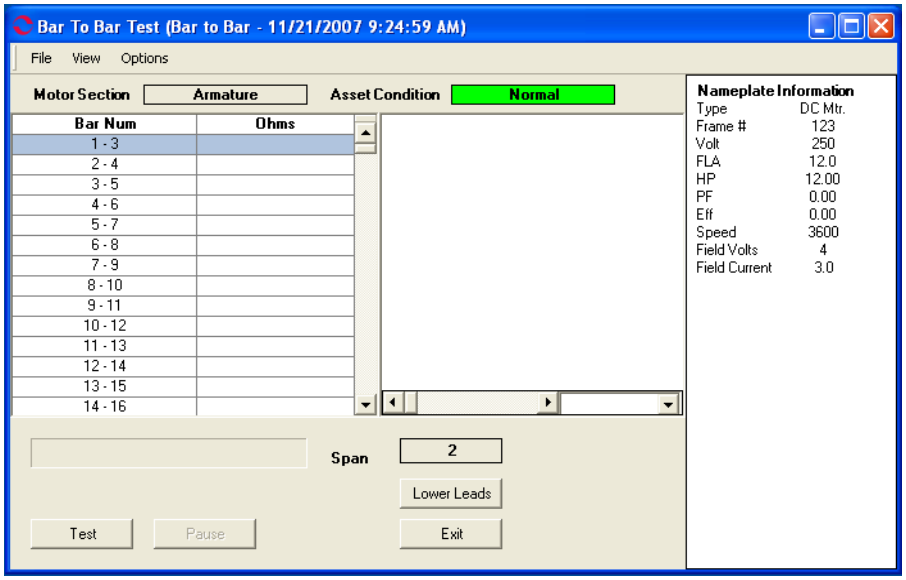


Figure 5-52: Bar-to-Bar Test Window

File Menu

Exit. Exit (Ctrl+X) closes the Bar-To-Bar Test window and returns you to the Home window.

View Menu

Create Message. Create Message (Ctrl+S) opens the Compose Asset Message window (Figure 5-53). The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-41.

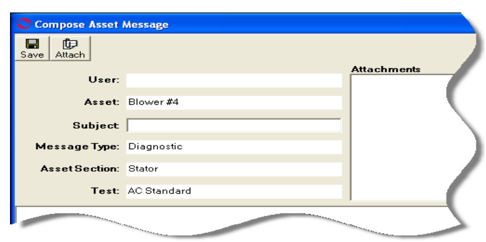


Figure 5-53: Compose Asset Message Window

Options Menu

Set Condition Code. Change the condition code by selecting the desired condition code option button (Figure 5-54). The Asset Condition box on the Bar-To-Bar Test window changes and a note is automatically generated by the software. The note is viewed in the Message Center. For more information on the Message Center, see Chapter 3, page 3-43.

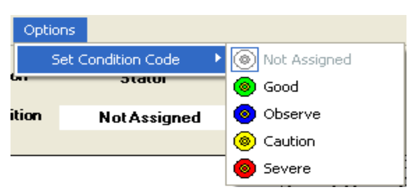


Figure 5-54: Set Condition Code Window

Raise Leads/Lower Leads Button

The Raise Leads/Lower Leads button toggles to signify the action to be taken with the test leads during testing.

Exit Button

The Exit Button is inactive (dimmed) during testing, but is active between moving the leads.

Pause Button

The Pause Button is inactive (dimmed) during testing, but is active between moving the leads.

Test

The lower left area of the Bar-to-Bar test window, Figure 5-55, informs you what action is required. The Test Dialog box displays the testing progress. The software checks for the leads and if no leads are found displays, "Waiting for Leads" in the text box. When the leads are in position, testing begins automatically. During testing the text box displays Read Resistance, Checking Leads, Test Completed, Waiting for Leads.

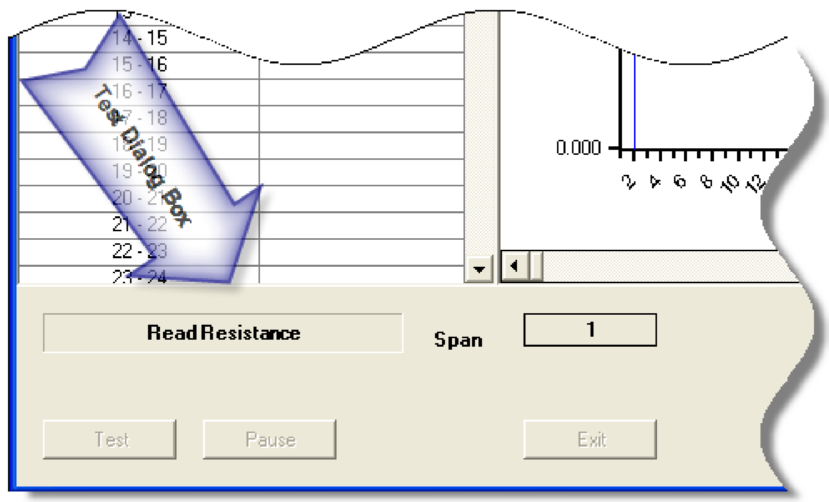


Figure 5-55:

Step-by-Step Bar-to-Bar Testing

1. Deenergize and lock out the starter and the asset.

2. Check for low level induced voltages using a Fluke multimeter or equivalent.

   Verify that the values do not exceed 0.5 VAC phase-to-phase and 15 VAC phase-to-ground. Check for low level stored voltage by verifying less than 15 VDC phase-to-ground.

3. Connect the bar-to-bar test leads to the MCE and to the laptop parallel port.

4. Highlight the asset to be tested on the Site Navigator.

5. Select the Test Selection icon on the toolbar. The Test Selection window opens, Figure 5-56.

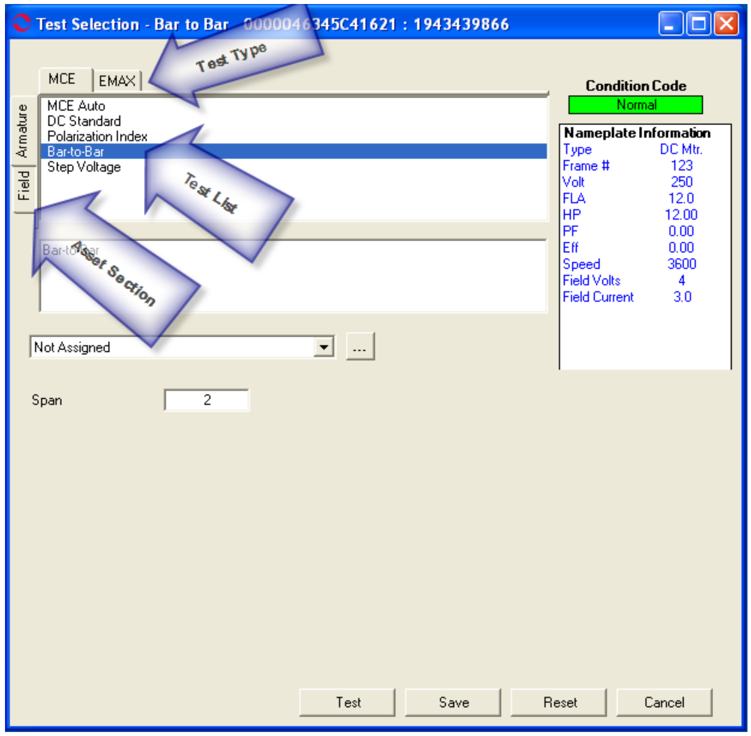


Figure 5-56: Test Selection Window

6. Verify that the MCE (Test Type) and Armature (Asset Section) tabs are selected. The type of asset determines which asset sections are available.

7. Click Bar-To-Bar from the Test List.

8. Verify the Test Location in the Test Setup section.

   To insure consistent trending and assist in trouble shooting, the actual test location should be stored for each test.

   The Test Location default is Not Assigned. To assign a test location, click the down arrow and select from the list. If the location is not known, click the browse button . The Test Location Selection window opens displaying a test location graph for the type of asset selected. Use the graph to determine the location, then click the down arrow, select from the list, and click **OK**. See Figure 5-57.

