ZGS-15000-3
Magnetic Wire Rope Inspection System (MagSens™)
NSN# 3950-01-580-1775

Operation and Maintenance Manual
United States Patent # 7,429,031 B1

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DEFINITIONS OF WARNINGS, CAUTIONS and NOTES contained in this manual

WARNING

Shall be used when there is danger of injury or death to personnel

CAUTION

Shall be used when there is danger of damage to equipment

NOTE

Shall be used to highlight essential procedures or statements which may facilitate performance of a procedure or operation.

Table 1 - Warning and Caution Symbols used through the manual.

	Warning		Warning Electrical Hazard
	Warning Hot Surface Burn Hazard		Warning Lifting Hazard
	Warning Moving Parts		Warning Strong Magnetic Field
	Must Wear Eye Protection		Must Wear Hand Protection
	Switch Off Before Operating		

Safety Precautions

Before operation of the Rescue Hoist Ground Support Equipment (RHGSE) and the Magnetic Wire Rope Inspection System (MagSens™) , thoroughly review the entire manual to prevent damage to the cable, hoist, helicopter, or operator.

WARNING

Never operate the RHGSE with loose clothing, jewelry, ties, long hair, or anything that may become entangled.

CAUTION

Always observe the rescue hoist cable and be prepared to stop at any time.

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Members Only Website

Visit our Members Only site that is accessible via Zephyr International's website at http://www.zephyrintl.com. Select the "Members Only" link at the top right of the website or go directly to http://members.zephyrintl.com/. Once there, select "Sign Up" and create a user name and password. It is a very simply process and there are no costs involved.
Once logged in, go to "Product Info" and select "Hydraulic RHGSE". Through the Members Only website, customers have access to training videos, training presentations, service bulletins, a spare parts list, quick start guides and the latest manual revision. The training videos can help with recurring training. This portion of the website was just launched for you to benefit from and to be used as a valuable resource.

Product Support for Zephyr RHGSE
To ensure that we can contact you in case of any updates to the manual, service bulletins and/or updated information, it's highly recommend that you register your RHGSE with us, the serial number on the Hydraulic RHGSE is located on the control box. Please email us at info@zephyrintl.com the following information, or you can fax it to us 1-843-365-2677.

NOTE

We would appreciate your feedback so that we may continue to improve upon the website, our equipment, and our customer support.

Zephyr RHGSE Model(s) ____________________

RHGSE Serial Number(s) of the ____________________

Organization Name: ____________________

Organization Address: ____________________

POC Name for receiving information on your Zephyr ____________________

POC Email to send information to ____________________

POC telephone ____________________

Date the RHGSE was received ____________________

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1.0 Purpose

To provide Operation Instructions for the ZGS-15000-3 when installed on any model of the Zephyr Rescue Hoist Ground Support Equipment (RHGSE) and provide guidance for interpreting the output signal of the MagSens™.

- The MagSens detects indications of internal and external anomalies, that when correlated with the results of a visual inspection and upon consideration of the cables history, allow the rescue hoist maintainer to determine if the cable should remain in service until the next inspection.
- The MagSens allows fast and efficient isolation of internal and external indications. This reduces the time and manpower required to perform rescue hoist maintenance.
- The MagSens provides objective documentation of the condition of the cable and the date and time the test was performed.
- The MagSens provides a method to move off of the zero indications policy in use today and scientifically track the deterioration of the cable until replacement is required.

2.0 Power

The MagSens uses a 12 volt battery to provide power. The ZGS-15000-3 system has been designed to allow the user the ability to recharge the battery using a 120 / 240 50 / 60 Hz VAC source.

The system includes a battery voltage monitor that illuminates when the power switch is on. The voltage monitor includes an LED to indicate the charge of the battery. When the LED is green then the battery is above 12 volts, when the LED turns Amber or Red the battery is low, when the LED flashes red then the system should be charged prior to or during use.

When the MagSens is not in use, optimum battery life will be obtained by keeping the AC power inlet plugged in when in storage.

3.0 Background

Magnetic Flux Leakage inspection has been used for over 50 years for the purpose of cable inspection in deep mines and in the offshore oil industry. The MagSens has been adapted from this technology for the purpose of augmenting visual inspection and providing an increased level of safety and cost effectiveness for rescue hoist maintainers. Magnetic flux leakage inspection is particularly effective when combined with visual examinations and a thorough understanding of the rescue hoist cable deterioration modes.

4.0 Operating Principle

The MagSens uses Magnetic Flux Leakage to locate indications in the cable. The device uses strong permanent magnets to create a magnetic flux circuit and Hall Effect sensors mounted to magnetic flux concentrators detect variations in the magnetic flux circuit that result from local faults (LF) or loss of magnetic area (LMA). The variations or anomalies show up as signals that are recorded and displayed on the laptop computer mounted inside the standalone.
The MagSens signal characteristics are suggestive of the cable indication characteristics. However the indications, or the spike size and shape, may be similar for different types of indications. Pattern recognition is important when determining a defect within the cable. A similar pattern on both extend and retract will eliminate the possiblity of an anomaly produced by EMI. This will allow users to further investigate the section of the cable where a pattern has been recognized. Using the MagSens along with a visual examination and knowledge of the history of the cable provides the users the ability to determine when the cable should be replaced.

4.1 Basic Concepts

- **<u>Magnetic Flux</u>** -Term used to describe the total amount of magnetic field in a given region. The term *flux* was chosen because the power of a magnet flows out of the magnet at one pole and returns to the other pole in a circulating pattern. These patterns are called lines of induction. The lines of induction originate on the north pole of the magnet and end on the south pole; their direction at any point is the

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direction of the magnetic field, and their density (the number of lines passing through a unit area) gives the strength of the field. Near the poles where the lines converge, the field and the force it produces are large; away from the poles where the lines diverge, the field and force are progressively weaker.

- **Flux Leakage** - A distortion of the magnetic flux that has been introduced into a wire by a permanent magnet. Flux leakage is used to detect wire indications since flux leakage is caused by changes in the thickness of the wires (LMA) and by pits and holes or tears (LF) in the surface of the individual wires. Flux leakage distorts the magnetic-flux lines and induces a signal into the Hall Effects sensors.

- **Hall Effect Sensors** - Are devices that generate a voltage based upon the strength of the magnetic field that they are placed in. Digital Hall effect sensors provide a digital signal that is proportional to the magnetic field that they are placed in. The variation the in the flux leakage is detected by Hall Effect sensors and the signal is amplified and conditioned for use in the MagSens circuitry, then stored and displayed on a laptop computer.

- **LMA** - Loss of Metallic Area(LMA) indicates loss of cross sectional area due to external or internal corrosion, external wear due to abrasion, nicking, high pressures or poor lubrication.

- **LF** - Local Fault(LF) indicates a wide variety of external and internal discontinuities such as broken wires, corrosion pitting, internal strand nicking and abrasion, and welds of individual wires.

- **Paramagnetic Behavior of Cold Worked 302 / 304 Stainless Steel** - 302 /304 Stainless Steel is non-magnetic when annealed, however the act of cold working gives it great strength and imparts magnetic properties in the hardened condition. In a rescue hoist cable cold work is imparted to the wires as they are drawn through dies to form the individual wires. The wires are pulled through many dies in order to reduce the wire size from about ¼ inch to .015 inches, and they are also preformed imparting additional cold work. This means that the individual wires are quite magnetic. This is also the basic reason the MagSens can detect many different types of indications in individual wires. Individual wire softening due to any cause can be detected.

4.2 Limitations

A magnetic flux leakage indication is a function of the size and type of indication in the wires of the cable, and the flux leakage is proportional to the size of the surface breaking indications or softening in individual wires. Surface breaking conditions on individual wires produce large variations in the magnetic flux leakage while indications such as cracks produce small variations in the magnetic flux leakage. Internal crushing and abrasion can produce heat and thus softening and indications that appear as large or larger then the more expected indications such as broken wires. Broken wires that are not separated produce almost no variation in the magnetic flux leakage until they are physically separated. Stress or load is known to impact flux leakage by separating the surface indications.

The MagSens when used in conjunction with the Zephyr RHGSE measures magnetic flux leakage with the cable under stress and allows the easy isolation of the indication for a subsequent visual inspection.
Since the Rescue Hoist Manufacturers have adopted a zero defect policy based on the relatively low static safety factors, and considering the possibility of high dynamic loads that can not be predicted in advance, the Local Fault indications are the first warning to determine if a cable is ready for replacement.
As a result of the introduction of the MagSens into service many brand new wires have been discovered with welds in them. If a welded wire is present in a cable and no other factors are considered, there is the possibility for premature cable replacement. *Therefore careful study of this interpretation guide is important to prevent unnecessary warranty claims.* Welds are not rejectable.

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4.3 Welded Wires

According to one cable manufacturer it is possible that welded wires are in strands used to form individual cable assemblies. The weld is a soft section of the wire due to the high temperature annealing welding produces. Therefore it is possible to get a large spike from a weld on a new cable. If no visual indications are noted then the cable assembly can be used as is and the size of the weld indication monitored over the life of the cable assembly.

Comments on welded wire indications. Depending on the post treatment of the weld and the environmental conditions the cable is subjected to, the welded area may start to corrode as a result of carbide precipitation due to the heating process. The localized corrosion then leads to loss of cable strength.Therefore the weld indication should be monitored closely over time to determine if it is increasing, and a visual inspection should be performed to identify any external signs of corrosion such as staining.

5.0 Installed Software

The MagSens system can be supplied as an integral part of any of the RHGSE supplied by Zephyr or can be supplied individually, to be used with a previously purchased Zephyr RHGSE.

The system uses National Instruments Measurement and Automation Software and the MagSens Software. The software is initially installed on the supplied laptop.

6.0 MagSens™ System Description

The ZGS-15000-3 is supplied in a Pelican case and includes the MagSens head, laptop, AC input power cord, and the MagSens head cable.

Figure 1 MagSens System

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7.0 Components Description

7.1 Magnetic Sensor Head (MagSens Head)

The magnetic sensor head includes four powerful Neodymium magnets that are arranged in a magnetic circuit that is completed by two flux bars and four LMA pole pieces as shown below. The magnetic circuit is a magnetic flux path. If there is a disruption in the magnetic flux path the Local Fault cage concentrates the distortion such that the Hall Effect sensors can detect it. The Hall Effect sensors then emit a small voltage that is amplified and conditioned by the electronics board for use by the converter in the DaqPad.

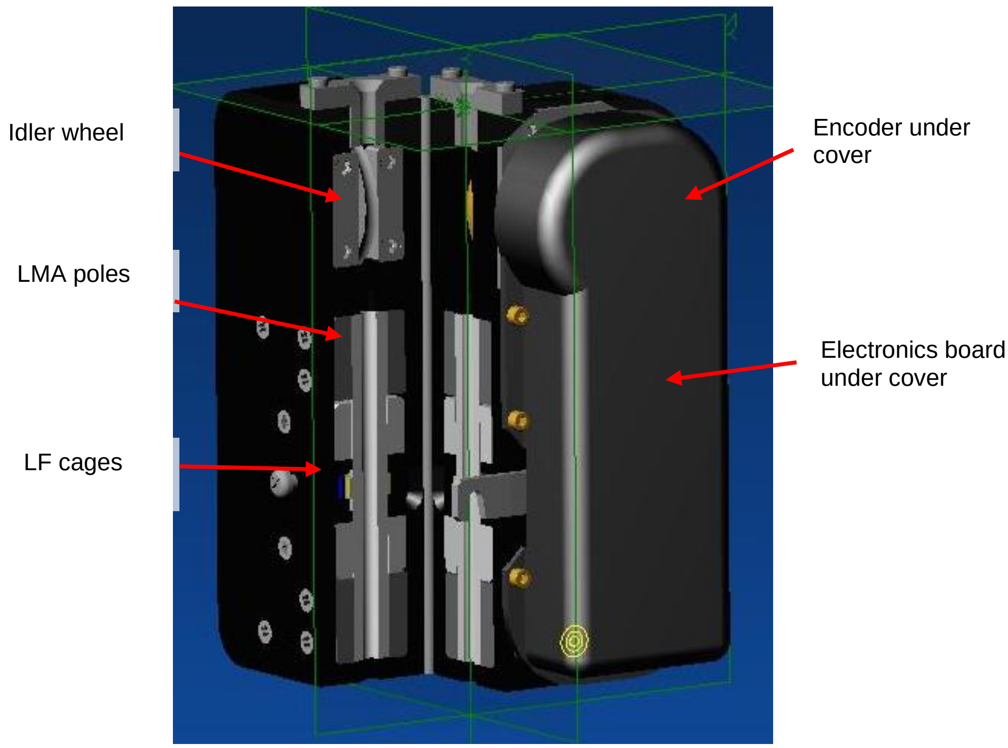

Figure 2 Magnetic Sensor Head

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7.2 The cross section of the MagSens head

The main function of the MagSens TM is the detection of local faults (LF), the secondary function is to display the LMA signal.

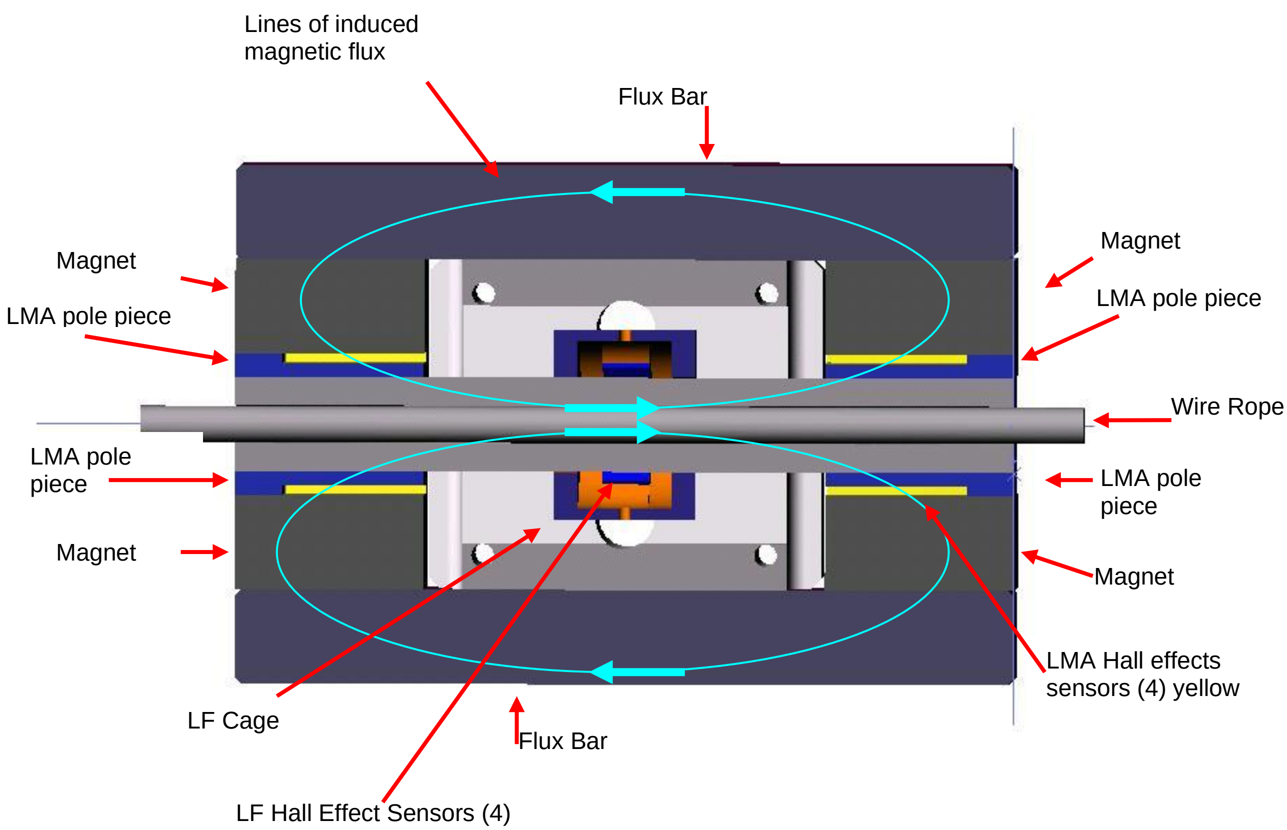

Figure 3 MagSens cross section

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7.3 The cross section of the LF Cage Assembly when closed

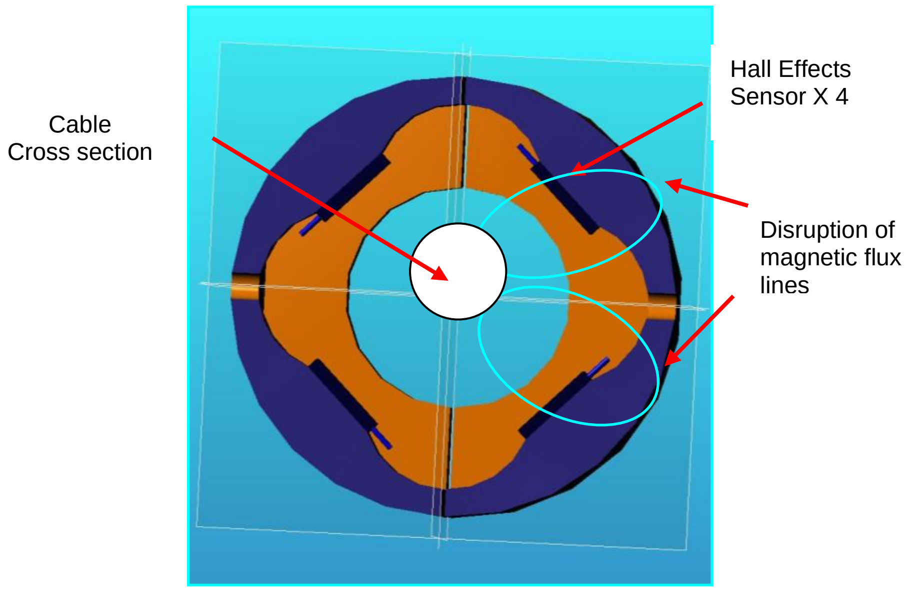

Figure 4 LF Cage cross section

By using four Hall effect sensors, arranged as shown above, the LF cage assembly is extremely sensitive to small discontinuities in the magnetic flux field in three planes.

As the local fault passes through the LF cage it sets up a north and a south pole disruption in the magnetic flux field. The Hall Effect sensor then emits a voltage variation that is proportional to the size of the indication.

However this effect is only qualitative in nature and not quantitative, i.e. we know something is there, but not exactly what it is. Therefore the system requires a visual inspection of the area in question and it is helpful to have knowledge of the cables life history.

The main point is the MagSens can detect flaws in a matter of minutes and then track them throughout the installed life of the cable.

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8.0 Test Settings

8.1 New Test Setup

Step 1 Open MagWin program on supplied laptop.

Step 2 From the **Start** dialog box, select the **Cancel** button.

Step 3 At the top toolbar, select the **Set Up** menu item.

NOTE

When the Set Up menu expands, you will see many options. Because the MagSens has been adapted to the rescue hoist inspection task, there are many setup options that you will not need and others that should not be changed. The only setup information that should be changed from time to time may be found by selecting the **New Test** menu item.

Step 4 Click **New Test** from the **Set Up** menu. The **New Test Setup** dialog box will open.

NOTE

The MagSens system can automatically generate test names, if the Automatically Generate Test Name option is selected. You may specify a combination of the month, date, year, and test number for automatically naming the files.

Step 5 If desired, Change the *Automatically Generated Test Names* that are used.

NOTE

Once the next test number is specified, the MagSens program will automatically increment the test data file name by one for each test performed.

Step 6 If desired, Modify the **Next Test Number** value.

NOTE

Test information is set to be saved in the default "MagSens Data" folder in "My Documents". If you prefer to send the data to a different folder, you can uncheck the **Always Use Last Test Folder** option and then specify where the next data file should be stored.

Step 7 Select or unselect the **Always Use Last Test Folder** option in the *Test Folder* section, as desired.

Step 8 Change the Tests Default Folder, if desired.

Step 9 Select desired Units to be used in the *Test Parameters* section. The choices are Metric or Imperial.

Step 10 Click the **OK** button.

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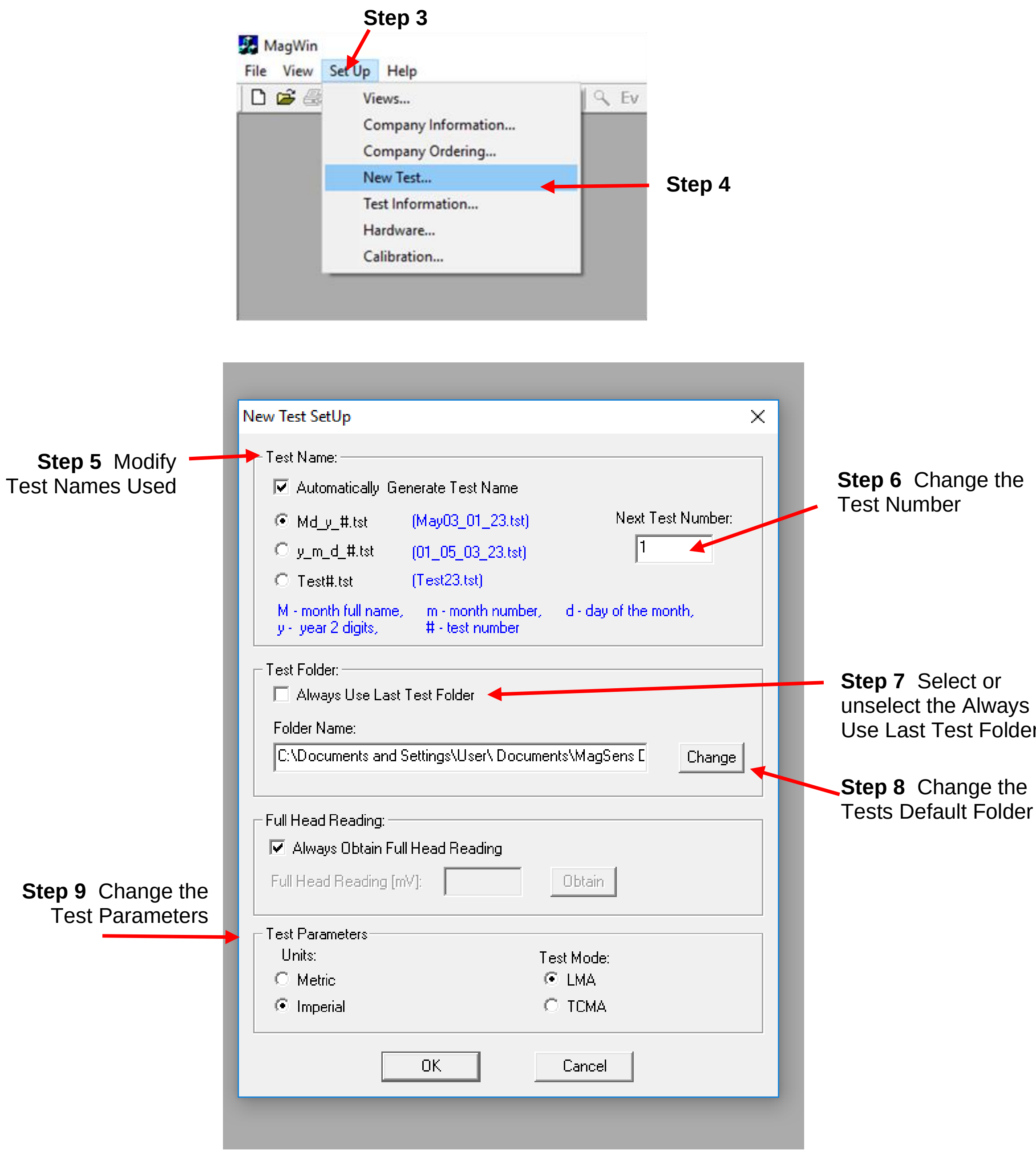

Figure 5 New Test Setup

8.2 Set Scale for Viewing

NOTE

The LF Scale is shown on the left side of the graph, and is measured in volts (V).

Step 1 While test is open, Right-click on the data screen.

Step 2 Select **Scale – Select**. The **Enter New LF Scale** dialog box should open.

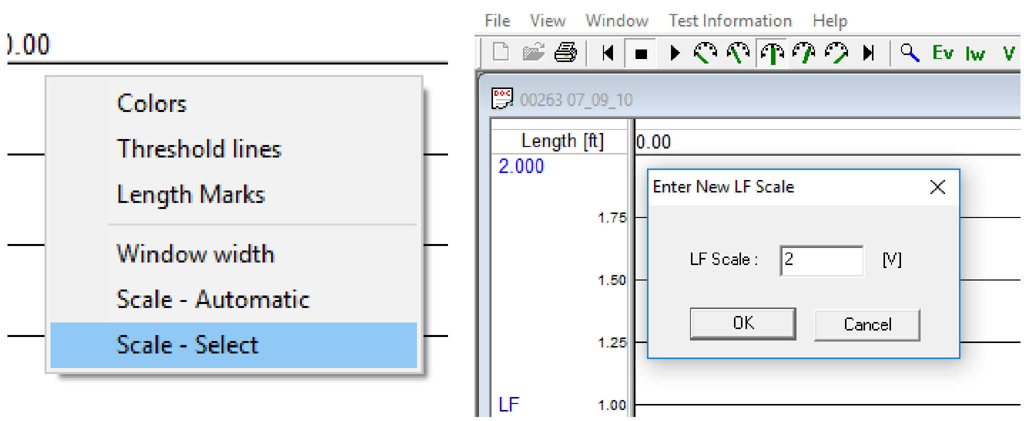

Figure 6 Scale Select

NOTE

The scale can be set from 0.1V up to 5V, but the recommended value is 2V.

Step 3 Enter a value in the **LF Scale** field.

Step 4 Click the **OK** button.

8.3 Adjust the Window Width

NOTE

The Window Width is shown on the scale at the top of the graph and is measured in feet (ft.) or meters (m).

Step 1 With test open, Right click on the screen.

Step 2 Select **Window width**. The **Window Width** dialog box will open.

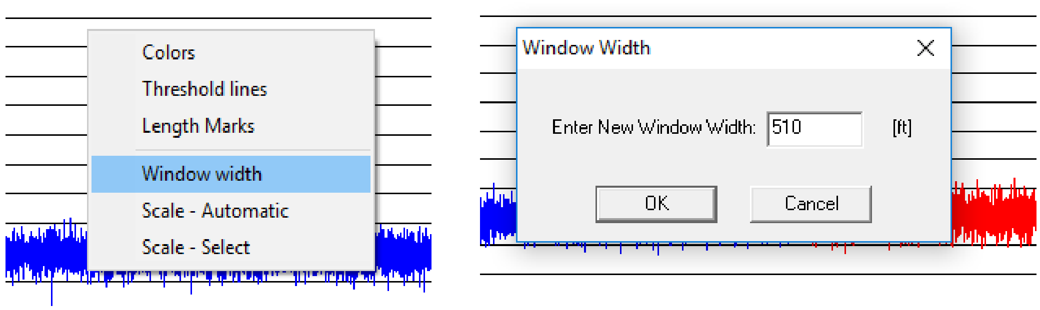

Figure 7 Window Width

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8.4 Modify Threshold Lines

Right-click on the graph and select **Threshold lines**. The **Enter Threshold lines** dialog box will open.

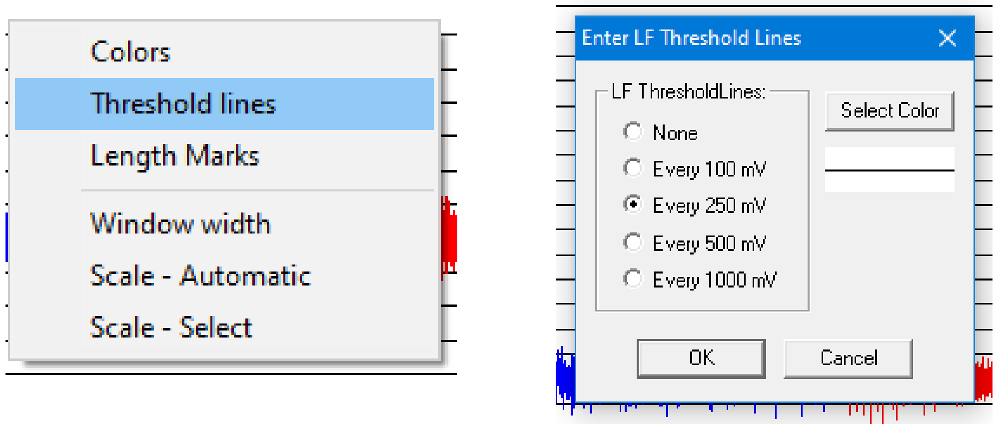

Figure 8 Threshold Lines

NOTE

The preferred setting for the threshold lines is 250 mV, although they may be set to any value allowable by the selection box.

Step 1 Choose value for Threshold lines.

Step 2 Click the OK button.

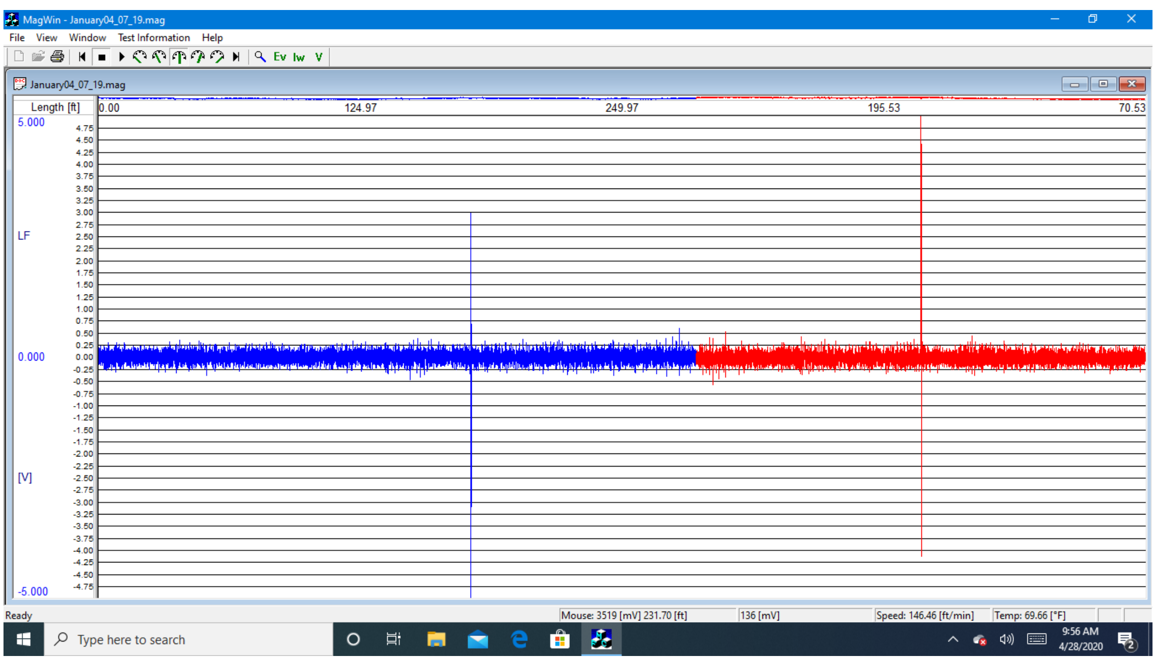

Figure 9 View of Threshold lines

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8.5 Zoom In on an Indication

NOTE

The Zoom feature is only available after a test has been ran, saved, and reopened.

Step 1 Click on the **Start Zoom** (magnifying glass icon) option in the toolbar at the top of the screen.

Step 2 Click, hold, and drag to form a box around the indication to Zoom In. Another window should open with the zoomed in image.

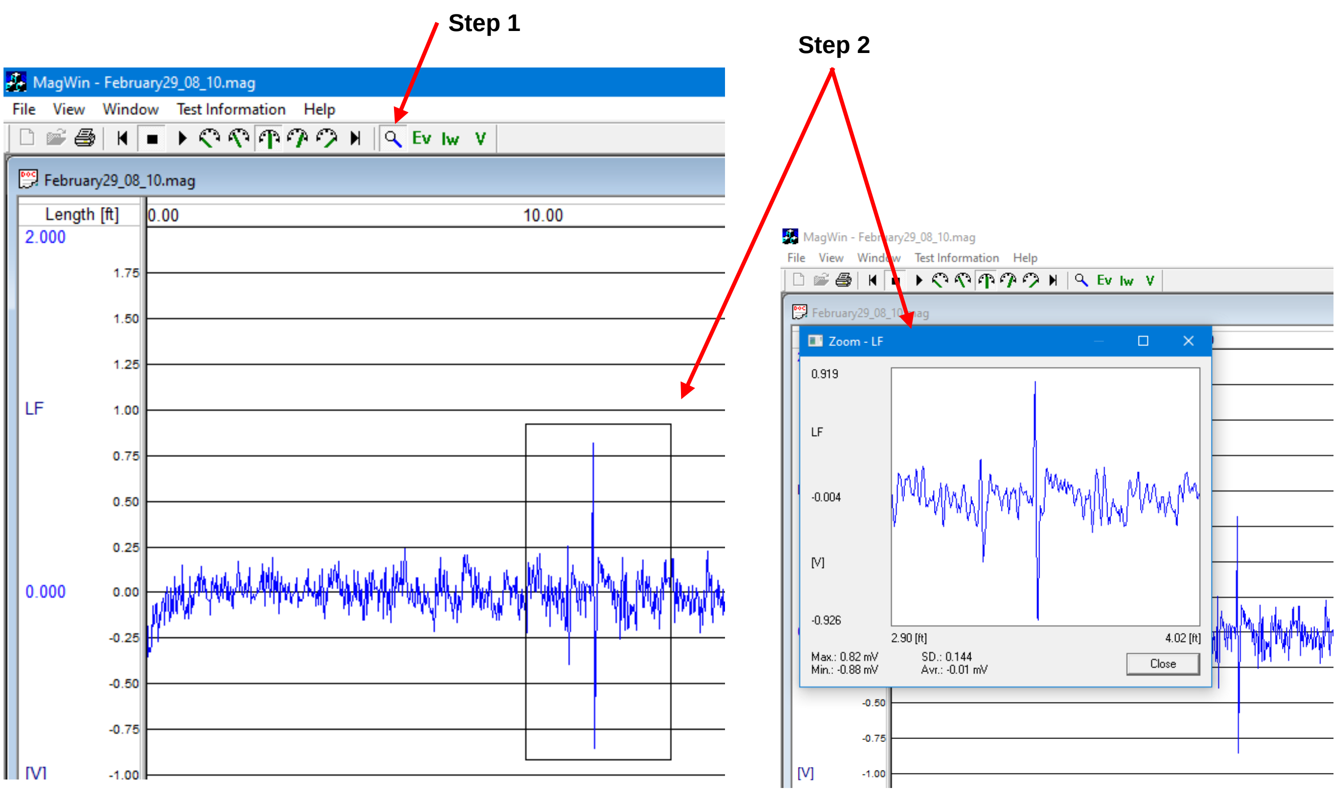

Figure 10 Zoom In on an Indication

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8.6 Mark an Event

Step 1 Click the **Ev** option in the toolbar menu

Step 2 Enter text for event. For example, “Two Broken Wires.”