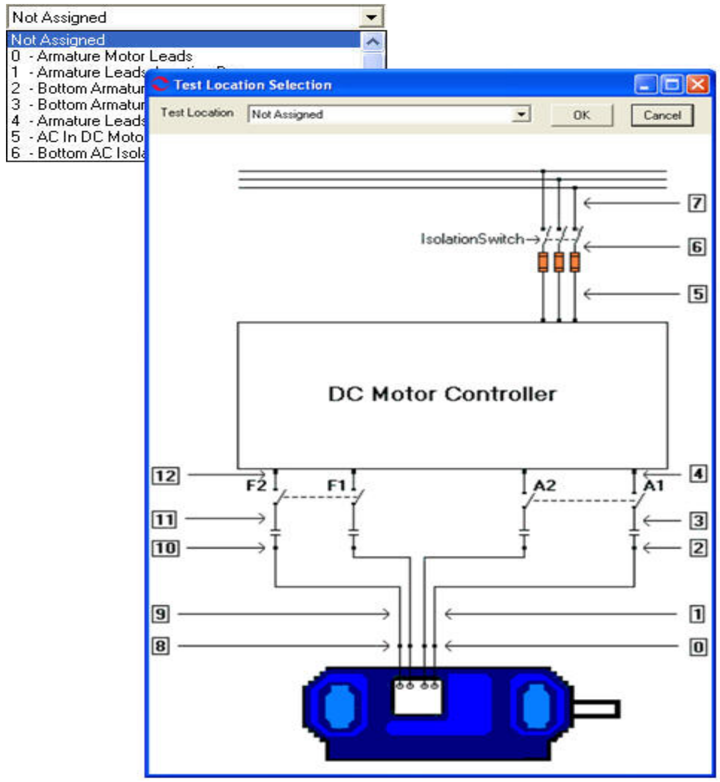


Figure 5-57: DC Asset Test Location

9. Verify the Span is correct.

10. Click **Save** to save the settings for this asset for future testing. Or click **Reset** to return the original settings. This can only be done if the new settings have not been saved.

11. Click **Test** to go to the testing window

12. To begin the Bar-to-Bar Test, click **Test.**

13. When "Waiting for Leads" appears in the Test Dialog Box, position the leads. Testing will begin automatically. The dialog box will inform you of the testing progress beginning with Read Resistance, Checking Leads, and finally Test Complete. See Figure 5-58.

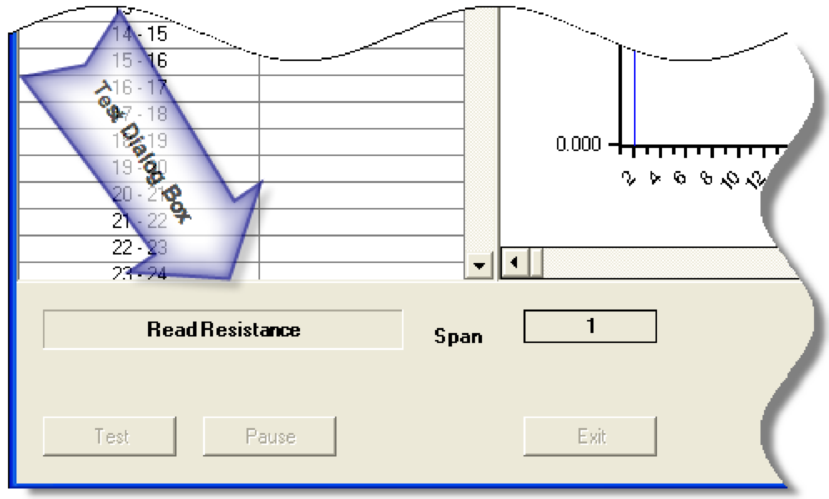


Figure 5-58: Test Dialog Box

14. During testing the test values are entered in the table on the left and are displayed in graph format in the center of the window. The magnification of the graph can be changed by using the down arrows below the graph area and selecting a new value from the drop down list. The default is Full.

15. When Test Complete appears in the Test Dialog box, reposition the leads. Testing will begin automatically.

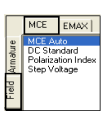
16. Repeat Step 14 until all bars have been tested.

17. At the end of testing, you will be asked if you want to continue testing. Click **Yes** to continue or **No** to end testing.

18. Click **Exit**. You will be asked if you want to save test data.

    Click **Yes** to save the test data. Click **OK** in the Save Completed window. The Bar-to-Bar test window closes.

    Or click **No** to exit the window without saving.



Field Section Tests

MCE Auto

MCE Auto is the same as for an AC Induction asset. See MCE Auto on page 5-7.

DC Standard

DC Standard test for the Field section is the same as for the Armature section. See DC Standard on page 5-40.

Polarization Index

The Polarization Index test for the Field section is the same as for the Armature section. See Polarization Index on page 5-45.

Step Voltage

Step Voltage test is the same as for an AC Induction asset. See Step Voltage on page 5-24.

TEST DATA ANALYSIS INFORMATION

Standard Test

The standard test is similar for both AC and DC assets. In an AC asset, the following are either measured or calculated during a standard test:

Resistance-to-ground
Capacitance-to-ground
Resistance phase-to-phase
Inductance phase-to-phase
Resistive imbalance (calculated)
Inductive imbalance (calculated)
Power loss

In a DC asset, the following are either measured or calculated during the standard test:

Resistance-to-ground
Capacitance-to-ground
Armature and/or field resistance
Armature and/or field inductance

Resistance-to-Ground

What Does it Tell You?

The resistance-to-ground (RTG) measurement indicates the cleanliness and health of the insulation system. As the insulation ages, cracks and small holes develop. It also becomes brittle over time, as the wiring expands due to heating and contracts when it cools off. Aging and temperature variations also break down the molecular structure of the insulation.

These factors allow contaminants and moisture, which collect on the surface of the insulation, to penetrate to the conductor. Since current follows the path of least resistance, some of the total current is diverted from the circuit to these alternate paths, and ultimately to ground. As the RTG value decreases over time, capacitance-to-ground often increases, indicating the presence of many current leakage paths to ground and the accumulation of contaminants.

Why is This Important?

A low RTG value indicates that the insulation needs to be cleaned. If the condition causing the low RTG is not corrected and the RTG value continues to drop, the insulation could completely fail and the asset windings could be damaged. This could require a complete rewind of the stator. If the condition causing the low RTG is corrected, a less expensive clean, dip, and bake may suffice.

Setting Warning Levels

Minimum Value. IEEE (the Institute of Electrical and Electronics Engineers, Inc.) has established a standard for the minimum value of insulation resistance which can be applied to most AC windings, DC armature windings, and AC and DC field windings. The

standard is IEEE Std 43-2001. The equation for most windings made circa 1970 or before, all field windings, and others not noted in the exceptions listed below is IR_{1min}=kV+1.

In the formula:

IR_{1min} is the recommended minimum insulation resistance-to-ground, in megohms, at 40°C (104 °F) at the asset windings

kV is the rated terminal-to-terminal potential, in RMS kilovolts

Examples

A 480 volt asset has a minimum RTG value of 1.48 megohms (480 volts = .480 kilovolts; .48 + 1 = 1.48 megohms)

A 4160 volt asset has a minimum RTG value of 5.160 megohms (4160 volts = 4.160 kilovolts; 4.160 + 1 = 5.160 megohms)

MCEGold computes the minimum acceptable RTG value using this equation. This value is corrected to 40 °C. MCEGold provides both the temperature corrected RTG reading along with the actual measured RTG value. To make comparisons and trending valid, always enter actual asset winding temperature and trend the corrected measurement.

Exceptions to the equation are:

- Most DC armature and AC windings built circa or after 1970 (form wound coils). That standard is $IR_{1\ min}$ = 100.
- Most machines with random-wound stator coils and form-wound coils rated below 1 kV. That standard is IR_{1min}= 5.

Stator of AC Induction, Synchronous, and Wound Rotor Assets; Field and Armature of DC Assets

If the corrected RTG is between R_m and 2 times R_m, then the value is set at caution. The reading appears in yellow on the tester display or underlined on a printed copy of the Test History. If the reading is less than R_m, the value is set at alarm. The reading appears in red on the tester display or bolded on a printed copy.

Wound Rotors, Resistor Banks

Voltages in wound rotors and their three-phase resistor banks are typically too low to use the minimum resistance equation to figure minimum values. The warning levels should be set based on your experience. Establish a baseline test for new assets and assets tested for the first time, and watch the trends. Compare values on similar assets operating under similar conditions.