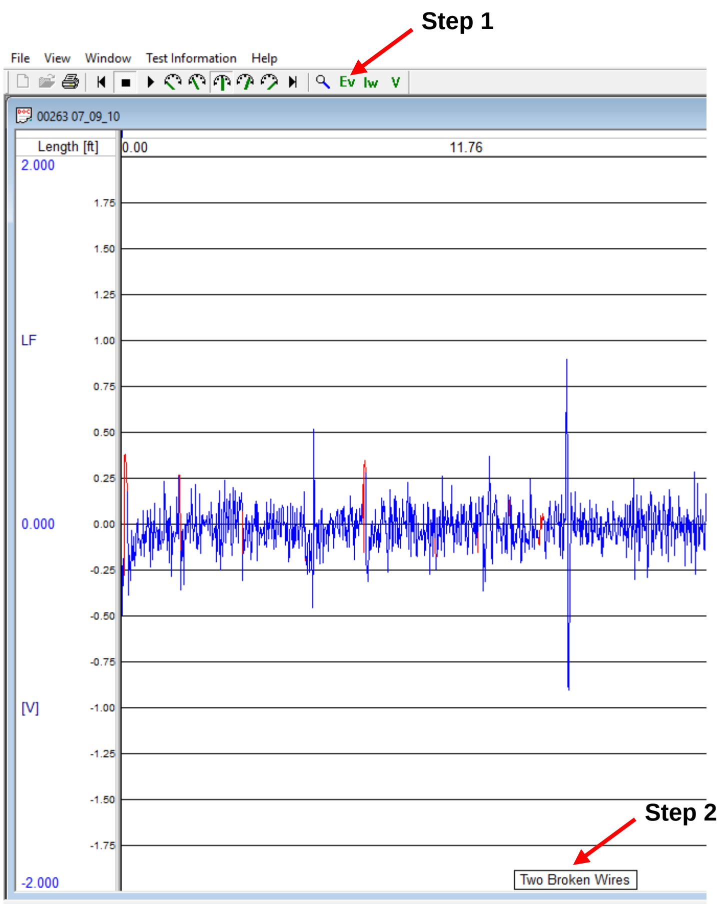

Figure 11 Mark an Event

9.0 MagSens Operating Procedure

CAUTION

The MagSens Head contains strong permanent magnets. Do not place it near credit cards or any object with a magnetic strip as the strong magnetic field will erase any data on these devices.

Failure to properly ground the helicopter may result in erroneous data or static electrical discharge.

Do not install a separate ground to the RHGSE or MagSens, the ground is through the rescue hoist cable.

NOTE

The MagSens output can be affected by the movement of a metallic object in close proximity to the MagSens Head.

The MagSens output must be interpreted by a trained person.

9.1 Start a New Test

Step 1 Attach the upper upright bracket extension ZGS-10245-1, if not installed.

Step 2 Attach the MagSens Head to the upper upright bracket extension of the RHGSE with two supplied 5/16 thumbscrews.

Figure 12 Upper Upright Bracket

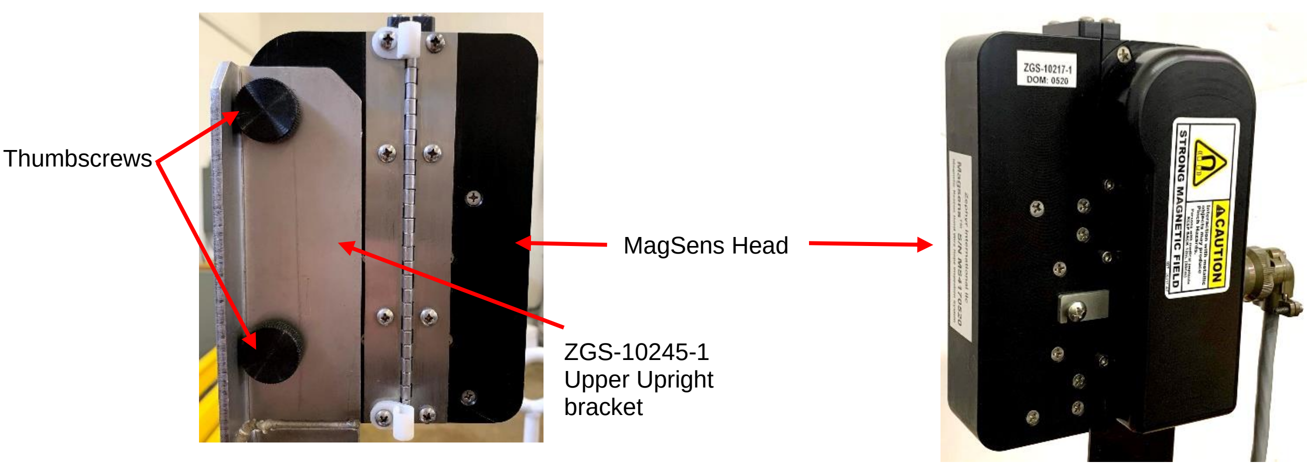

Figure 13 MagSens head

CAUTION

Ensure the MagSens cable is connected prior to turning MagSens Head power on.

Step 3 Attach the 10ft MagSens cable between the MagSens Head connector and the MagSens standalone connector.

Figure 14 Attaching MagSens Cable

Step 4 Turn on the MagSens laptop and let it boot up.

Figure 15 Power On Standalone

Step 5 Turn on power to the MagSens Head.

NOTE

The blinking lights should go out and become a steady green, or amber. If light is blinking red, the battery needs to be charged.

When not in use, keep battery plugged in using the AC Input provided in the pelican case to keep the MagSens system charged and ready for use.

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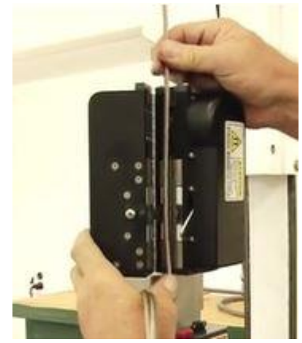

CAUTION

Because of the strong magnetics used in the MagSens Head, the cover may spring open when unlatched. Care should be taken not to let this happen. When the cover springs open, it can damage the MagSens Head.

NOTE

When opening the MagSens cover, it is recommended to hold the cover with the left hand while the right hand unhooks the latch.

Step 6 Open the MagSens Cover.

Step 7 Insert the cable into the MagSens Head.

Step 8 Close and latch the MagSens Head.

NOTE

Refer to the RHGSE Operating Manual to insert the cable before running a new test.

Step 9 Thread the Cable Through the RHGSE Components.

Step 10 Click on the **MagWin** shortcut.

NOTE

When you first start the MagSens program you will see the startup screen with the Zephyr International LLC logo.

Step 11 Click anywhere on the Start Up screen. The **Start** dialog box will open.

Figure 16 MagWin startup screen

Step 12 Make a choice to proceed.

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a. To start a new test, proceed to step 13.

b. To view and compare previously collected test data, proceed to Section 9.3.

Step 13 Click on the **Start New Test** button.

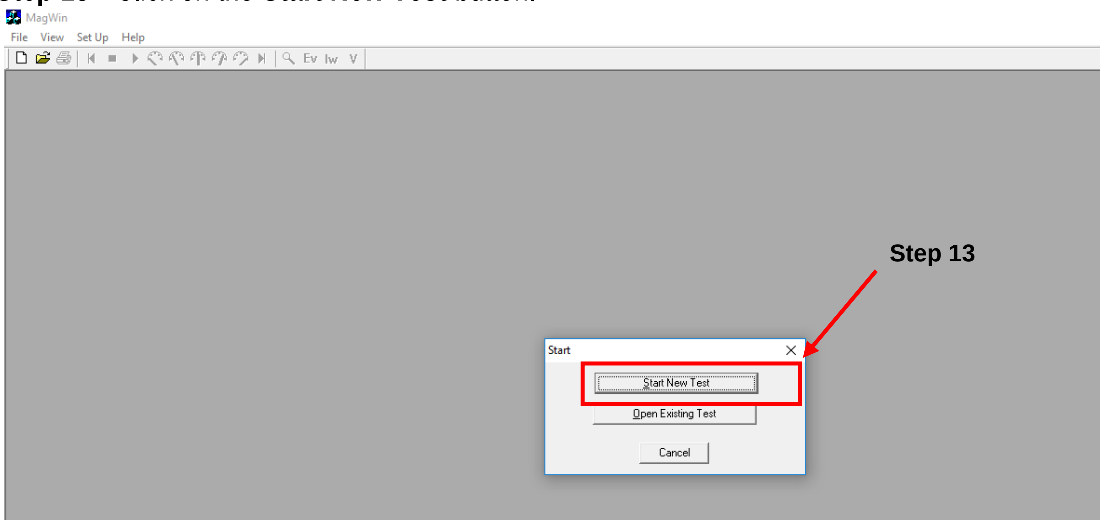

Figure 17 Start New Test

NOTE

When you start a new test, the **Magnograph Windows** dialog box with a **Start New Test** tab will open.

In the *Initial Parameters* information, there will be a red dot to the right of the **MA Full Head** field. This indicates that a Full Head Reading is required.

Step 14 Click on the **Obtain** button. The **Obtain Full Head Reading** dialog box will open.

Step 15 Click on the **Obtain** button. The value for **Full Head Reading** will be shown.

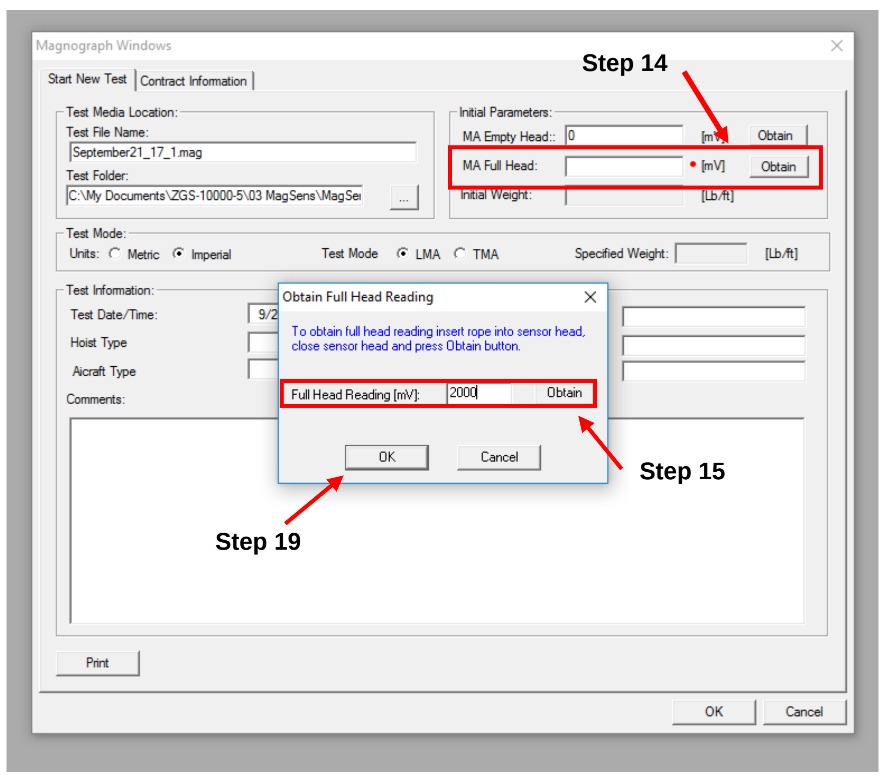

Figure 18 Obtain Full Head Reading

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NOTE

The Full Head Reading should be 2000 mV, within +/- 100 mV. The Zero Adjust potentiometer on the control panel is used to adjust this value.

Turning the zero adjust clockwise adds positive value to number while counter clockwise adds negative value to the number.

The Zero Adjust potentiometer is very sensitive, Use small incremental adjustments until the desired value is achieved.

Step 16 If **Full Head Reading** is < 1900 mV or > than 2100 mV, use the Zero Adjust potentiometer on the control panel to adjust the reading of the MagSens Head.

Step 17 Click the **Obtain** button.

Step 18 Repeats Steps 15 and 16 until the **Full Head Reading** is within the desired limits.

Step 19 Click on the **OK** button. The **Magnograph Windows** dialog box will open with the **MA Full Head** value populated.

NOTE

The *Test Information* section provides a way to track each cable individually, in the event that multiple aircrafts and multiple hoists are being monitored with the MagSens system. The following fields are provided: Test Date/Time., Hoist Type, Aircraft Type, Technician, Hoist S/N, Aircraft Tail # and Comments.

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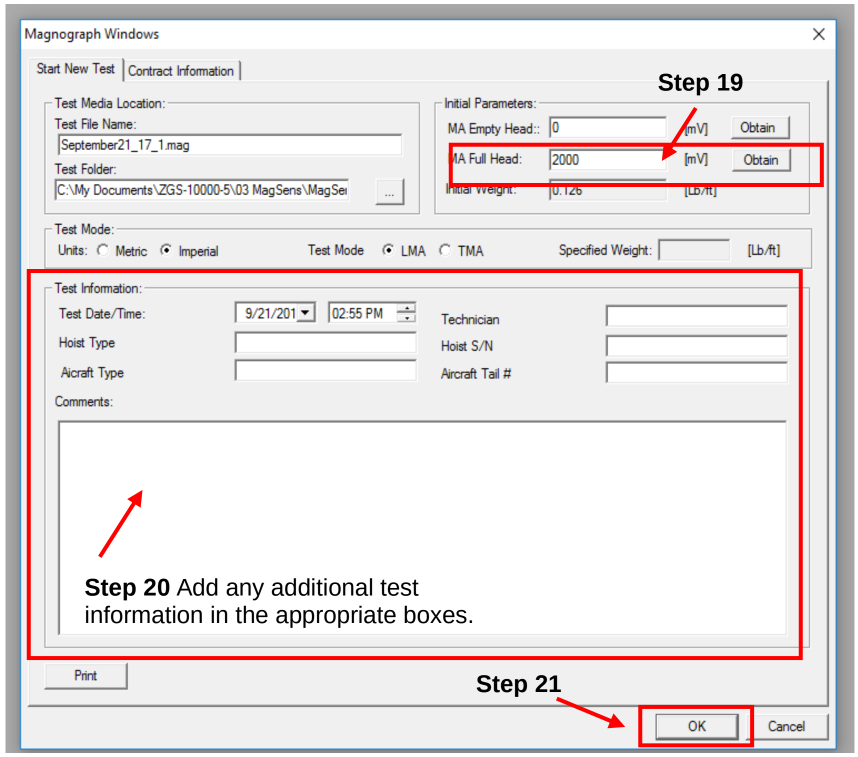

Figure 19

Test Information may also be added at a later time.

Step 20 Optionally, add any additional Test Information in the appropriate boxes.

Step 21 Click on **OK** to start the test.

Step 22 Upon opening the test, the software defaults to a 3V scale. For ease of viewing a running test, the scale can be set to 2V.

Step 23 Extend and Retract the Cable per the RHGSE Operations Manual while Observing the MagSens trace.

CAUTION

If obvious indications are observed in the MagSens trace, such as kinks or broken strands, terminate the test and replace the cable.

- The MagSens output can be affected by high accelerations of the cable, therefore, use a steady moderate speed of 100 fpm, or 30 mpm, when inspecting the cable.
- As the hoist extends (pays out) the cable a blue trace should begin moving across the screen.
- If the MagSens trace does not start or the appearance is not normal, stop and check the connectors for correct attachment and the position of the MagSens head under the hoist.
- If no indications are observed, run the cable back. Using the rescue hoist pendant, retract at a steady speed until the cable is almost completely out of the Rotatub. As the hoist retracts, the cable trace should continue in Red. Any indications noted in the extend trace should appear in the retracting trace.

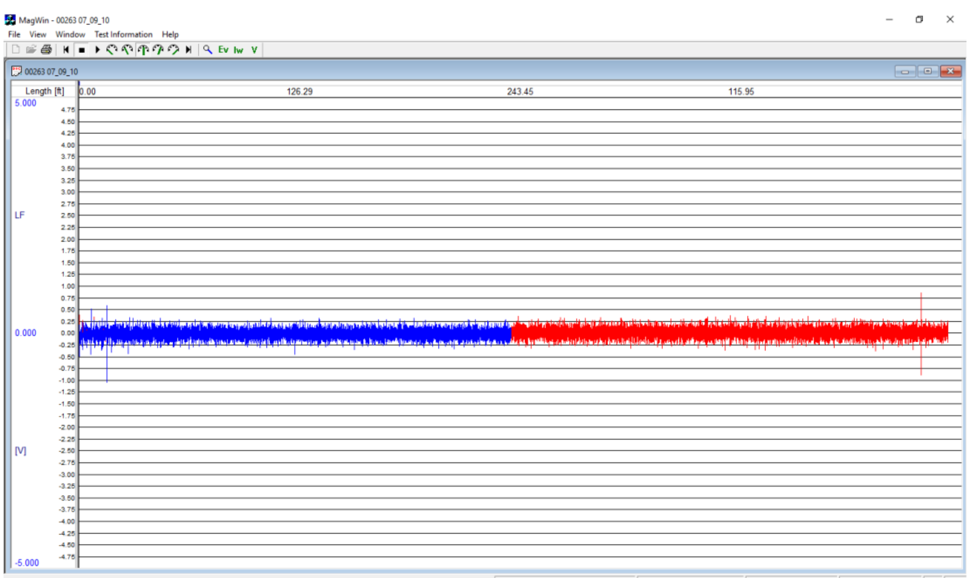

Figure 20 Completed MagSens trace

Step 24 Remove the cable from RHGSE components as specified in the Zephyr RHGSE manual.

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NOTE

Cable should be removed from the RHGSE's Exit and Pressure Rollers, Capstans, and Lubridryer. Do not remove the cable from the MagSens Head.

CAUTION

The cable should not be touching anything as it is retracted to avoid damaging the cable.

Step 25 Use the rescue hoist pendant to retract the cable through the MagSens Head.

Step 26 Stop when the hook is within approximately 20 in./50 cm of the MagSens Head.

Step 27 Grasp the cable above the MagSens Head with a gloved hand.

Step 28 Pull the remaining length of cable through the MagSens Head manually until the Hook reaches the bottom of the MagSens Head.

CAUTION

Hold the MagSens cover before opening it to keep the cover from springing open and damaging the MagSens Head.

Step 29 Open the MagSens head.

Step 30 Remove the cable from the MagSens head.

Step 31 Close the MagSens and latch it.

NOTE

The MagSens can not inspect the entire length of the wire rope without disassembling the hook and bumper assembly. Therefore a careful visual inspection of the cable in the area of the hook attachment is required.

Step 32 Visually inspect the Ball End of the cable, as MagSens does not inspect this.

Step 33 Finish the RHGSE Run, until the Hook is stowed, per the RHGSE Operations Manual.

Step 34 Click on the **X** in the top right of the MagSens window to save the MagSens Data.

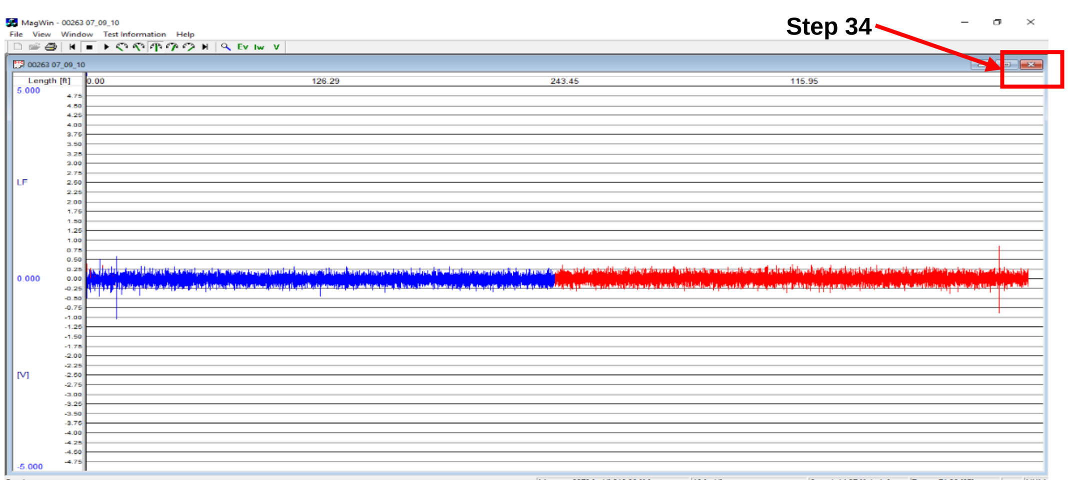

Figure 21

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Step 35 Review test for any defects, if cable is defect free the test is complete. If

Step 36 Close MagSens software and turn off standalone power.

⚠ **CAUTION**

Do not disconnect the MagSens cable from either end with the power still on. Power must be off to prevent damage to the MagSens head.

Step 37 Disconnect MagSens cable.

9.2 Verify Indications

Step 1 Start new test to verify any indications observed in the MagSens data.

Step 2 Use the RHGSE to run the cable back to the indicated location.

Step 3 Mark the cable on both sides of the indication using a marker.

Step 4 Verify the indication either visually or by feel.

Step 5 If indications are verified visually or by feel, determine if cable needs replacing. If yes,

a. Remove cable from the RHGSE per the RHGSE Operations Manual.

b. Replace the cable as per manufacturer's instructions.

Step 6 If no visible or tactile indication are observed,

a. Measure the diameter of the cable carefully in the area indicated using calipers or micrometers. 10% less than the original diameter is cause for further inspection.

b. Note the indication in the **Test Information** comment field for future inspection reference. For example, a possible weld, internal crushing or an internal wire may be broken and may separate further on future inspections.

Figure 22 Marking cable for inspection

Step 7 Close the MagSens software by clicking on the **File** menu item and select **Close**, or click on the **X** in the upper right hand corner.

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CAUTION

Do not turn off the power switch on the standalone with the MagSens Software still running. Doing so will cause a fatal error and the Laptop will require rebooting.

Do not disconnect the MagSens cable from either end with the power still on. Power must be off to prevent damage to the MagSens head.

Step 8 Turn off the standalone power switch.
Step 9 Remove cable from RHGSE.

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9.3 Open Existing Test Data

Step 1 Click on the *MagWin* shortcut, if MagSens program is not already running.

Step 2 Select the **File** menu and then **Open Existing Test** from the dropdown menu, or Click the **Open Existing Test** button in the **Start** window.

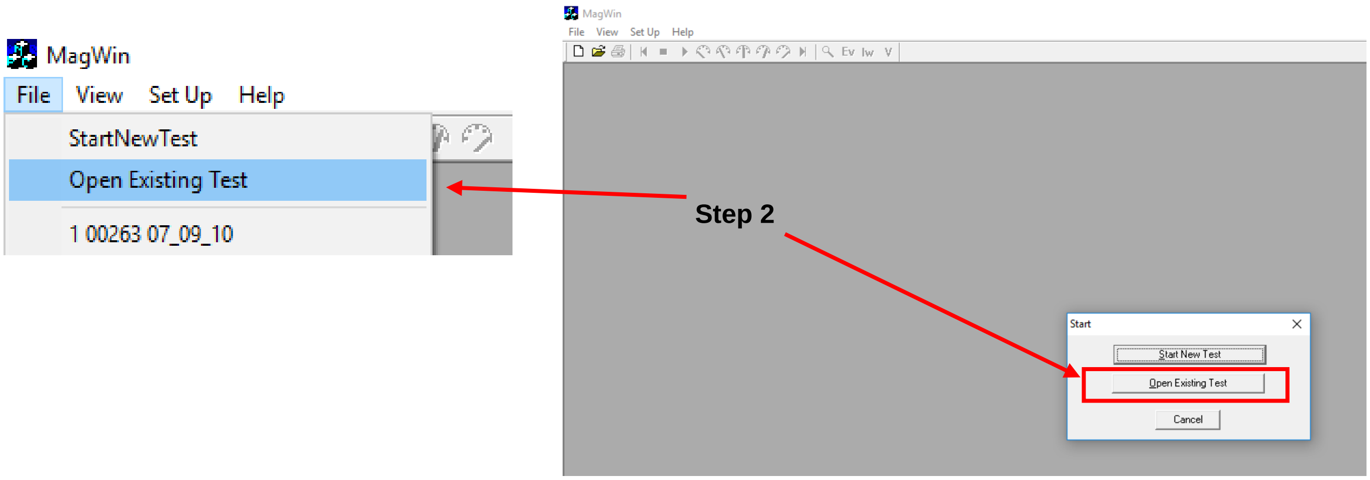

Figure 23 Open Existing Test

Step 3 From the **Open** window, go to the **MagSens Data** folder and select a test data file to view.

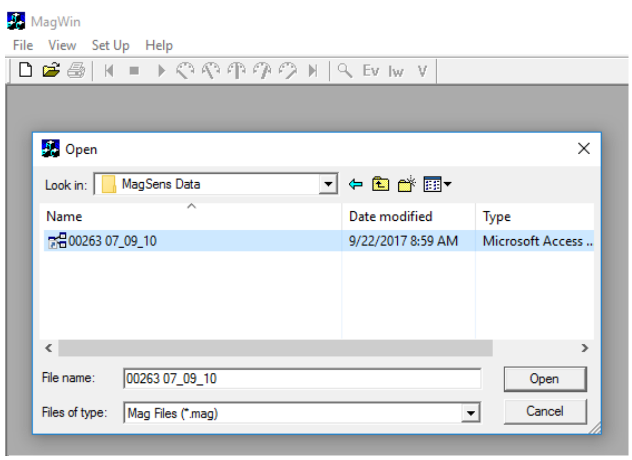

Figure 24

Step 4 Click the **Open** button. The test record will open and the test will be shown.

NOTE

The system, by default, selects a scale based on the maximum voltage it recorded when initially opened.

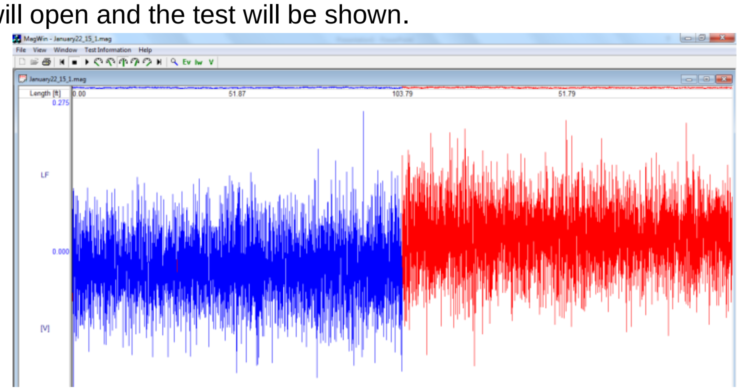

Figure 25 Open test

Step 5 Select **Test Information** menu item. The **Magnograph Windows** dialog box should open.

Step 6 Note the value in the **Total Test Length** field. In the example shown, the total test length is approximately 502 ft.

Step 7 Click on the **"x"**, or **"OK",** to close the dialog box.

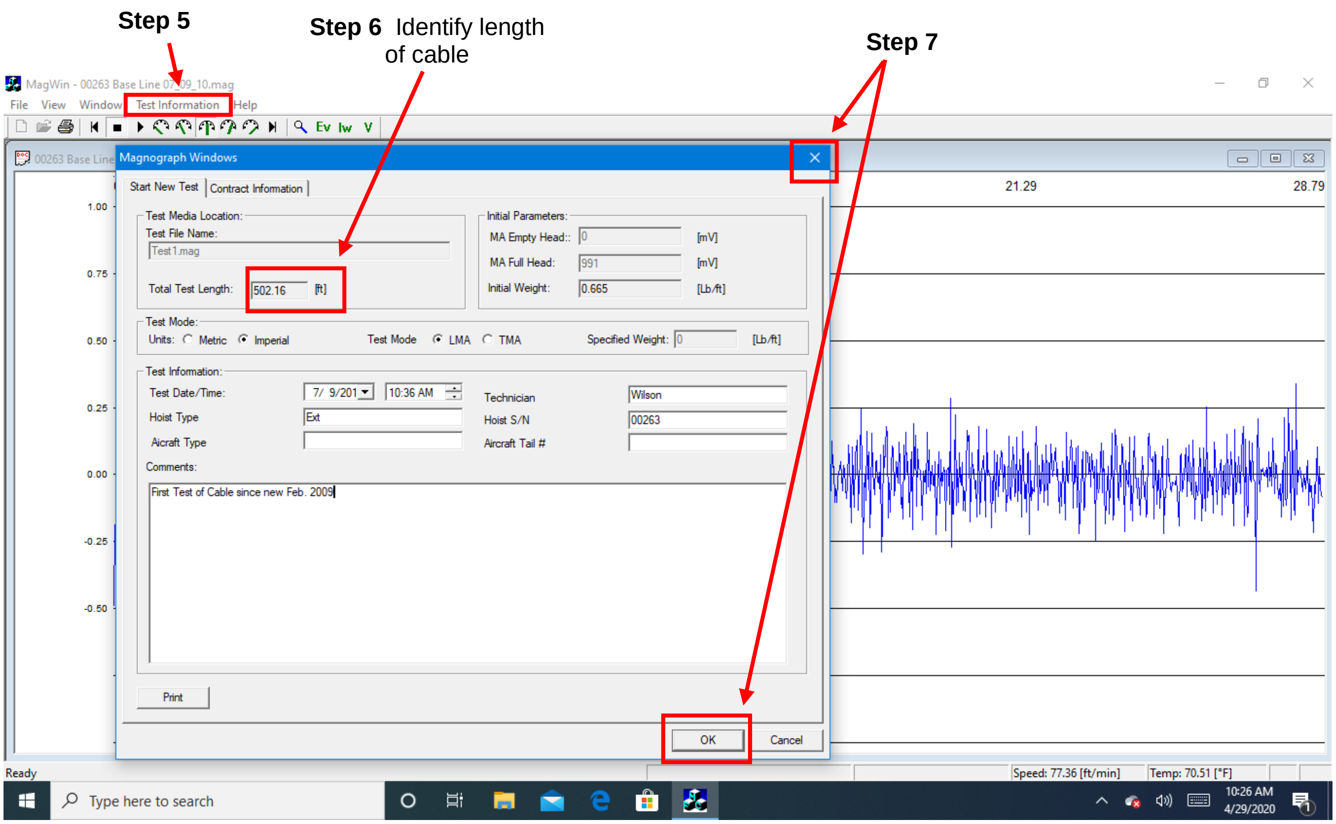

Figure 26 Open Test Information

Step 8 Right click on the test and set the Window Width to the same length as the Total Test Length. In this example, 502 ft.

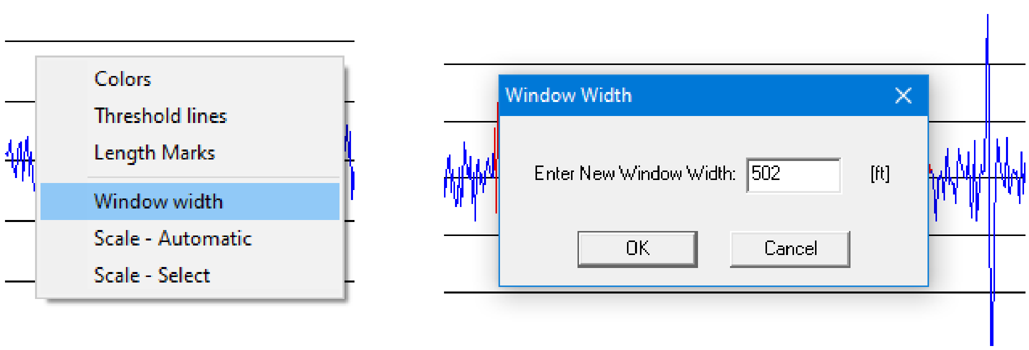

Figure 27 Set Window Width

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Step 9 Right click on the test and set the Scale you would like to use. The preferred scale is 2V, as shown.

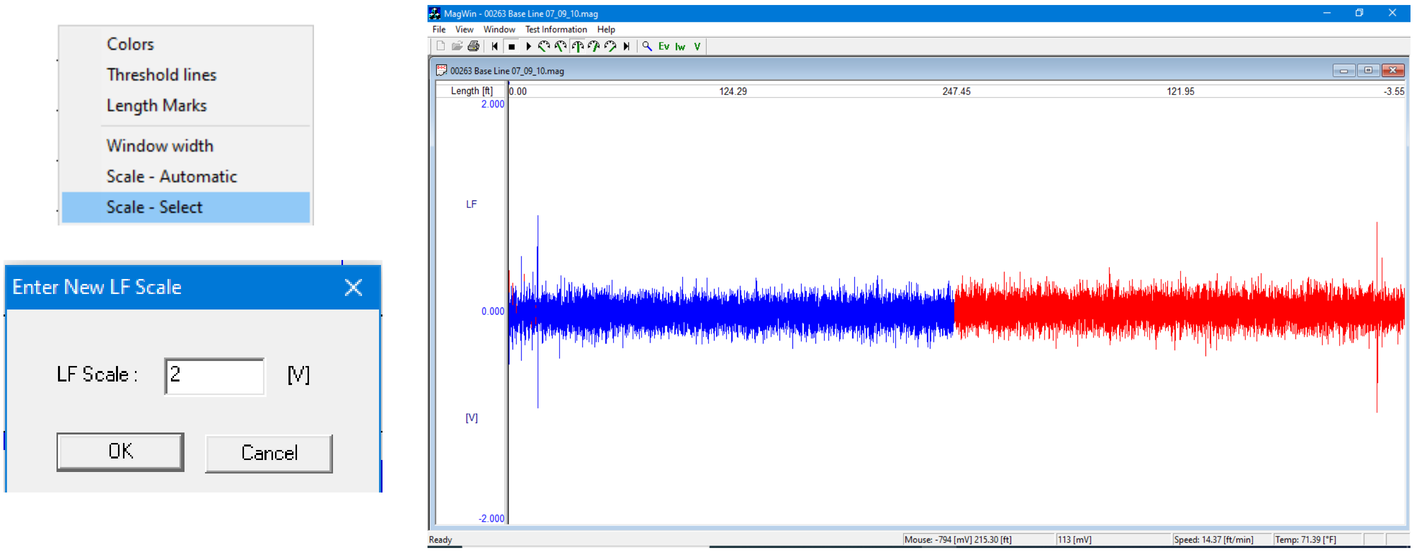

Figure 28 Adjust the scale

NOTE

The scale can be set between 0 and 5V.