Exceptions

Some assets may show insulation resistance readings which are lower than the IEEE recommended minimum value and still have “good” insulation. These include:

- Windings with an extremely large surface area
- Large or slow-speed assets
- Assets with commutators

A DC armature with a low RTG value typically has multiple paths for leakage current, not just one. Because of this, finding the exact location of ground faults is almost impossible and repair is very difficult. This problem is much more complex than in AC assets. Therefore, lower minimum acceptable RTG values are generally tolerated. In these cases, the IEEE standard of IR_{1min}= kV + 1 is typically relaxed to IR_{1min}= kV.

Out-of-service assets, without installed heaters operating, may absorb enough moisture to lower insulation resistance to less than the recommended limits.

Interpreting Readings

There are two factors, which require user input, which affect the value of RTG measurements. They are temperature and charge time. In order to compare temperature-corrected RTG readings for similar assets operating under similar conditions, these factors MUST be taken into account.

Temperature

The Test Selection window uses the IEEE standard reference value of 40°C as the default value for the winding temperature. This can be changed. The corrected RTG reading shown at the end of the test and in the Test History is the value that would be expected at 40°C regardless of the *actual* temperature of the asset winding insulation when the test was performed. In other words, if the reading is always corrected to the same temperature, then temperature is removed as an influencing factor. This allows you to use the corrected RTG value from test to test as a valuable trending tool.

Temperature correction is necessary since the resistance of an insulation material decreases significantly as its temperature increases. The materials which make up insulation have a negative temperature coefficient (inversely proportional). In other words, as the temperature increases their ability to stop current flow decreases. This means it is necessary to know the temperature of the asset when determining the condition of the insulation system.

Therefore, as the temperature of the asset increases, the measured insulation resistance decreases. To compare the reading you got today with a reading you got last month, it is important that you compare like results. The way to do this is to calculate the corrected resistance to a given temperature. MCE resistance values are corrected to a standard temperature of 40°C. This temperature is selected because the normal operating temperature for an asset is typically approximately 40°C (104°F). When comparing the results of different tests note the temperature input for possible variations.

Table 5-9 shows the report results for the same insulation with resistance to ground measurements taken at a variety of temperatures and compensated to different temperatures.

Table 5-9: Temperature Compensation

Temperature	Actual Resistance	25 °C Compensated	40 °C Compensated
20 °C	20 Megaohm	14 Megaohm	5 Megaohm
25 °C	14 Megaohm	14 Megaohm	5 Megaohm
30 °C	10 Megaohm	14 Megaohm	5 Megaohm
35 °C	7 Megaohm	14 Megaohm	5 Megaohm
40 °C	5 Megaohm	14 Megaohm	5 Megaohm
45 °C	3.5 Megaohm	14 Megaohm	5 Megaohm
50 °C	2.5 Megaohm	14 Megaohm	5 Megaohm

It can be seen from the chart that if temperature compensation is not performed, the reported (actual) resistance to ground changes with temperature. When temperature compensation is performed, the reported resistance does not change when the test temperature changes. In order to compare results, all measurements MUST be compensated to the same temperature.

Test Voltage and Charge Time

The ground wall insulation in a asset has a conductor on either side. On one side of the insulation is the stator windings, the conductors that make up the individual coils in each pole group for each phase. On the other side is the stator core, formed by the stator laminations connected to the frame/casing of the asset. This design has the fundamental components which make up a capacitor. When a DC potential is applied, the insulation “charges” the way a capacitor does. This is important because if the resistance to ground reading is recorded as soon as the test potential is applied, it is lower than if it is recorded after the insulation is “charged.”

A rule of thumb for performing RTG measurements is to *apply the test potential for 1 minute or until the reading has stabilized*. This allows for different technicians to obtain values from test to test which can be compared. However, this is not very accurate. On the MCE, the duration of time the voltage is applied to the insulation system is selectable.

Test voltage potential can be from 250 to 5000 volts, based on asset nameplate voltage. Charge time can be set between 15 and 600 seconds, at 15 second intervals. Defaults are set at 500 volts and 60 seconds. Again, using the same values every time makes comparison and trending a valuable tool.

Data Interpretation

If the RTG value is low, isolate the problem to either the power circuit or the asset. Assuming the first test was made at the MCC, perform another test at the asset connection box. Disconnect the asset leads and test the asset. If the RTG value is higher testing the asset, the fault is in the cables between the MCC and the asset. Check the connections in the asset connection box, look for moisture in the conduit, and examine the cables. The cables may require cleaning, drying, or replacement.

If the RTG value at the asset connection box is still low, the fault is in the asset. If the value is in caution, the asset may need to be dried, cleaned in place, or removed for a clean, dip, and bake. If the value is in alarm, the asset may need to be rewound. If the RTG value is less than the IEEE minimum, look for a ground fault and clear this condition before starting the asset.

Examples

A conveyor asset was tested and had <.1 Megohm RTG. When the technician removed the terminal box cover, he found that one of the taped connections had arced to ground. The leads were repaired and the asset was retested. RTG increased to 263 Megohms.

A compressor asset was tested and had <.1 Megohm RTG. When the technician removed the terminal box cover, he saw that the box was half full of water. The leads were dried and the asset was retested. RTG increased to 21.5 Megohms

Capacitance-to-Ground

What Does it Tell You?

The capacitance-to-ground (CTG) measurement is indicative of the cleanliness of the windings and cables. As dirt and contaminants build up on windings and cables, CTG values increase. An increasing trend showing rising CTG values indicates that the asset needs to be cleaned.

Why is This Important?

A capacitor is formed by any two conducting materials, called plates, separated from each other by a dielectric material. Dielectric material is anything that is “unable to conduct direct electric current.” A cable or winding surrounded by insulation provides one conductor and the dielectric material. The second plate is formed by the stator core and casing iron.

Normally, when the outside of the insulation is clean and dry, it is not a good conductor. When dirt, moisture, and other contaminates begin to cover the stator windings inside the asset, they cause the outer insulation surface areas to become conductive. Since this surface is in contact with the ground, it allows an AC current path to ground. Cables in the power circuit are also subjected to the same affect, when moisture penetrates the outer casing. The cleanliness of the windings and cables can be determined by looking at the CTG value.

With a buildup of material on them, dirty windings and cables produce higher capacitance values than clean ones do. Over time, CTG values steadily increasing indicate an accumulation of dirt and that cleaning is necessary. This can be correlated with decreasing RTG values.

Dirt and contamination also reduce a asset’s ability to dissipate the heat generated by its operation, resulting in premature aging. A general rule of thumb is that insulation life decreases by 50% for every 10 °C (50 °F) increase in operating temperature above the design temperature of the insulation system. This holds true with the asset operating at or above a 75% load. Heat raises the resistance of conductor materials and breaks down the insulation. These factors accelerate the development of cracks in the insulation, providing paths for unwanted current to flow to ground. If capacitance is higher than normal, a low RTG reading is an indication that such a path already exists.

Setting Warning Levels

Preset warning levels for CTG values in MCEGold are based on a percent change from the baseline measurement. This is merely a comparison warning. A 100% increase from baseline produces a caution (yellow on the computer display or underlined on the printed copy). A 200% increase from baseline produces an alarm (red on the computer display or bold on the printed copy). These values are guidelines. As you gather data on a single

asset or on similar assets operating in the same environment, reset the warning levels to reflect your specific conditions.

Data Interpretation

Capacitance-to-ground is a function of many factors. Therefore, comparison of CTG values is more revealing of a asset's condition than is the analysis of a single snapshot CTG value. For example, capacitance to ground is influenced by the design of each individual asset, the length of the cable between the MCE and asset, the type of insulation on the cables and asset windings, and the number and type of connectors in the circuit.

A new or recently refurbished asset may have a very low CTG reading. A "normal" capacitance value can vary from asset to asset and is NOT an absolute value. CTG must be analyzed by trending readings on the same asset or by comparing values taken on similar assets, with similar histories, operating under the same conditions. If CTG increases over time, dirt, moisture, and/or contaminants are building up on the windings, cables, or both.

Surge capacitors are used in some circuits and will affect CTG readings. Whenever possible, CTG tests should be performed with the capacitors in the circuit as well as disconnected, to indicate the health of the capacitors. This allows for trending the condition of the capacitors as well as the CTG of the asset.

Examples

Capacitors and surge caps were left in the circuit for tests of two chillers used to cool vital computers. Table 5-10 shows how several values were affected. Notice the difference in the readings when the power factor capacitors were removed.