Setting the Scale to 1V will aid you in seeing potential indications which may signal cable damage.

Step 10 Right click on the test and Set the Threshold lines to 250 mV.

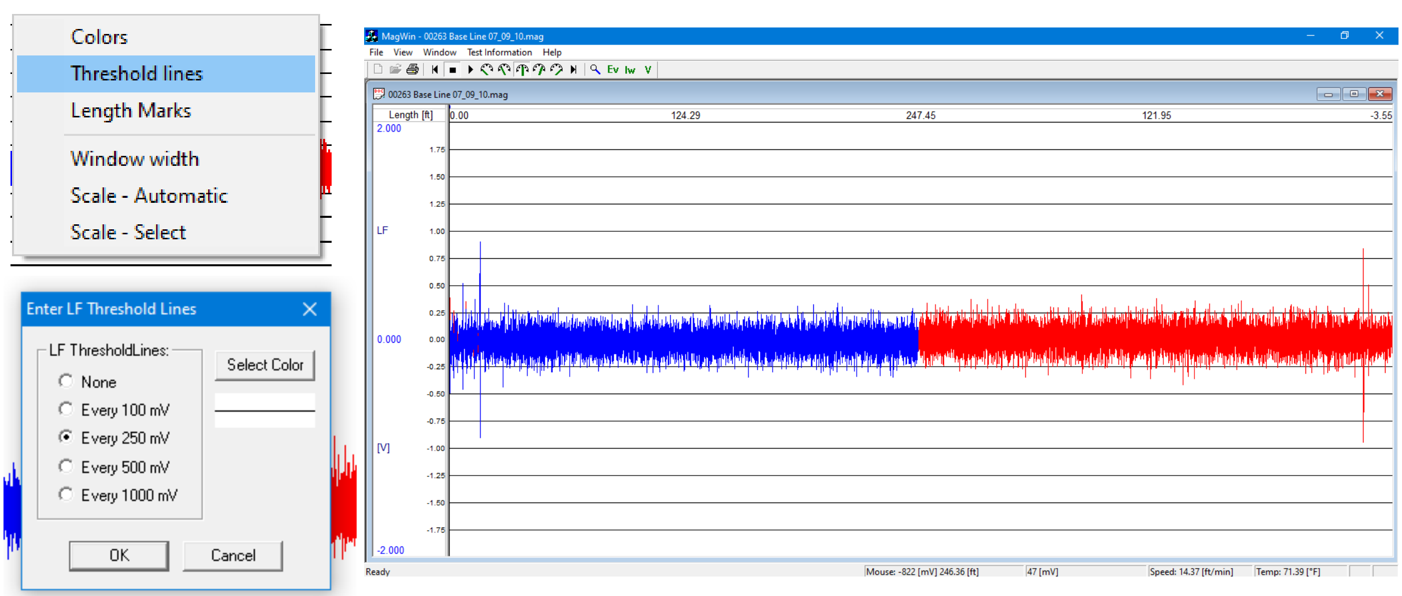

Figure 29 Adjust Threshold Lines

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Step 11 Play back the trace looking for any indication that appears in the same location while extending and then retracting. The Window width will need to be adjusted to a smaller number in order to use the playback feature.

Step 12 Compare the current test data to base line test or previously collected data for this cable.

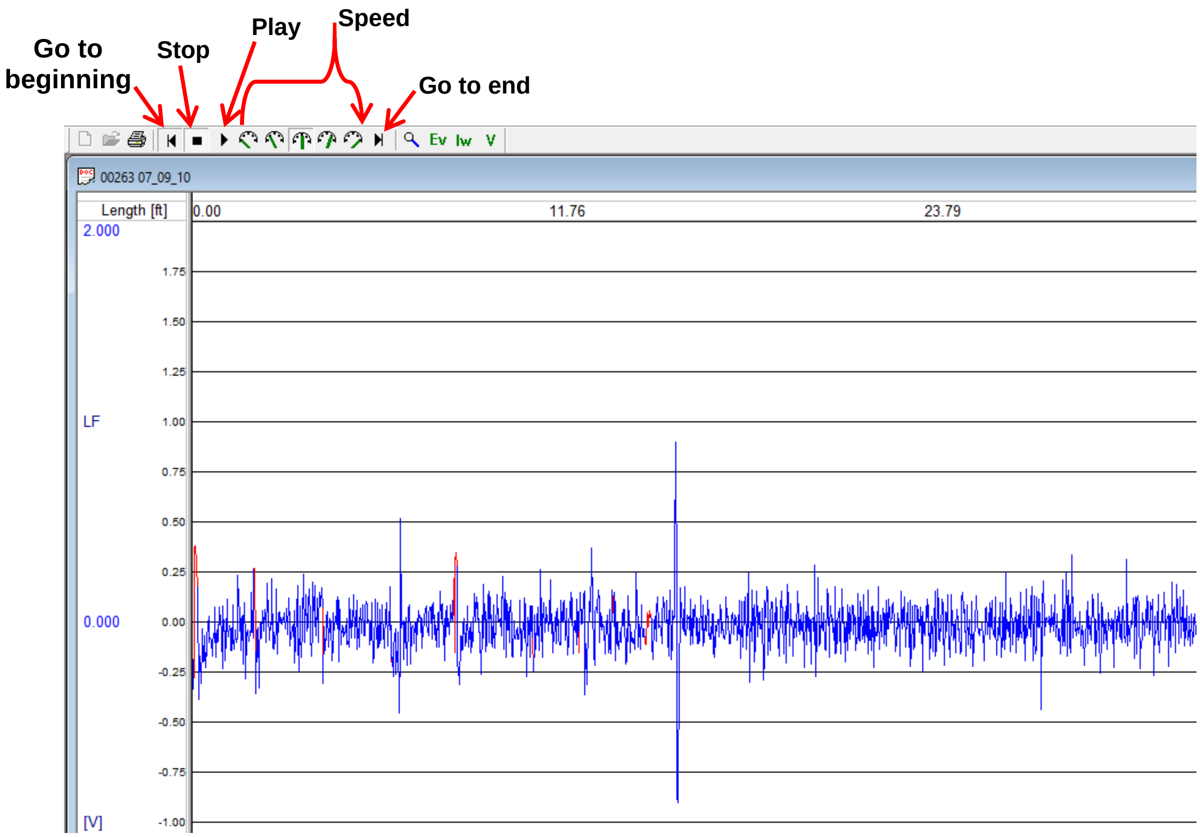
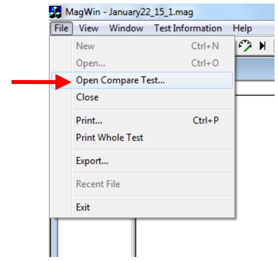


Figure 30

9.4 Compare Tests



Step 1 With a test already open, Click on the **File** menu.

Step 2 Select **Open Compare Test…**

Step 3 Select the appropriate prior test

Step 4 Right click on the prior test

Step 5 Adjust the Scale, Window Width, and Threshold Lines, as desired, to match the first set of data.

NOTE

The screen now shows the two tests.

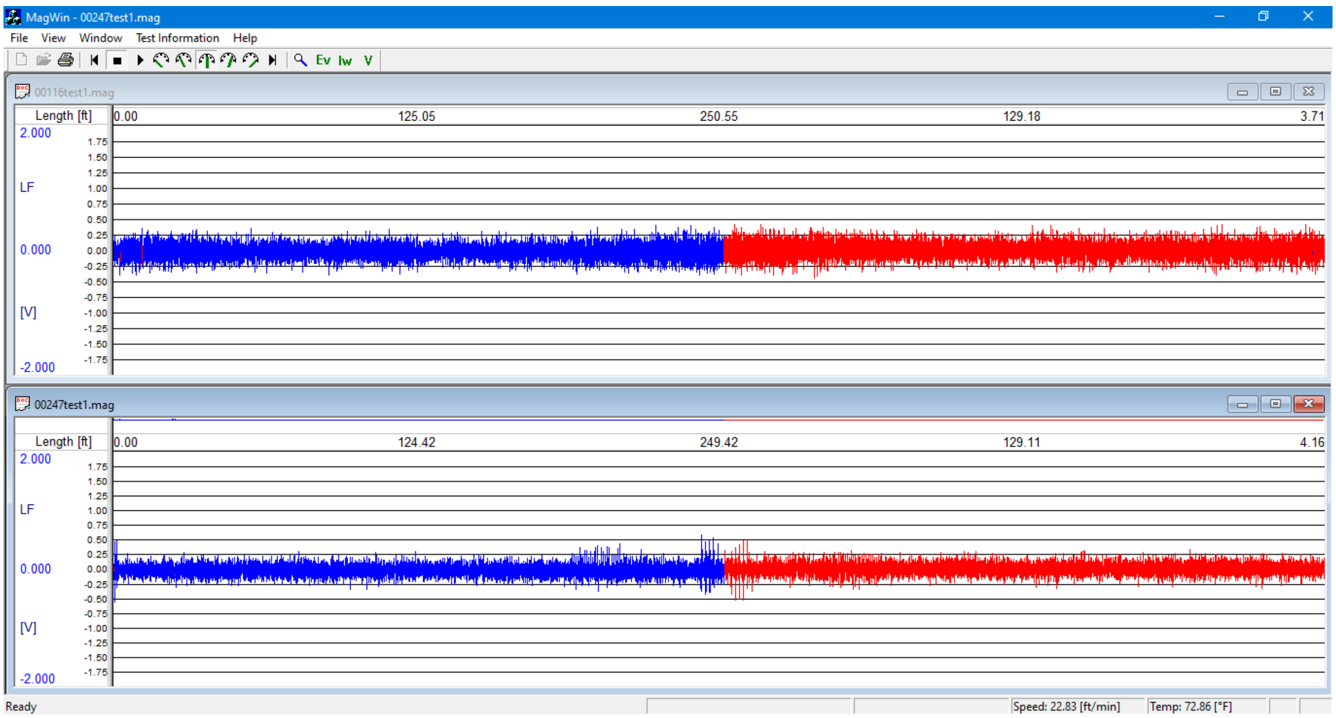


Figure 31 Compare Tests

Step 6 Click on the first test.

Step 7 Click on the **Test Information** menu item.

Step 8 Click on the second test.

Step 9 Click on the **Test Information** menu item.

NOTE

Figures 32 and 33 show how the data that is entered gives a historical record of the life of the cable and allows accurate tracking of the cable over its installed life.

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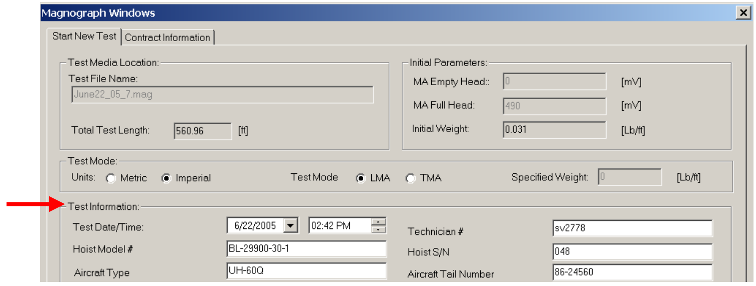

Figure 32 "Test 1" Data

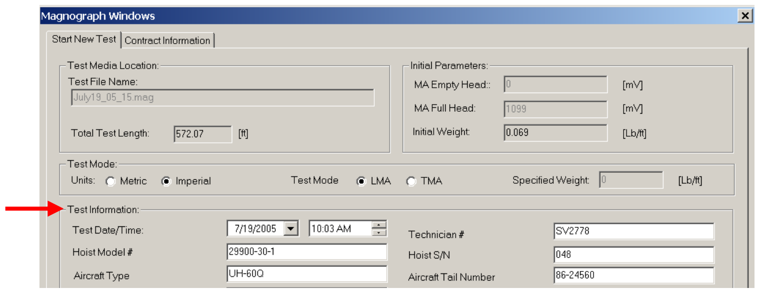

Figure 33 "Test 2" Data

Step 11 Playback the RHGSE run comparing the two tests. Look for any indication that appears and compare to the older test to determine if there has been any degradation in the condition of the cable.

Step 12 If indications are observed, determine the cable location and perform a visual and tactile inspection.

10.0 Interpretation Guidelines

The MagSens output along with the physical condition of the cable in the area of interest and a detailed knowledge of the cable history is required to make an accept or reject decision.

The indications on the MagSens readout by themselves do not give the rescue hoist maintainer enough information to reject the cable outright unless visual and tactile correlation exists. After an anomaly has been isolated, a thorough visual and tactile inspection should be performed in the area of interest. The MagSens provides the capability to measure the exact location of the indication by running the cable in and out to determine if the indication has a repeatable signal allowing the location to be isolated. Factors that need to be considered are the length of time the cable has been in service, prior data records that may or may not exist, and the report of the crew who flew the last mission.

Scenario 1) No prior data record exists, no recorded history of the length of time the cable has been in service, no indications or reports from the prior flight.

This is the most common scenario because the MagSens is a new tool that is now available to the rescue hoist maintainer. Consider the cases of a cable that shows no indications and a cable that shows indications. In the first case of no indications, it is an easy call. The test data record becomes the baseline for comparison to future tests.

In the second case, if there is no measurable variation of the outside diameter of the cable and no tactile indications of any kind, the indication should be identified as an unknown internal indication. Upon future

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inspections, the size of the indication should be compared to the past data. If no increase in size is noted, the cable can remain in service until such time that additional indications start to appear. Increased frequency of inspections should be used to determine if the indication is stable or changing.

In the event that there is a measurable variation in diameter, or if external damage is detected, then the cable must be replaced immediately.

Scenario 2) Prior data exists
In the case where prior data has established a baseline and the original baseline indicates no indications, and a present measurement now indicates a new anomaly has developed, then the indication should be isolated and the location marked using the MagSens. If no external visual variation in outer diameter is measurable or detectable, then the flight crew from the previous mission should be questioned as to the possibility of an in-flight event. This will allow the maintainer to determine the possibility of internal damage as a result of a dynamic event. If no in-flight event has been noted then the location of the indication should be compared to possible correlation with the turnaround points on the rescue hoist drum to determine if possible internal crushing has started as a result of misalignment of the rescue hoist levelwind mechanism. If no correlations can be drawn then the location and size of the indication shall be noted and compared to future inspections and the frequency of future inspections should be increased. Upon future inspections the size of the indication should be compared to the past data. If no increase in size is noted. The cable can remain in service until such time that additional indications start to appear. In the event that there is a measurable variation in diameter, or if external damage is detected, then the cable must be replaced.

10.1 Establish a baseline

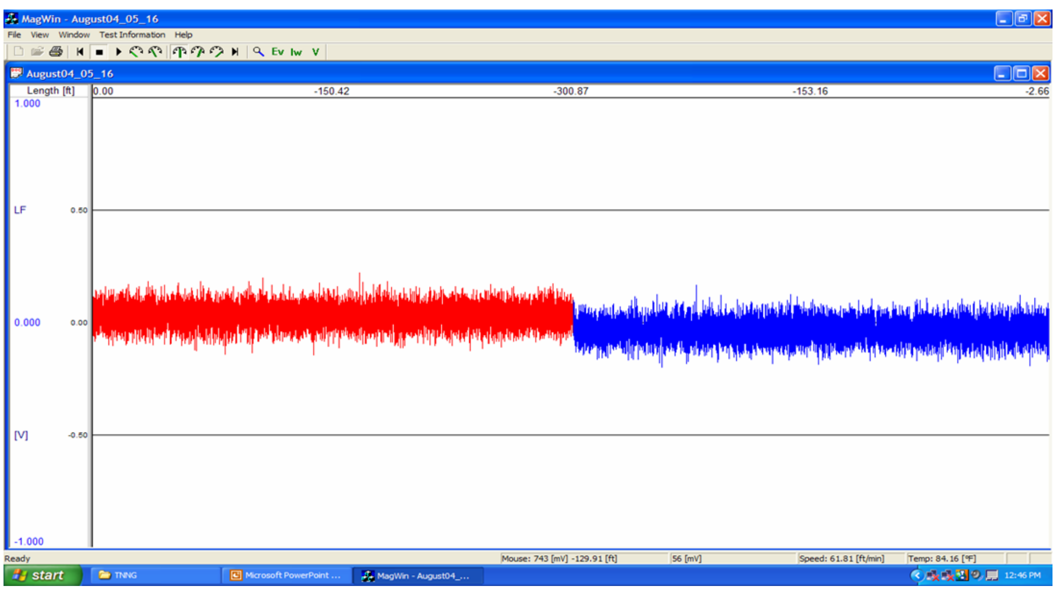

Figure 34 New cable baseline

Establishing a baseline When a new cable is installed and after it has been conditioned to remove constructional stretch it should then be checked using the MagSens to establish a baseline for comparison to future inspections.

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11.0 Indication Examples

11.1 Single Internal Indication

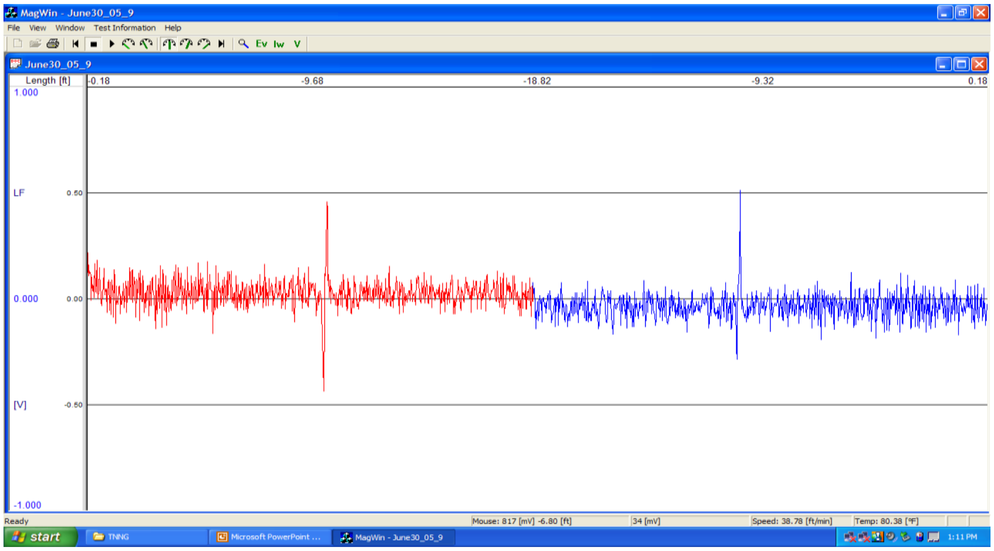

Figure 35 Cable Peening

In this case the internal indication was determined to be due to peening of the internal strand wires against the external strand wires. This is a common yet undetectable flaw that occurs on a 19 x 7 rotation resistant cable that is being wrapped on a multilayer drum at high speed. Plastic wear takes place as two surfaces slide or roll against eachother and the forces of relative motion gradually remove material. Peening is a plastic wear produced by localized impact or very high bearing pressure. This can occur by the slap of the rope at the crossover points as the rope slips from layer to layer. Plastic wear can cause a raised edge of a worn wire that could be the introduction site of fatigue cracks. A SEM (scanning electron microscope) image of the specified indication is shown below.

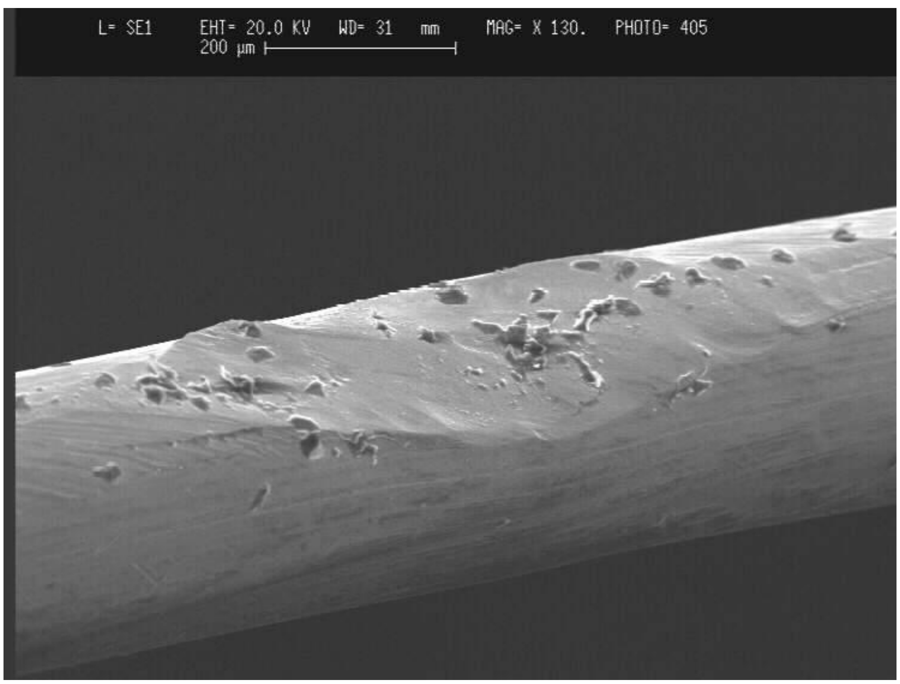

Figure 36 SEM image of peening

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11.2 Multiple Internal Indications

The following example shows two indications. Note that the indications repeat in each direction. The first indication is larger then the single indication above by approximately 30 %.

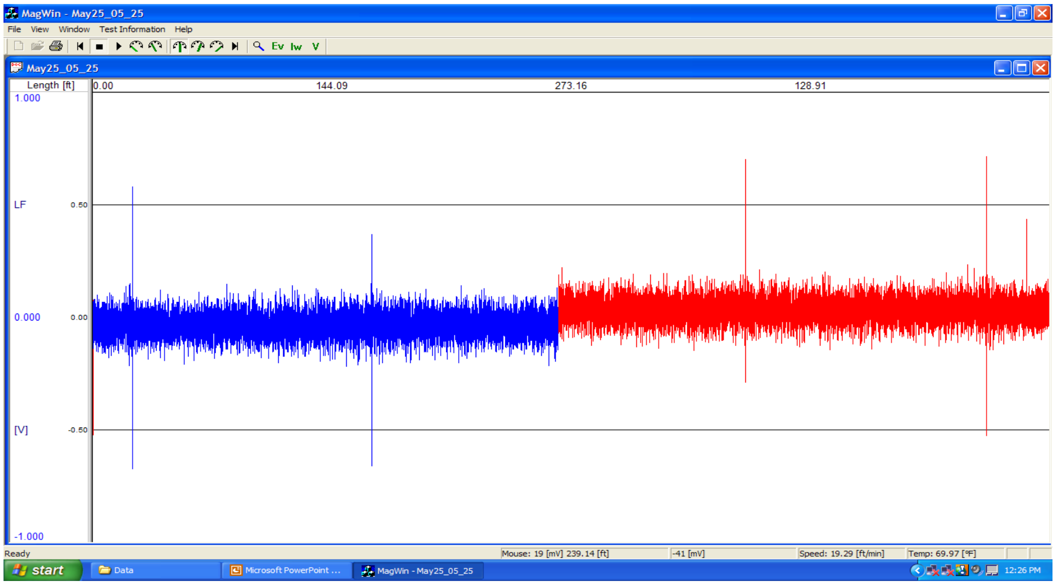

Figure 37 Multiple internal indications

When this cable was disassembled the first indication was discovered to be multiple cases of severe internal peening between the internal and external strands.

The first indication was located at approximately 38 feet from the ball end. When one of the internal strands was disassembled the external wire broke at one of the pits created by the peening.

Figure 38 Severe internal peening

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Figure 39 Broken wire

The second indication at 183 feet was only discovered after disassembling 18 of the 19 strands. It was a center wire of an external strand that broke upon disassembly. The wire was soft in the area of the break and still hard in the rest of the sample. This may mean that the wire was annealed somehow, possibly this was a weld.

Figure 40 Possible weld

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11.3 Single Broken Wire

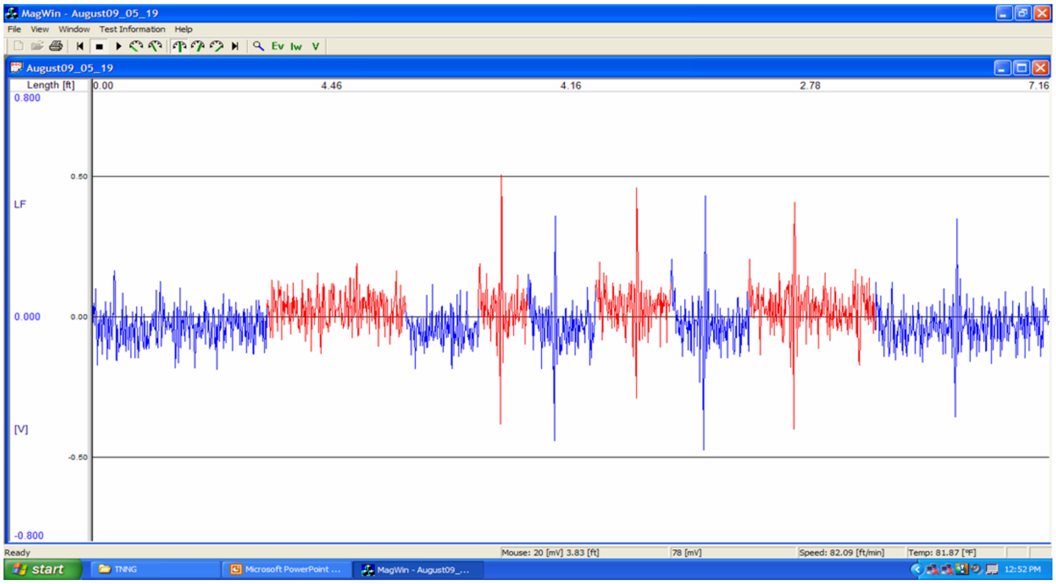

Figure 41 Single broken wire trace

As stated above a single broken wire may not allow very much flux leakage until it pulls apart. The flux leakage increases as the ends separate. The trace above shows this concept very clearly. In the first three passes through the MagSens there is no indication, but on the fourth pass the wire separated and the indication was quite evident. Note that the signal strength is approximately 500 mV or about the same size as the internal peening noted above.

The single broken wire is shown below

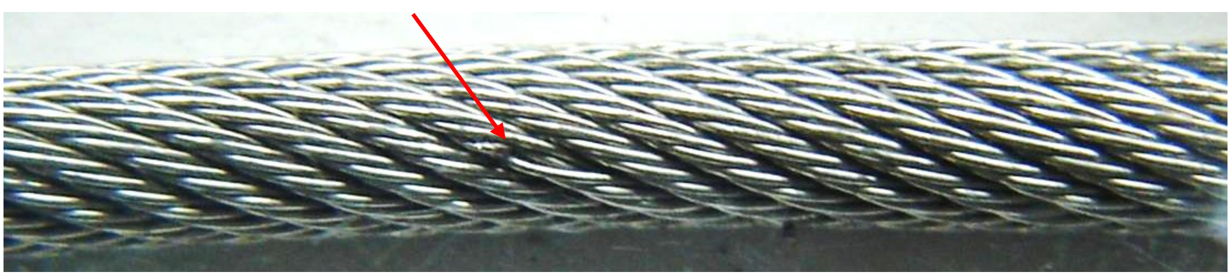

Figure 42 Single external broken wire

Signal strength may vary for the same indication. MFL (Magnetic flux leakage) inspection techniques provide a qualitative indication but not a quantitative indication. i.e. the techniques show that an anomaly is present but it can not tell with certainty what type of anomaly it is.

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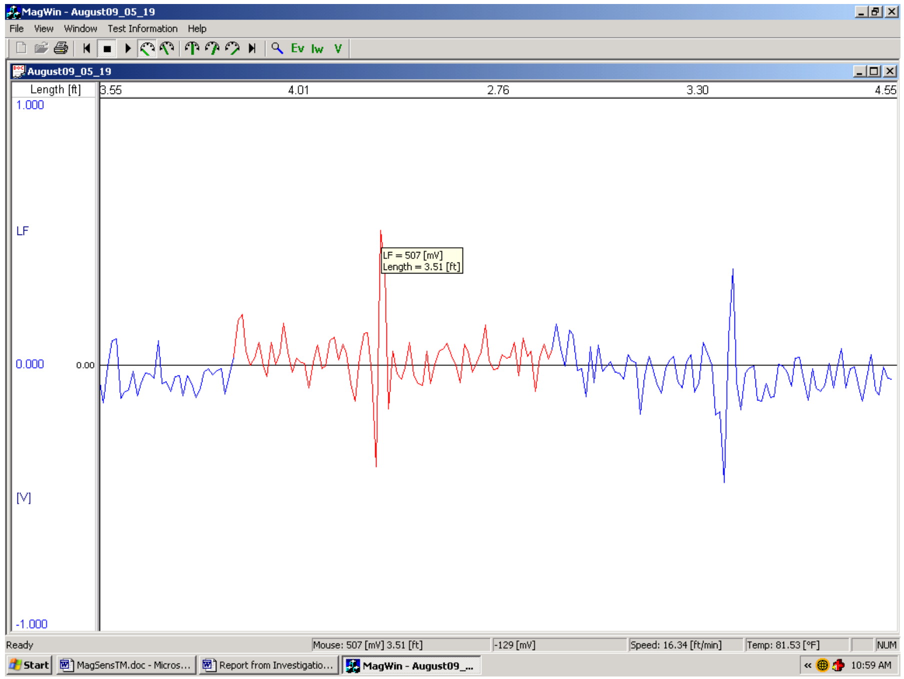

Figure 43

This picture shows the size of the indication during each pass through the MagSens head.The signal strength will appear, as shown in Figure 38, when the cursor is placed over the top of the indication.

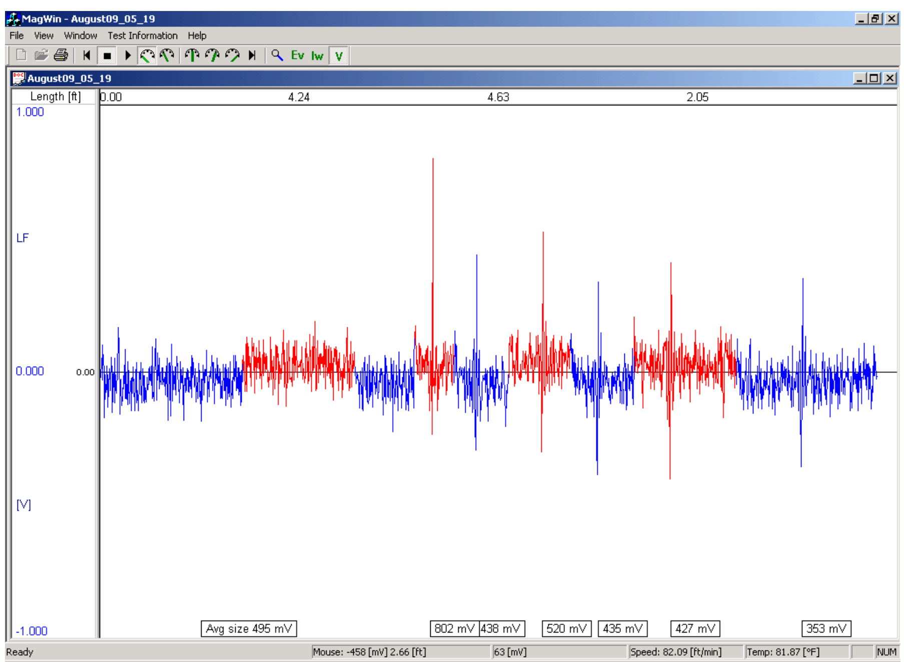

Figure 44

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11.4 External Cut Strand

An external strand produces a very strong signal

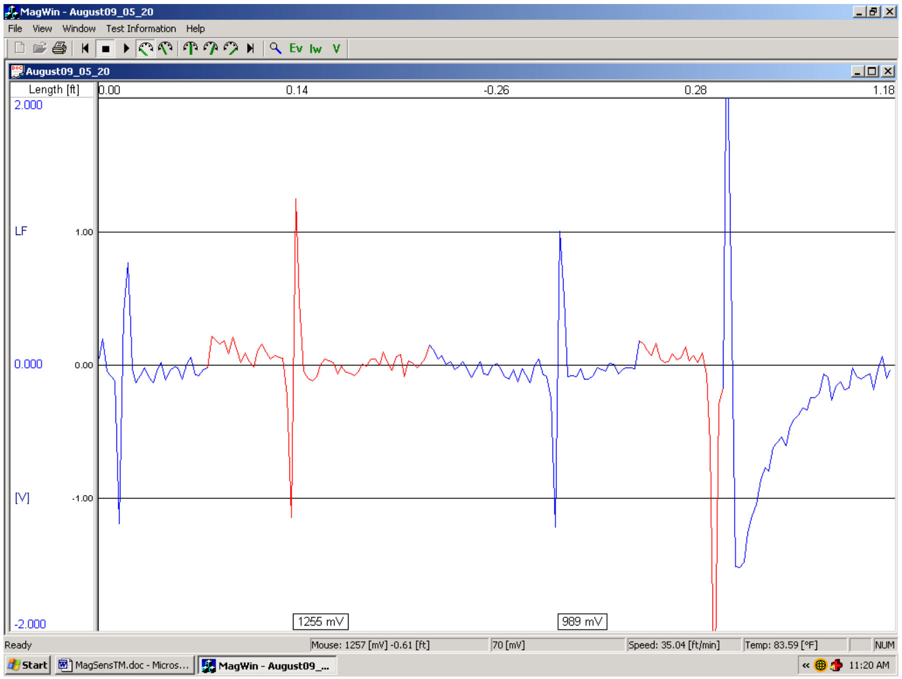

Figure 45 External strand break

11.5 Internal Cut Strand

Sometimes an internal cut strand does not produce such a strong signal due to the fact that the wire ends are in close proximity to each other.