Table 5-10: Effects of Power Correction Capacitors

	With Power Factor Capacitors Installed		With Power Factor Capacitors Removed	
	Chiller #1	Chiller #2	Chiller #1	Chiller #2
Balance of Resistance	1.74%	2.164%	0.050%	2.000%
Balance of Inductance	16.0%	0.520%	2.560%	0.500%
CTG	999,999 pF	999,999 pF	38,750 pF	37,250 pF
RTG	0 Megohms	0 Megohms	>2,000 Megohms	> 2,000 Megohms

A conveyor asset was tested and had <.1 Megohm RTG and 999,999 pF CTG. When the technician removed the terminal box cover, he found that one of the taped connections had arced to ground. The leads were repaired and the asset was retested. RTG increased to 263 Megohms and CTG decreased to 67,750 pF.

A compressor asset was tested and had <.1 Megohm RTG and 83,000 pF. When the technician removed the terminal box cover, he saw that the box was half full of water. The leads were dried and the asset was retested. RTG increased to 21.5 Megohms and CTG decreased to 8,000 pF.

Phase-To-Phase Resistance

What Does it Tell You?

Phase-to-phase resistance is the measured DC resistance between phases of the stator in an AC asset and between polarities of the armature and field coils in a DC asset.

In AC induction assets, use the phase-to-phase resistance values and resistive imbalances for trending, troubleshooting, and quality control. In DC assets, use trending and relative comparison to determine the condition of the phases in the asset and power circuits. This includes comparing readings taken from identical assets operating in similar conditions and comparing current readings against past readings for the same asset.

An increasing resistive imbalance or a changing resistance over time can indicate one or more of the following:

- High resistance connections
- Coil-to-coil, phase-to-phase, or turn-to-turn current leakage paths
- Corroded terminals or connections
- Loose cable terminals or bus bar connections
- Open windings
- Poor crimps or bad solder joints
- Loose, dirty, or corroded fuse clips or manual disconnect switches
- Loose, pitted, worn, or poorly adjusted contacts in asset controllers or circuit breakers
- Mismatched components (incompatible materials, wrong sizes, etc.)
- Undersized conductors (misassembled or improperly engineered)

Why is This Important?

Circuit resistance is determined by the length, size, width, composition, condition, type and temperature of the conductors and connectors. When two different conductors are connected, dirt, corrosion, or an improper connection increases the circuit resistance. Also, inadequate connections cause heating of the conductor, which increases resistance even more. This could be caused if only a few strands of a conductor or portions of a soldered joint are improperly connected to a terminal or if undersized connectors are used.

In a three-phase asset circuit, the resistance in the conductor paths should be balanced. A “resistive imbalance” occurs when the phases have unequal resistances. The formula below shows that a very small resistive imbalance results in a high voltage imbalance. This produces uneven current flow and excessive heat.

$$Vimb = \frac{\frac{2}{3} \times (Rmax - Rmin) \times FLA}{Vl - \left(\left(\frac{2}{3}\right) \times (Rmax - Rmin) \times FLA\right)} x100$$

In the formula:

Vimb = voltage imbalance
Rmax = maximum winding resistance value
Rmin = minimum winding resistance value

FLA = full load amp rating of asset
Vl = line voltage
100 = converts number to percentage

When voltage applied across three-phase asset leads is unbalanced, circulating currents, called “negative sequence currents”, are induced. When these negative sequence currents are present, they cause heating in the windings. EPRI’s (the Electric Power Research Institute) Handbook to Assess the Insulation Condition of Large Rotating Machines states “a 3.5% voltage imbalance can raise winding temperature 25% in the winding(s) affected by such currents.” EASA (the Electrical Apparatus Service Association) says a 1% voltage imbalance results in a 6-7% current imbalance.

The most extreme case of resistive imbalance occurs when a asset “single phases.” This “single phasing” quickly causes the asset to fail because the remaining two phases compensate by increasing current by 200% to 300% of normal. Rapid heating of the windings which are still connected destroys the insulation surrounding them.

Resistance to the flow of current in a circuit is of concern from the standpoints of safety, energy conservation, and insulation life. High resistance points in conductors generate heat both at the point where the resistance is located and in the three-phase assets being supplied.

Regardless of the source, some of the effects of increased heat production in the asset include:

- Higher resistance due to heat in conductor materials adjacent to the fault
- Deterioration (accelerated aging) of the surrounding and supporting insulating materials
- Imbalance in multi-phase circuits, which adversely affects equipment performance and life
- Increased power consumption in all cases
- Fire or failure in extreme situations

Setting Warning Levels

The preset warning levels in MCEGold are based on both actual values and on a % change from the baseline value.

Data Interpretation

Resistive imbalance above the setpoint indicates that a problem exists in either the power circuit or in the stator windings. First, isolate the problem to the asset or the circuit. Looking at individual resistance readings can help isolate the problem to a phase. Also, look for the following characteristics which indicate faulty connections.

- Aluminum cables connected to lugs marked for copper wire only
- Discoloration of insulation or contacts
- Damaged insulation having small cracks, bare conductors, or metal components
- Mismatched cables in common circuits
- Poor lug crimps on T-Leads
- Oxidation of conductor metals
- Presence of contaminants such as dirt

Example

The following information is from a 7,000 HP vertical reactor coolant pump asset at a nuclear power plant. A high resistance solder joint between phases 1 and 3 produced a resistive imbalance of 37.15%. The cost associated with the power loss was calculated to be $58,517.84 per year. Multiple tests, shown in Table 5-11, were performed to verify the problem.

Table 5-11: MCE Tests Used in Troubleshooting Efforts

Test Date	5/31/96	5/31/96	5/31/96
Test ID:	331	332	333
Frequency	1200	1200	1200
	BASELINE		
Mohm Ph 1 to Gnd			
Charge Time	30	30	30
Voltage	1000	1000	1000
Motor Temp	40	40	40
Measured Mohm	>2000	>2000	>2000
Corrected Mohm	OVR	OVR	OVR
pF Ph 1 to Gnd	116250	116250	116250
ohm Ph 1 to 2	0.27450	0.26800	0.27400
ohm Ph 1 to 3	0.43750	0.43700	0.44100
ohm Ph 2 to 3	0.24500	0.24300	0.24200
mH Ph 1 to 2	6.750	6.750	6.750
mH Ph 1 to 3	6.755	6.750	6.750
mH Ph 2 to 3	6.745	6.745	6.745
% Res. Imbalance	37.15	38.29	38.24
% Ind. Imbalance	0.07	0.05	0.05
$ Power Loss	58517.84	58973.83	60493.78

Phase-to-Phase Inductance

What Does it Tell You?

In AC assets, phase-to-phase inductance readings can:

- Indicate the condition of the stator windings
- Detect phase-to-phase and coil-to-coil current leakage paths
- Reveal poor or incorrect rework

These readings can also be used to detect faults in power cables. A Rotor Influence Check (RIC) can be performed to further troubleshoot the asset to reveal faults such as:

- Broken/cracked rotor bars or end rings
- Porosity and lamination damage
- Eccentricity problems

In DC assets, inductance changes within the field or armature can indicate current leakage paths in the windings.

Inductance changes when leakage paths develop. These paths can be either within the winding coils, or directly to ground. Leakage paths result from mechanical, thermal, environmental, or electrical damage to the insulation system of the windings. Additionally phase-to-phase and turn-to-turn shorts can occur. In either case, current flow bypasses some coils, thereby reducing inductive reactance and increasing current in other phases of the stator. Temperature rises in the remaining conductors and in the surrounding insulation. This accelerates the deterioration, which can cause an avalanche effect, as heat produces more insulation failures, resulting in more leakage paths and more coils removed from the circuit, further increasing temperature.

As there are fewer winding turns in a given phase actively creating the magnetic field upon which the asset is functioning, the windings in the other phases compensate to meet the requirements of the load on the asset. These windings in turn draw more current than is normally supplied by a balanced asset.

Why is This Important?

A large inductive imbalance causes torque-induced vibration at two-times line frequency ($2F_L$). This vibration can be linked to mechanical degradation. Also, inductive imbalance can contribute to other problems, among which are:

- Bearing damage
- Coupling damage
- Loosened rotor bars
- Insulation failure at winding end turns or at exit of stator slots

Setting Warning Levels

The preset warning levels in MCEGold are based on both actual values and on a change from the baseline value.

Data Interpretation

Many factors affect inductance readings, including asset winding coils, the stator iron, the rotor, and the number of rotor bars. The power circuit has little or no effect on the inductance readings unless there are power factor or surge capacitors in the circuit.

Power correction and surge capacitors are used in some circuits and will affect phase-to-phase inductance readings. Whenever possible, phase-to-phase inductance tests should be performed with the capacitors in the circuit as well as disconnected, to indicate the health of the capacitors. This allows for trending the condition of the capacitors as well as the phase-to-phase inductance of the asset.

If both inductive and resistive imbalance are high, look for a leakage path in a coil or an open coil. If resistive imbalance is low, the fault may be in the rotor.

A rotor bar/cage anomaly may not produce a large inductive imbalance on one single test. If inductive imbalance has increased or is high, perform a RIC to further define the problem. Excessive vibration can also be an indicator of inductive imbalance. If you notice high vibration readings, perform a RIC to collaborate the data.

Example

A new asset with a cast aluminum rotor was load-tested prior to installation. The asset failed to reach rated HP. A RIC was conducted and indicated the presence of broken rotor bars.

When the rotor bars were cast, high resistance connections were formed. Operating the asset during the load-test produced excessive heat at those points. The melted paint on the rotor identified the high resistance connections beneath them.

Test Lead Check

The MCE verifies the resistance of the test leads before and after each test. This ensures test lead continuity and proper connection prior to running the test. If any test lead resistance exceeds a predetermined value, the MCE stops the test. That lead must then be reconnected and retested successfully to continue. This ensures maximum accuracy and repeatability of the collected data.

Resistive Imbalance

Resistive imbalance is calculated from the three individual phase-to-phase resistance readings taken during the standard test. It is displayed as a percentage and will be put into a caution or alarm state if it exceeds a specific limit. This limit can be changed in the MCEGold software. Because this value is calculated from *three* phase-to-phase readings, there is no resistive imbalance value for DC assets.

In AC assets, resistive imbalance is an indication of one or more high-resistance connections in the circuit or shorted turns. Assuming the original test was performed at the MCC, isolate the problem to the asset or to the power circuit by retesting the asset at the connection box. If the resistive imbalance remains, the problem is in the asset. If the resistive imbalance goes away, the problem is in the cables or power circuit. Look at the individual resistance readings to determine the faulty phase.

Inductive Imbalance

Inductive imbalance is calculated from the three individual phase-to-phase inductance readings taken during the standard test. It is displayed as a percentage and will be put into a caution or alarm state if it exceeds a specific limit. This limit can be changed in the MCEGold software. Due to the fact that this value is calculated from *three* phase-to-phase readings, there is no inductive imbalance value for DC assets.

In AC assets, this calculated value can indicate the condition of the stator and rotor/stator relationship. Turn-to-turn or phase-to-phase shorts in the stator causes a high inductive imbalance. Rotor/stator eccentricity causes a varying value of inductive imbalance, as seen on subsequent standard tests. To isolate a problem to the rotor or the stator, perform a Rotor Influence Check.

Power factor capacitors, line reactors, and other power correction devices can impact inductance values. Separation of these devices from the circuit may be required when troubleshooting the asset.

Average Inductance

Average inductance is calculated from the three individual phase-to-phase inductance readings taken during the standard test. Due to the fact that this value is calculated from *three* phase-to-phase readings, there is no inductance imbalance value for DC assets. In AC assets, this calculated value can indicate the condition of the rotor and rotor/stator relationship. Rotor defects will cause an increase in the average inductance. To isolate a problem to the rotor or the stator, perform a Rotor Influence Check.

Polarization Index Test

What Does it Tell You?

The Polarization Index (PI) and Dielectric Absorption (DA) ratios indicate the condition of the insulation system of the asset and power circuit. Both of these tests use ratios of measurements of insulation resistance taken at two different times. The PI is the ratio of the reading taken at 10 minutes and divided by the reading taken at 1 minute. The DA is the ratio of the reading taken at 60 seconds divided by the reading taken at 30 seconds.

There are three different currents that flow through an insulator when a voltage potential is applied. Since the RTG test measures the voltage and current to calculate insulation resistance, all of these currents must be taken into account.

- First, the "capacitive current" starts out high and drops to nearly zero after the insulation has been charged to full test voltage. This is normally negligible after the first few seconds of the test.
- Second, the "absorption current" also starts out high and drops off. The majority of this current dissipates after one minute, but continues to decay for up to 5 to 10 minutes.
- Finally, the "conduction" or "leakage current" is a small, mostly steady current which becomes a factor after the absorption current drops to a negligible value. This current should remain steady for the remainder of the test.

The relationship between all these currents is shown in Figure 5-59.

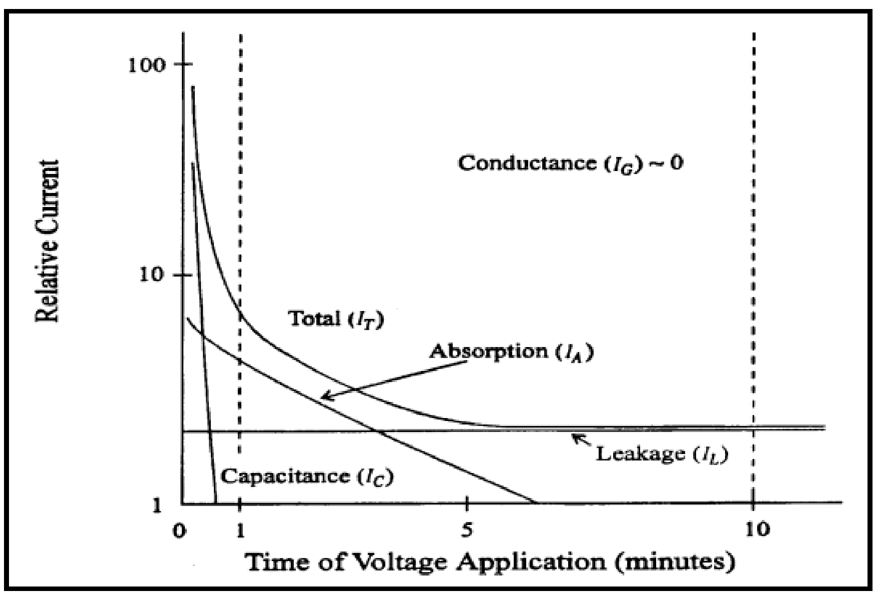


Figure 5-59: Current Relationships

As the asset accumulates dirt and as the insulation ages and cracks, the PI and DA ratios decrease. Dirt accumulates based on the operation and environment of the asset. The insulation cracks as a function of heat and aging of the asset.

Because of the effects of each of these varying currents, the resistance to ground measured by any insulation tester varies with the amount of time the voltage is applied to the insulation. In order to trend or compare insulation RTG values, the charge time for all tests

MUST be the same. If the charge time is not the same, the trend or comparison may not be valid.

Finally, the charging developed by these three different currents does not dissipate immediately when the voltage is removed at the end of the test. The insulation system must be allowed to discharge sufficiently between resistance to ground tests in order to obtain accurate results. A rule of thumb states that insulation takes four times the amount of charge time to discharge.

Why Is This Important?

Resistance-to-ground readings involve three different current components: capacitive, absorption, and leakage. The PI test allows the charging and absorption currents to decay so that only actual leakage current is measured. As a voltage is continuously applied, healthy insulation slowly polarizes and the absorption current diminishes. This causes a steady rise in resistance until the majority of the current is from the small amount leaking to ground. In poor insulation, leakage current is high enough to overshadow the lowering absorption current and provide little increase in the resistance over time.

Setting Warning Levels

In Managing Motors, Richard Nailen, P.E., offers the following guidelines for interpreting PI and DA ratios. If the PI ratio is less than 2 or the DA ratio is less than 1.5, look for insulation degradation.

	Unacceptable	Acceptable
PI	1 to 1.5	2 to 4
DA	≤1.25	>1.50

IEEE recommends the following values for PI. Machines rated at 10,000 kVA and less should have values at least as large as the acceptable values listed below before operation or hi-pot testing.

	PI
Class A	1.5
Class B, F, H	2.0

Data Interpretation

Because the PI and DA values are ratios, temperature correction is unnecessary. PI and DA can be used for both on-the-spot, one-time checks and for trending over time. Individual readings can be compared to the recommended setpoints.

A good PI Profile (PIP) shows a sharp rise followed by a steady, but slowly increasing trend. A downward trend suggests deteriorating conditions. A flat or ragged trace indicates short-term current transients. Such traces indicate insulation breakdown, possibly due to contamination or moisture in the power circuit or asset. Observing the readings over time permits scheduling of cleaning or reconditioning before failure occurs.