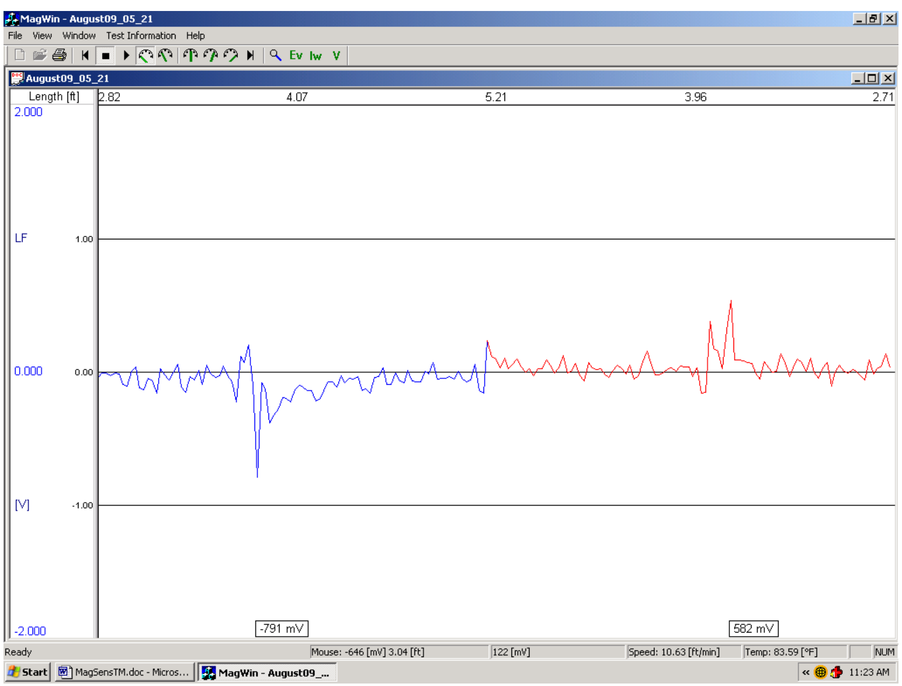

Figure 46 Internal strand break

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Depending on the severity of the damage a broken internal strand may look like this.

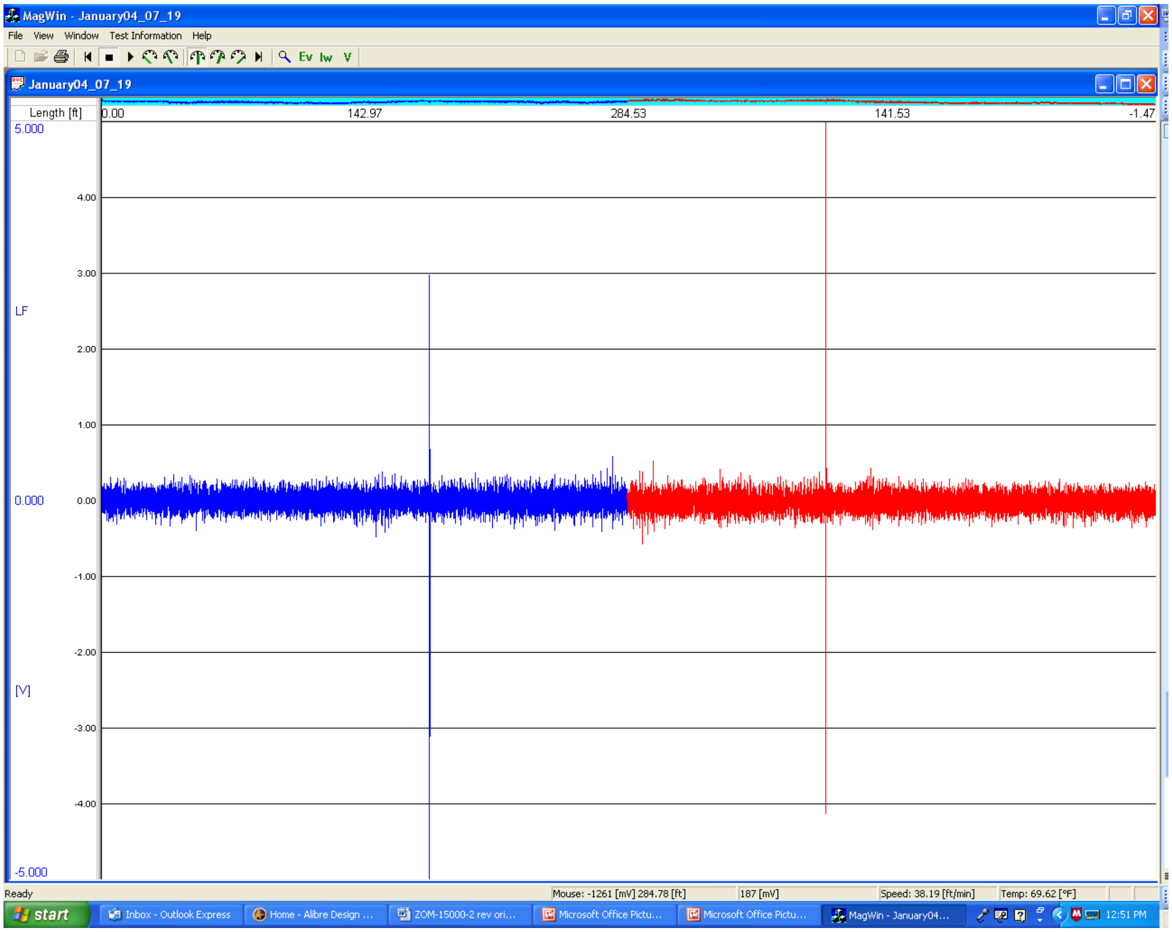

Figure 47 Broken Strand

This indication was a broken strand at the area of the turnaround on the drum.

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11.6 Multiple Internal Nicked Wires

This example shows the indication from two wires in the central strand that had been cut but not all the way through. When the sample was disassembled and the individual wires were flexed two wires broke apart.

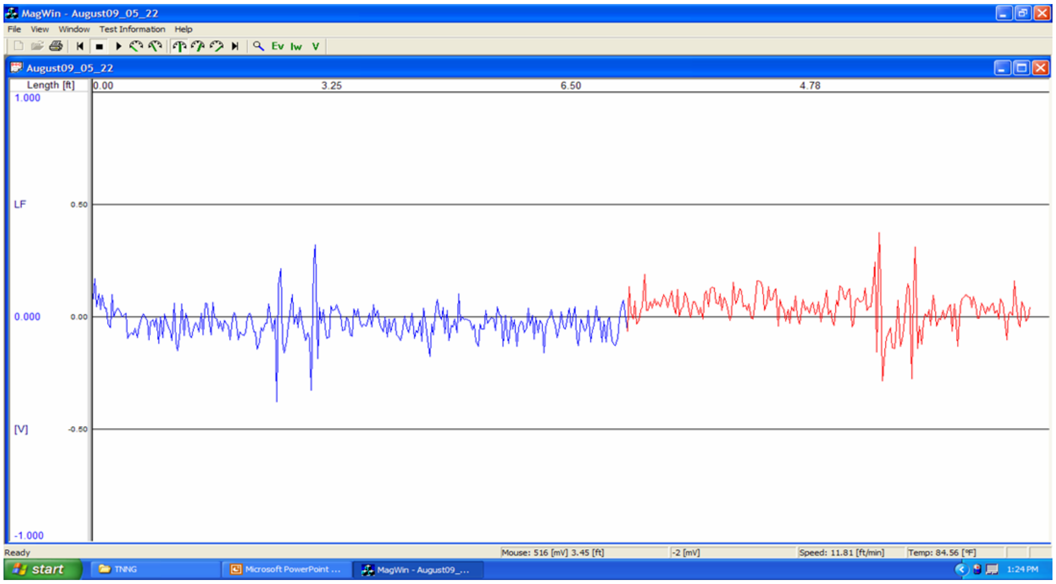

Figure 48 Internal Nicked Wires trace

Central Strand with two nicked wires

Figure 49

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11.7 Welds in Individual Wires

It is possible to receive a new cable with indications. The indication may be a welded wire. Per the Mil-W-83140 individual wire weld are permissible as long as they are no closer then 20 feet apart in any individual strand.

This trace show a weld in the center wire of the center strand. The signal strength is 1244 mV.

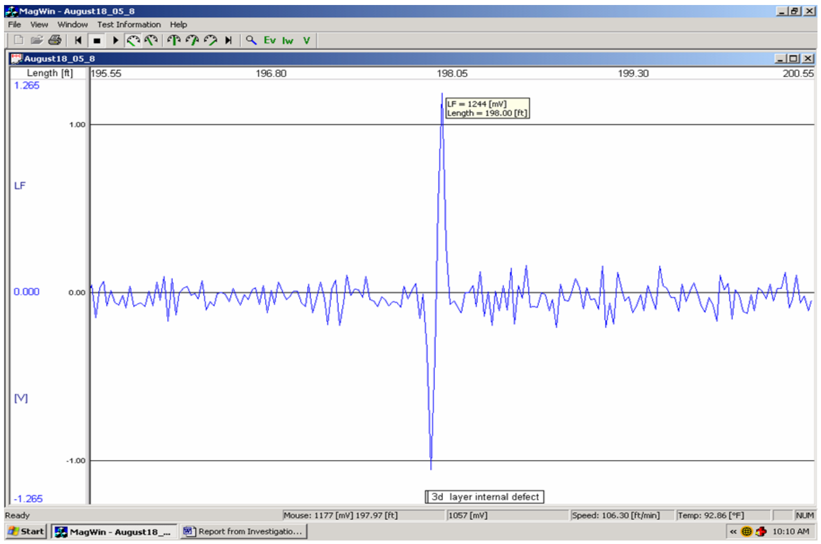

Figure 50

302/304 Austenitic wire when welded and a post weld anneal is not applied may develop internal corrosion in the area of the weld. Therefore it is important to monitor the welded area carefully upon future inspections.

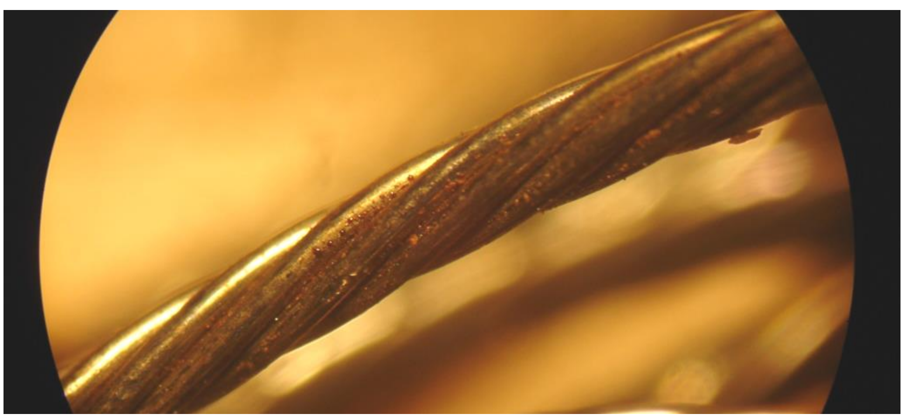

Figure 51 Surface corrosion as a result of carbide precipitation in the area of a welded wire.

Chlorides are a big problem for 300 series stainless steel. Outside of water; chloride is the most common chemical found in nature and remember that the most common water treatment is the addition of chlorine. Carbide precipitation causes the stainless steel to loose its corrosion resisting properties in the areas affected. Best seen at areas of welding, rusty discoloration indicates that the alloy was robbed of its Chromium.

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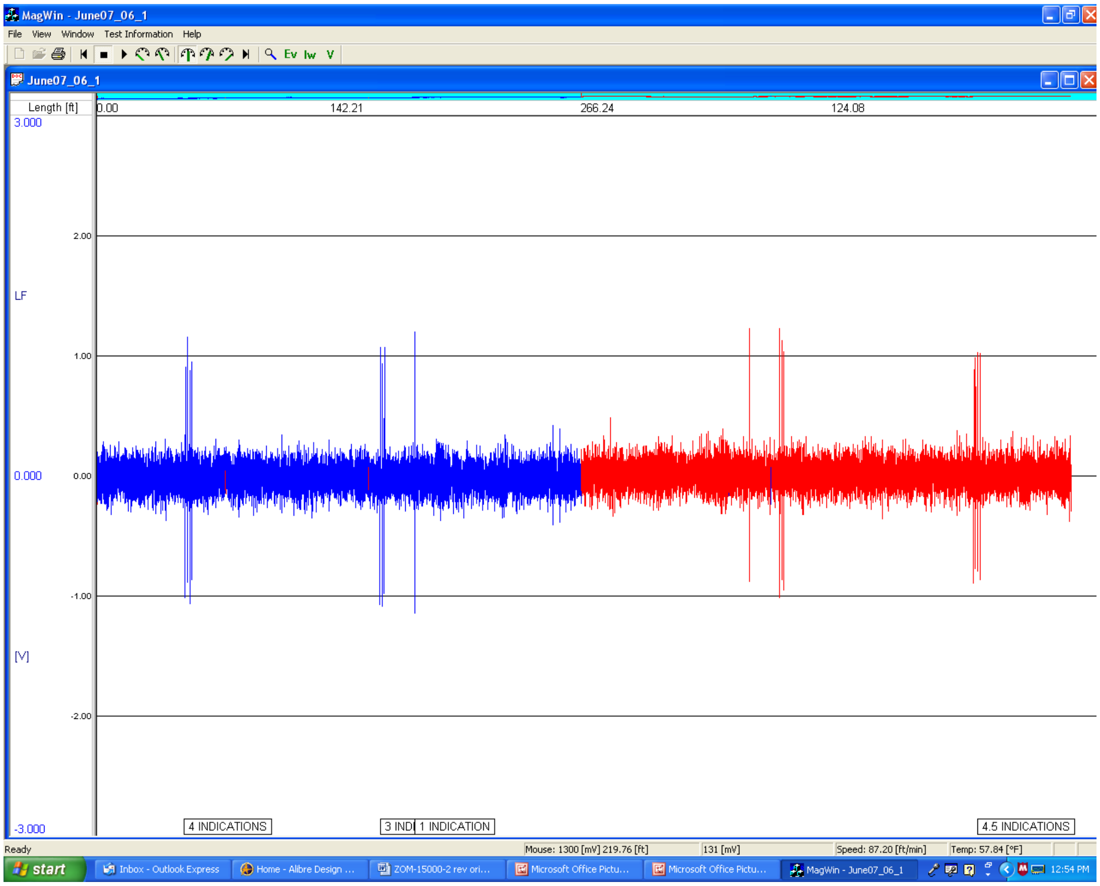
11.8 Multiple Welds

In the case where multiple welds are discovered, as shown below, then the cable should be replaced because the user can not determine if they are in the same strand or not.



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11.9 Broken Strands

Below is a trace where a broken strand was discovered, you can see the magnitude of the indication is quite large at about 4964 mV or almost 5 volts. This defect was due to crushing of the internal strand at the turnaround.