If the PI or DA ratio is low, isolate the problem to the circuit or the asset. Assuming the first test was made at the MCC, run another test from the MCC with the “T” leads disconnected.

If the low value is gone, the problem is in the power circuit. If the low value still exists, test the asset at the asset connection box with the leads to the MCC disconnected. If the

low value is gone, the problem is in the cables between the asset and the MCC. If the low value still exists, the problem is in the asset.

Examine the cables in the asset connection box. They could require cleaning, drying, or replacement. Also, check for water in the conduit.

If the PI or DA ratio is < 1.0, look for a ground fault. Clear this fault before starting the asset.

Some exceptions to be aware of include:

- Moisture or contamination on the windings decreases the PI
- The PI can be lowered by certain semiconducting materials which are used for corona elimination on the end windings of some high-potential AC machines
- Performing PI testing in ambient temperatures less than the dew point may significantly impact the PI values

Examples

The following pictures show the response of the insulation in both a good (Figure 5-60) and a bad (Figure 5-61) asset, with a constant voltage applied for a 10 minute period. The increase in the RTG value is due to the decrease in current through the insulation.

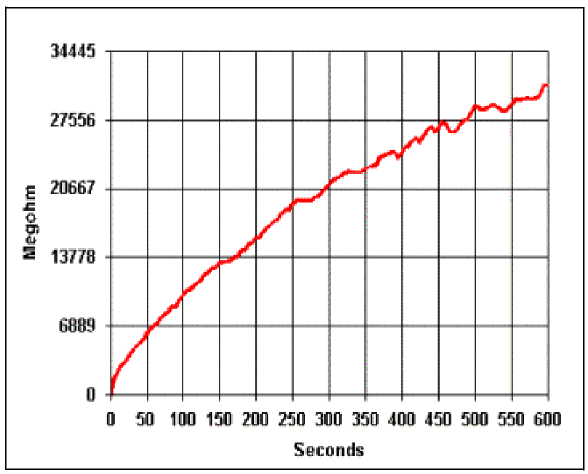


Figure 5-60: Asset with a Good PI

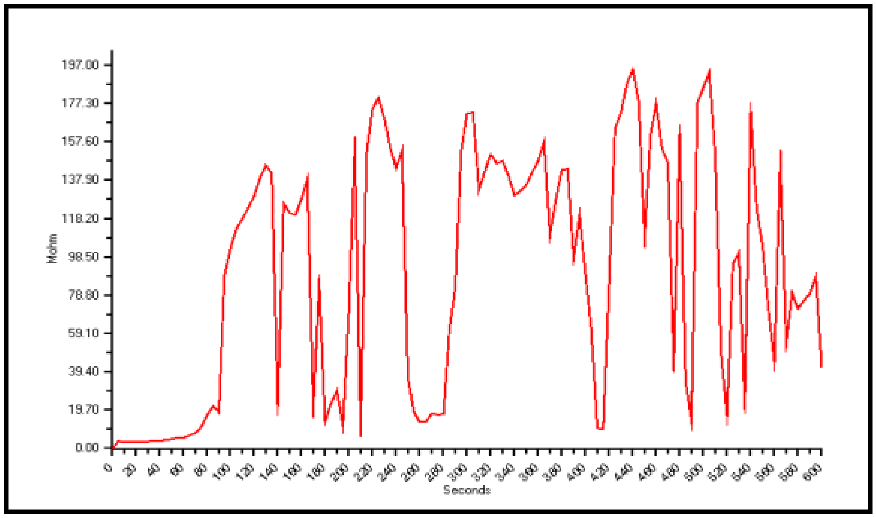


Figure 5-61: Asset With a Bad PI

The unstable RTG readings in the bad PI are a result of low level discharges occurring in faults in the insulation.

ROTOR INFLUENCE CHECK (RIC)

What Does It Tell You?

The Rotor Influence Check (RIC) is a graphical representation of the rotor/stator relationship. By analyzing variations in the magnetic flux while rotating the rotor, eccentricity and rotor defects are identified. The RIC can also be used to confirm stator faults. Figure 5-62 shows a RIC graph for a motor with no defects.

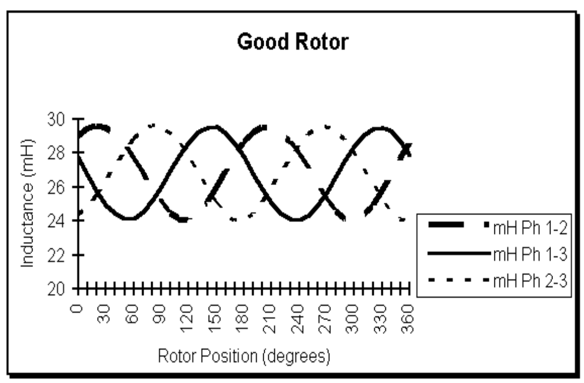


Figure 5-62: RIC from a Good Asset

A motor acts similar to an electromagnet. The rotor acts like the “core” and the stator acts like the windings of the electromagnet. A RIC shows how the rotor’s residual magnetism influences the stator inductance in different positions. As the magnetic field of the rotor interacts with more of the coils in each stator winding, the inductance of that winding changes. This influence causes repeatable patterns of change in the graph of the stator inductance, shown above as sinusoidal waveforms.

Why Is This Important?

Broken rotor bars can cause extreme heat and vibration, which can result in winding failure, bearing failure, and loss of torque in a motor. Eccentricity, a non-uniformity of the air gap between the rotor and stator, can cause excessive vibration, which can result in winding and bearing failure.

Rotor Position And Aliasing

Each RIC consists of a series of inductance measurements taken at predetermined positions of the rotor. The amount by which the rotor is moved for each measurement and the total rotation of the rotor for the test are determined by the number of poles in the asset. The increment and total rotation are calculated to show the RIC pattern for one complete pole group. If additional readings are taken beyond the total and at the same increments, the pattern should repeat itself. Table 5-12 shows the recommended increments and total rotation to cover one pole face for a asset with a given number of poles.

Table 5-12: RIC Degree Increments vs. Number of Poles

Poles	Increment	Total
2	10.0°	180°
4	5.0°	90°
6	3.3°	60°
8+	2.5°	45°

The number of increments and total rotation are automatically calculated by MCEGold, based on the entered nameplate data. You may reduce the increment and perform more tests to cover the recommended total rotation. Increasing the increments and performing fewer measurements than the default values is not recommended because doing this results in “aliasing.” Because not enough points are taken to reveal a true picture of the curve, aliasing produces an inaccurate and incomplete graph.

The following example shows how to determine the number of poles a asset has, the number of total degrees to turn the rotor, and the increments by which to turn it. Start with the basic equation:

$$F = \frac{NP}{120}$$

In the formula:

F = line frequency (60 Hertz in the US)
N = synchronous asset speed
P = number of poles in the asset
120 = 120 degrees of electrical spacing between poles

For a asset whose synchronous speed is 1800 rpm, use a variation of this equation to find the number of poles:

P = 120F/N
P = (120)x(60)/1800
P = 4 poles

Next, determine the number of degrees per pole face. To find this, divide 360 by the number of poles.

360/4 = 90 degrees per pole face.

Next, determine the increments, in degrees, by which to position the rotor to generate an accurate RIC pattern. To find this, divide the number of degrees per pole face by 18.

90/18 = 5 degrees.

Thus, the following would apply for a asset whose synchronous speed is 1800 rpm:

4 poles
90 degrees per pole face
5 degree increments per rotation to develop an accurate RIC

The increments were chosen since the RIC pattern typically repeats itself by the same number of poles in the asset through a complete 360° rotation of the rotor. Using these increments is recommended to increase consistency and reduce aliasing. Also, use the same increments and total rotation each time you perform a RIC. This ensures that the RIC is started and run the same way for each test. Doing this enables you to reliably compare the data and graph to subsequent tests for trending.

When the RIC is started, the MCE measures the resistance of each phase winding. At each increment the inductance of each winding pair is measured and recorded. Between measurements you are prompted to move the rotor to the next position.

Data Interpretation

Aliasing

Aliasing occurs when too few measurements are taken too far apart to show the true shape of the curve. The following figures show RICs which exhibit aliasing.

Figure 5-63 shows two waveforms of a good rotor in a 6-pole asset. The waveform with the connected circles was generated with measurements taken at the recommended interval of 3.3°. The waveform with the dashed lines was generated with measurements taken at 15° intervals. The waveform from measurements taken at 15° intervals shows a lack of definition.

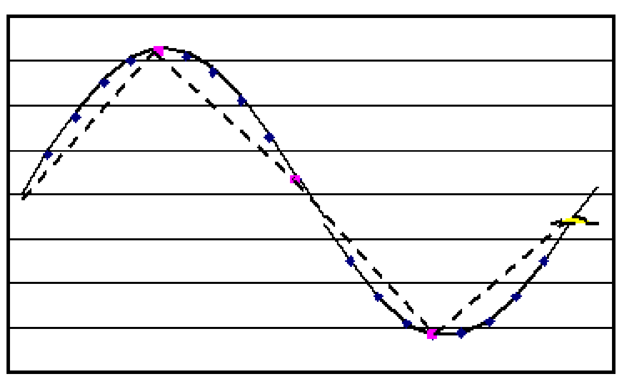


Figure 5-63: Aliasing

Figure 5-64 shows two waveforms taken on a asset which has known rotor faults. The presence of the fault is hidden when the measurements are taken at 15° increments (dashed waveform). When they were made at the recommended 3.3° increments (circles), the presence of the rotor fault is indicated by the flattened peaks. Note that the dashed waveforms shown in Figure 5-63 and 5-64 appear identical masking the true rotor conditions.

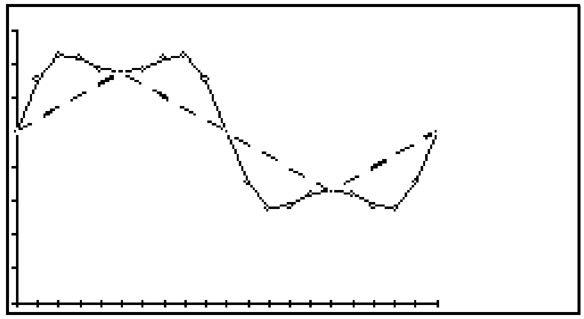


Figure 5-64: Aliasing

Good Asset

Figure 5-65 shows a RIC test for a typical AC induction asset with a good rotor. The three graphs resemble sine waves which are 120° out of phase with each other. The sinusoidal pattern is smooth and repeatable. The amplitude of the sine waves varies from asset to asset, due to factors specific to each asset, such as winding configuration, air gap, core steel quality, and rotor construction and design.

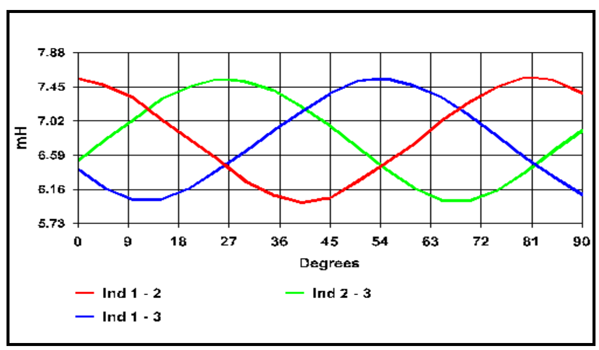


Figure 5-65: RIC from Good Asset

In some assets, the amplitude changes of the graphs are very small and may appear erratic. This erratic appearance may be due to measurement resolution steps, and not due to actual changes in inductance. This condition may indicate a low influence rotor with no rotor defects. One such low influence rotor is shown in the RIC graph in Figure 5-66.

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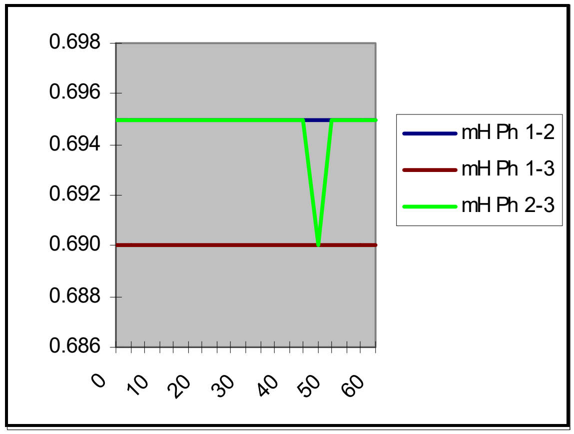

Figure 5-66: RIC from Asset with Low Influence Rotor

Eccentricity

Eccentricity is defined as the condition of the air gap between the rotor and stator, all the way around 360° of the asset. This gap should be the same width all the way around. If the rotor is bowed, the bearing clearances improperly set, or the end bell not aligned properly, the air gap will not be equal. An unequal air gap produces a phase-to-phase inductance graph that is markedly higher at one end of the graph than at the other. This is shown in Figure 5-67.

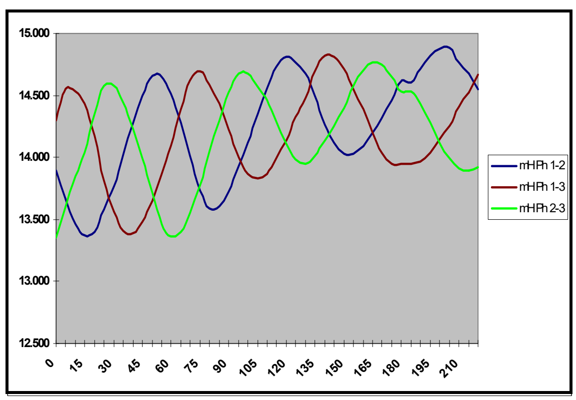

Figure 5-67: RIC from Asset with Eccentricity

If an eccentricity problem is suspected, continue performing the RIC to include at least two pole faces beyond the default increment setting. An exception to be aware of is when sleeve bearings are used in the asset. Due to their oil film, they can falsely indicate eccentricity problems since the rotor "settles" when the asset is not running.

Broken Rotor Bars

A rotor with broken bars produces graphs with anomalies in their wave shapes, such as flattened and staggered peaks.

Figure 5-68 shows a motor with ten broken rotor bars. These were found following a RIC. The flattening of the peaks in the phase-to-phase inductance graphs results from the influence of the broken bars. The irregularities in these traces are repeatable in each phase.

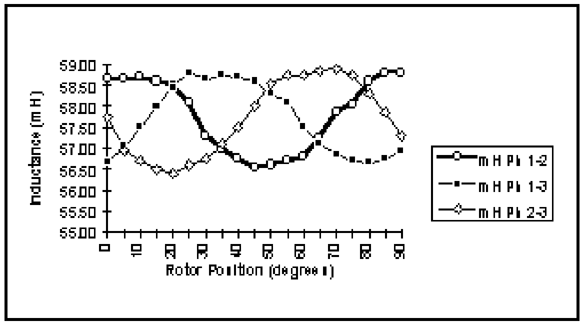

Figure 5-68: RIC from Motor with Broken Rotor Bars

Figure 5-69 shows a motor with cracked welded joints at the shorting rings. The cracked welded joints were found in 14 out of 122 rotor bars after a RIC was taken. The erratic pattern of flattened and staggered peaks points to the presence of the broken bars.

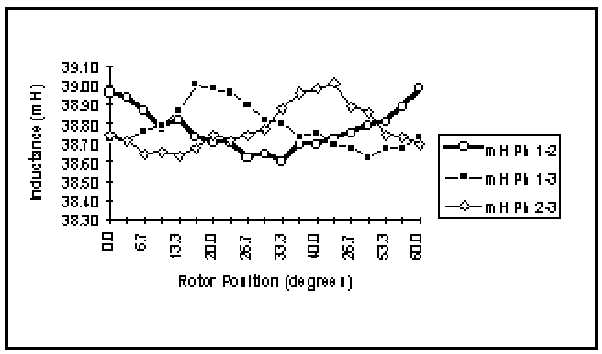

Figure 5-69: RIC from Motor with Broken Rotor Bars

Figure 5-70 shows the RIC test of a 480 volt 60 HP AC induction motor with broken rotor bars and a slight air gap problem. Note the flattened peaks in each phase-to-phase graph.

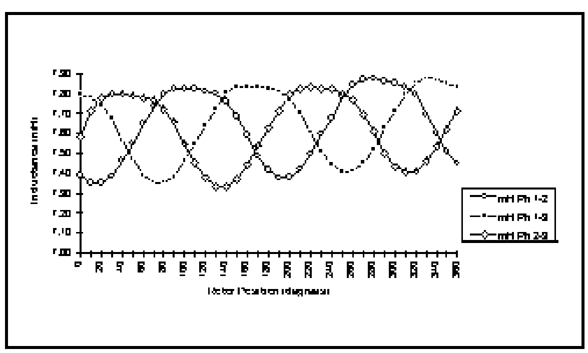

Figure 5-70: RIC from Motor with Broken Rotor Bars

Figure 5-71 shows the staggered peaks in a RIC for a 480 volt 5 HP motor. A rotor anomaly was determined to be the cause for these peaks. This was the result of a maintenance supervisor drilling a hole in one rotor bar as a demonstration.

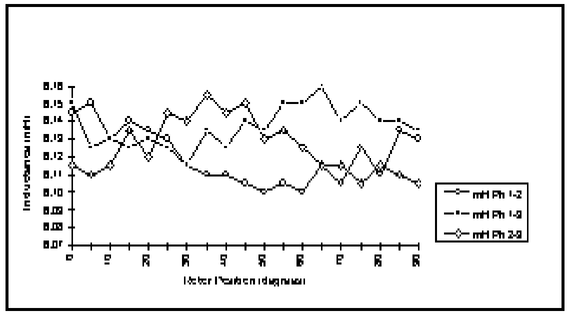

Figure 5-71: RIC from Motor with Broken Rotor Bars

One-Up/Two-Down and Two-Up/One-Down

Phase-to-phase or turn-to-turn stator winding shorts can result in either a one-up/two-down or two-up/one-down RIC pattern. This is shown in the graphs in Figure 5-72.

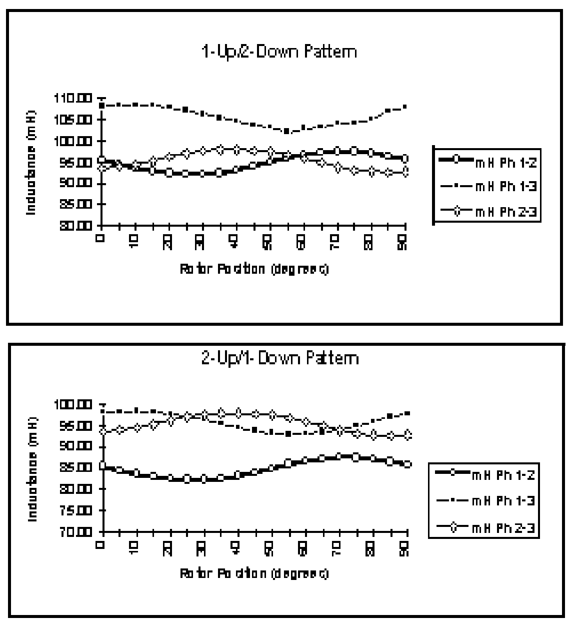

Figure 5-72: RIC from Motor with Phase-to-Phase or Turn-to-Turn Shorts

To assist in the analysis, compare the RIC with the phase-to-phase resistance readings on the standard test. If the same phases are affected resistively and inductively, this further confirms a winding defect. If resistance readings do not confirm this condition, evaluate the asset for eccentricity/air gap problems.

DC Bar-to-Bar Test

What Does It Tell You?

Testing the resistance between commutator bars gives an indication of the comparative value of resistance that exists between all like electrical circuits in an armature.

Why Is This Important?

The commutator consists of insulated segments assembled into a cylinder and held together by insulated rings. Electric current is transferred to the armature windings by "brushes" made mainly of carbon and graphite. Brush wear creates carbon dust, a conductive contaminant, which penetrates into crevices, cracks and openings of the armature. Copper particles add to the contaminant accumulation when the wrong brushes are installed or the brushes are improperly installed, or when maintenance is inadequate. If the insulating material on the commutator bars or their risers has cracked, these contaminants can short entire windings.

Also, high resistance connections can develop at the risers causing open or high-resistance armature coils. Equalizing connections can break and cause an imbalance due to the loss of equalization.

Data Interpretation

The resistance readings between bars are in the microhm range for medium to large machines. Most DC assets of this size have armatures constructed with equalizing jumpers or compensating shorting connections. The effect of these connections on the Bar-to-Bar test results shows as a regular pattern of change from bar to bar. Good bars have 1 or 2 different values. If a bar differs greatly from either of these 2 values then look for faults.

Armatures with 50% compensation have every other bar equalized; with 33% compensation have every 3rd bar equalized; with 25% compensation have every 4th bar equalized.

MCE ANALYSIS

AC Induction Assets

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - repeatable erratic inductance throughout the peaks of the waveforms
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity sometimes causes a consistent separation in the three sine waves, coupled with a low inductive imbalance.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase) or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA in Caution or Alarm indicates changing or excessive surface contamination.
- Breakdown of insulation system.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

AC Synchronous Assets

Stator

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - appears like a normal sine wave but has a larger than normal inductive imbalance
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity can sometimes cause a consistent separation in the three sine waves.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.

- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase), circuit defect (cable short or power factor correction capacitor failure), or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information on the rotor condition.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio- PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Field Circuit

Synchronous Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - Resistance in Caution or Alarm indicates a high or low resistance of the field windings.

  NOTE: The Caution and Alarm limits are set based on nameplate field voltage and current values at normal operating temperature of the asset. Testing on a cold asset may indicate values outside the Caution and Alarm settings.

- Low Inductance - Low Inductance in Caution or Alarm indicates turn-to-turn faults in the field coils.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

AC Wound Rotor Assets

Stator

Rotor Influence Check (RIC)

- Normal - smooth three-phase sinusoidal waveforms
- Rotor Defect - appears like a normal sine wave but has a larger than normal inductive imbalance
- Eccentricity - inconsistent variations in the amplitude of the waveforms. Static eccentricity can sometimes cause a consistent separation in the three sine waves, coupled with a low inductive imbalance.

One method of analyzing a RIC is done by following four steps, outlined by the acronym SAME.

- S - look at the *scale*; verify correct resolution
- A - check the *alignment* of the peaks; check for eccentricity
- M - check the *max-to-min* values of the peaks; all three waveforms should be the same; check for stator problems
- E - *evaluate* the characteristics of the waveforms

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection in the switchgear, disconnect, or asset connection box. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase) or severe eccentricity. Refer to the individual phase-to-phase inductance readings to assist in locating the fault. If a RIC has not been performed, perform a RIC to obtain additional information.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Rotor

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red for recommended actions.

- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection on the slip ring or winding connections. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.
- High Inductive Imbalance - Inductive Imbalance in Caution or Alarm indicates a winding defect (turn-to-turn or phase-to-phase). Refer to the individual phase-to-phase inductance readings to assist in locating the fault.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

Resistor Bank

Resistor Bank

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High Resistive Imbalance - Resistive Imbalance in Caution or Alarm indicates high resistance connection between the resistors or a faulty resistor. Refer to the individual phase-to-phase resistance readings to assist in locating the fault.

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.

Step Voltage

- If the plot of the curve of current versus voltage deviates from near linear, impending breakdown is suggested.

DC Assets

Armature Circuit

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - values in Caution or Alarm indicate high resistance connection in the switchgear, disconnect, or asset connection box. This can also indicate improper brush wear/seating or a poor commutator film.
- High/Low Inductance - values in Caution or Alarm indicate a winding defect (turn-to-turn or coil-to-coil).

Polarization Index/Dielectric Absorption

- Low PI or DA ratio - PI or DA ratio in Caution or Alarm indicates changing or excessive surface contamination.

Bar-to-Bar

- High/Low Resistance - values significantly above or below the average resistance reading indicate an open or a short in the armature winding or commutator segments.

Field Circuit

Standard Test

- In the Fault Zone Report, check for Caution and Alarm indications. Click the value highlighted in yellow or red to see the recommended actions.
- Low Resistance-to-Ground - RTG in Caution or Alarm indicates a possible breakdown in the insulation system.
- High Capacitance-to-Ground - CTG in Caution or Alarm indicates an increase in the contamination on the surface of the insulation.
- High/Low Resistance - values in Caution or Alarm indicate a high resistance connection in the switchgear, disconnect, or asset connection box.
- High/Low Inductance - values in Caution or Alarm indicate a winding defect (turn-to-turn or coil-to-coil).

Polarization Index/Dielectric Absorption

- Low PI or DA Ratio - PI or DA Ratio in Caution or Alarm indicates changing or excessive surface contamination.

At this point, a Condition Code may be assigned and Notes completed to explain the following:

- Asset condition/status; basis for the asset condition assigned.
- Anomalies that had to be overcome during the performance of the test.
- If multiple tests were performed during troubleshooting, explain where test leads were connected for each test.