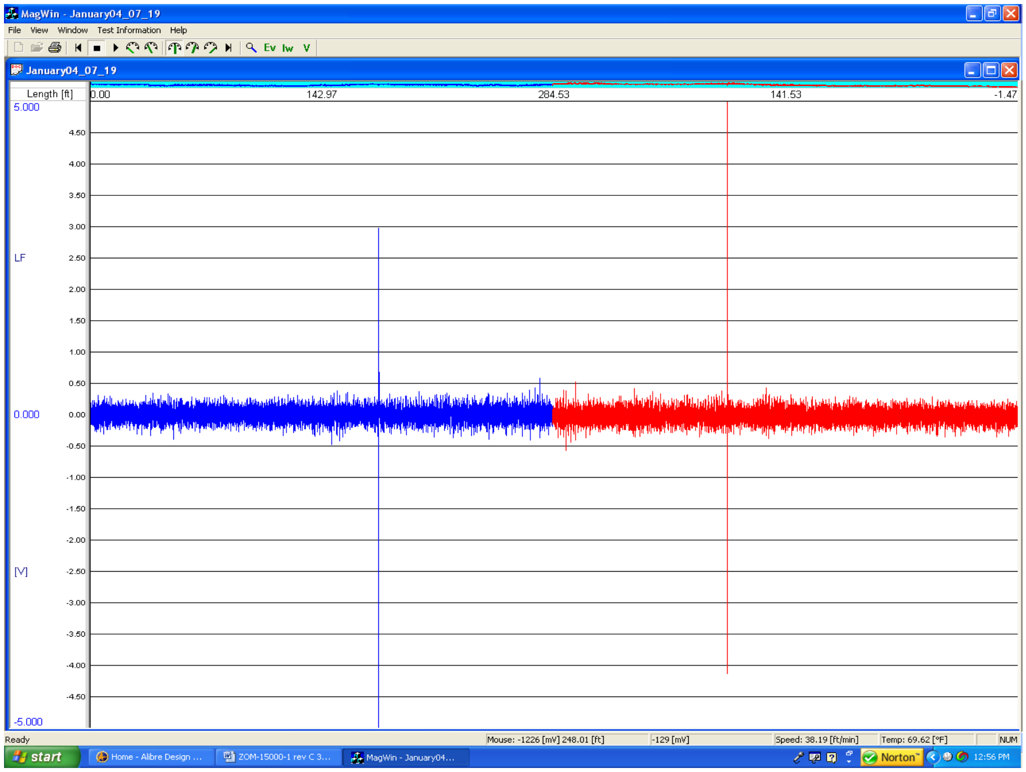

Figure 52 Internal crushing

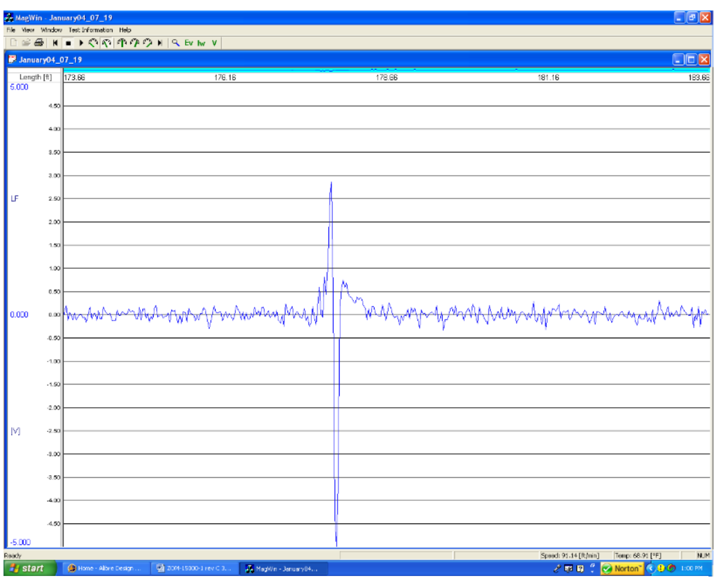

Figure 54 Indication during extend

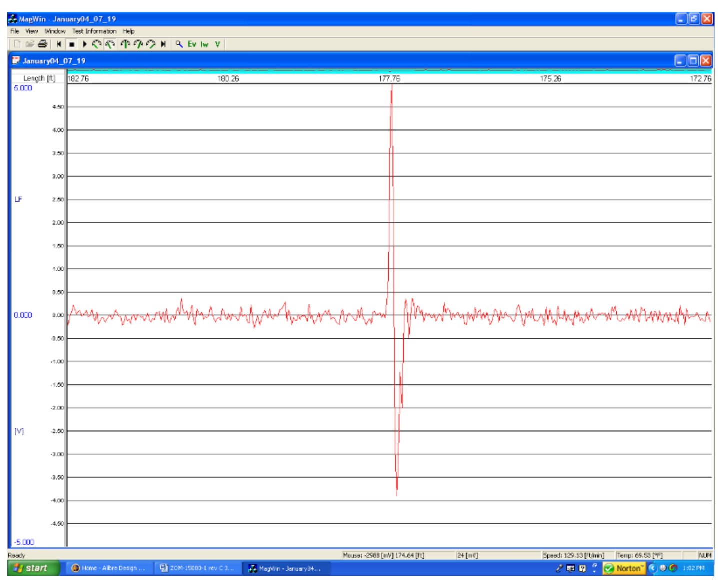

Figure 53 Indication during retract

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11.10 External Welds

The following trace shows what was discovered to be an external weld. The red trace is the cable retracting and the blue trace is the wire rope extending.

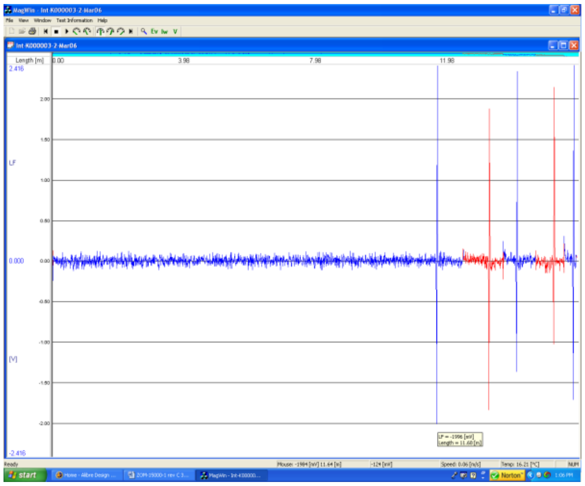

Figure 56

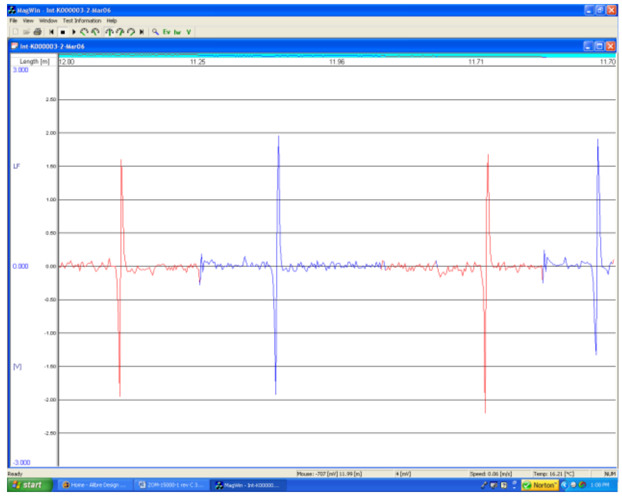

Figure 55

The external weld defect is shown in Figure 56. The close up view shows evidence of carbide precipitation in the vicinity of the welded wires.

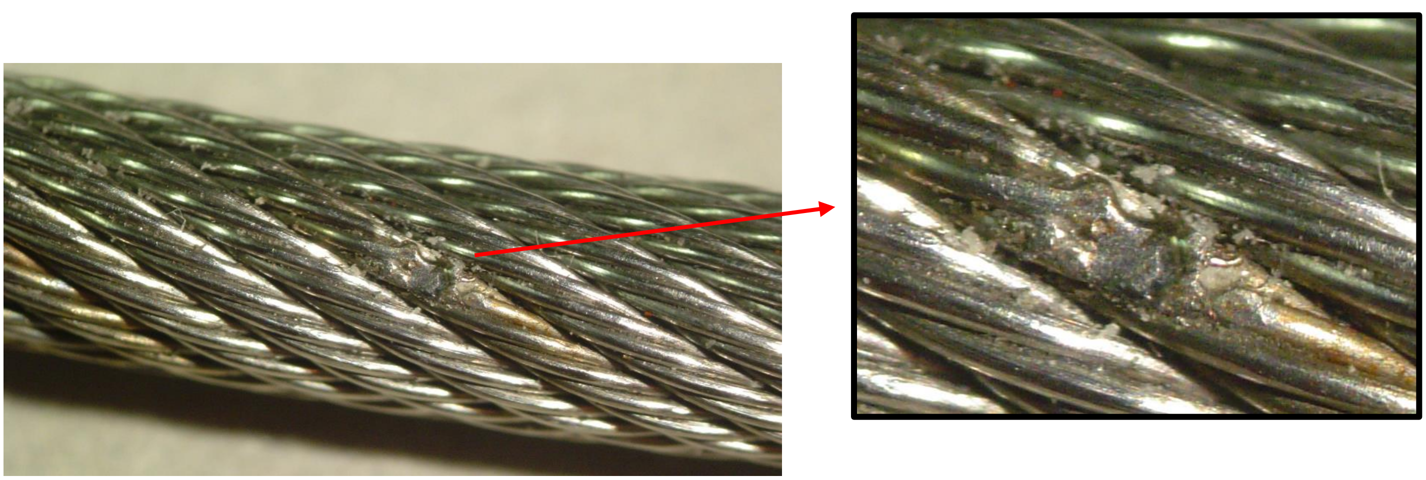

Figure 57 External Weld

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11.11 Broken wires due to abrasion

The following trace in Figure 58 shows broken wires due to abrasion of the cable on the helicopter. This cable has a weld in it but notice the two indications at the beginning and the end of the trace.

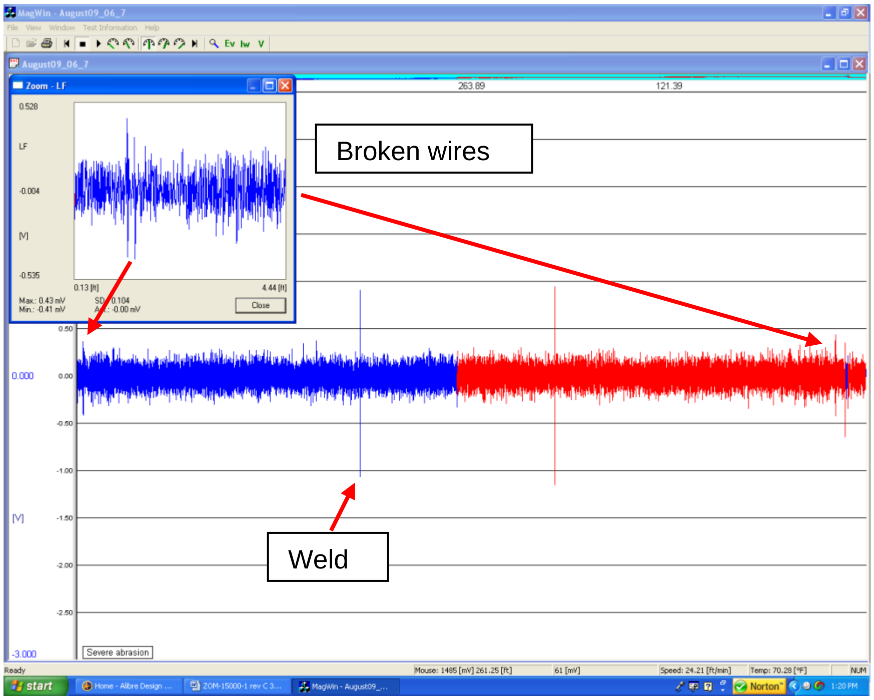

Figure 58

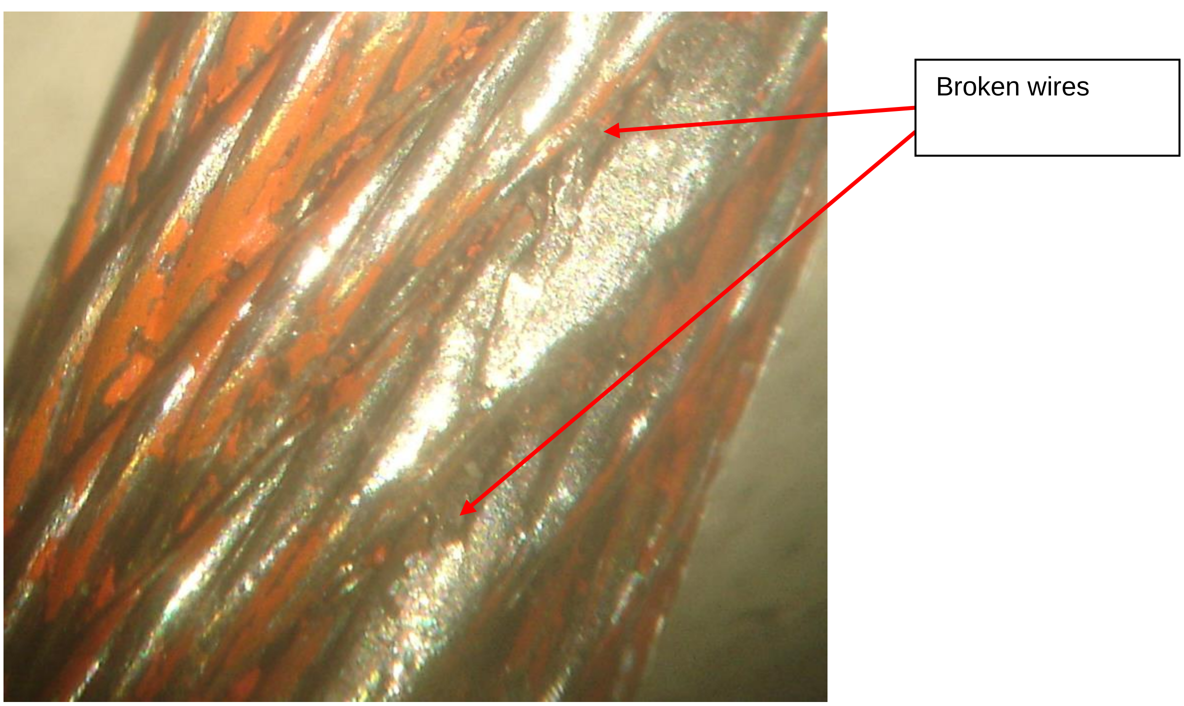

Figure 59

12.0 Yearly QA check or Maintenance

In order to check the system prior to inspecting a rescue hoist cable, use the following procedure:

Figure 60 Cable Standards

Step 1 Place the supplied cable standard that has one broken wire into the MagSens head.
Step 2 Start the Laptop and let it boot up.
Step 3 Connect the standalone to the MagSens head with the 10ft MagSens cable.
Step 4 Turn on the standalone power
Step 5 Open the MagWin program and obtain a full head reading of 2000 mV +/- 100mV.
Step 6 Click on OK and start pulling the test piece through the head
Step 7 Pull the entire length of the wire through the head and then reverse the direction and pull it through the opposite direction.
Step 8 Reverse direction multiple times.
Step 9 Verify the system is operating by observing the indication caused by the broken wire gap.The indication should look similar to the trace shown below.
Step 10 Close the test
Step 11 Turn off the standalone power.

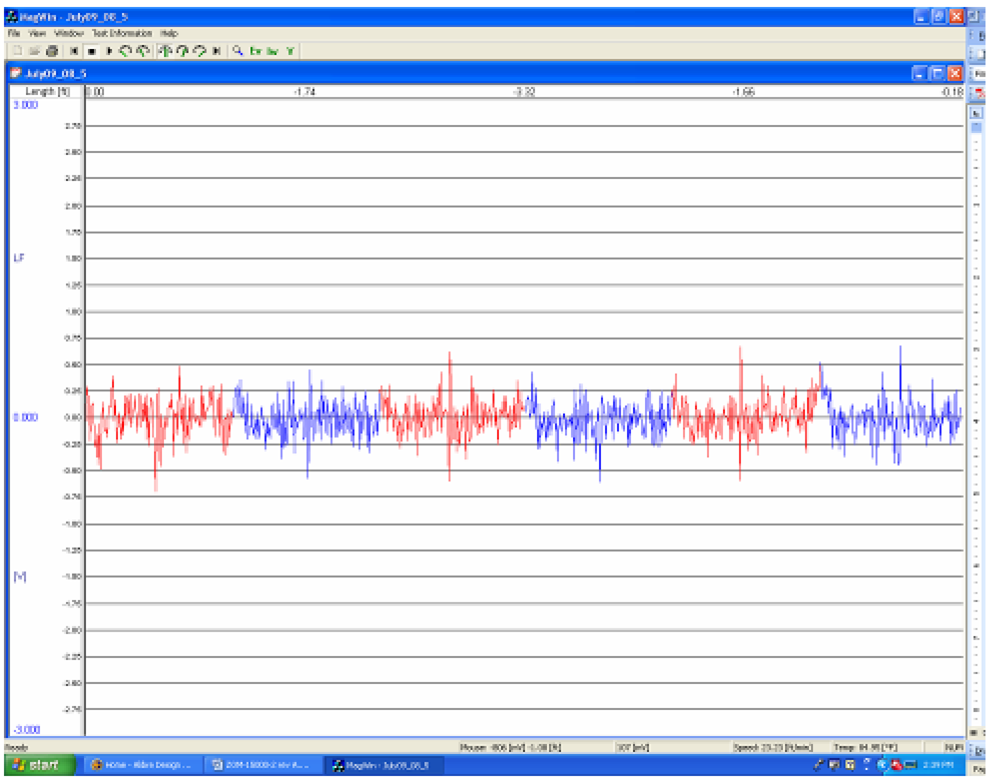

Figure 61

NOTE

The average value of the signal is about +/-.125 Volts and the peak due to the broken wire is approximately .5 to .7volts depending on direction of travel.

The actual size and shape of the peak may vary each time the direction is reversed.

13.0 Scaling Procedure

The MagSens system has been set up at the Zephyr International LLC factory. System scaling procedures are included here in the event the system requires adjustment. One of the only reasons one may need to perform a scaling procedure is possibly due to changing a head and standalone combination. In the event a head is replaced or repaired or swapped between systems the system may need to be rescaled. In the MagWin program, ensure there is a value of 2000 mV in the second row.

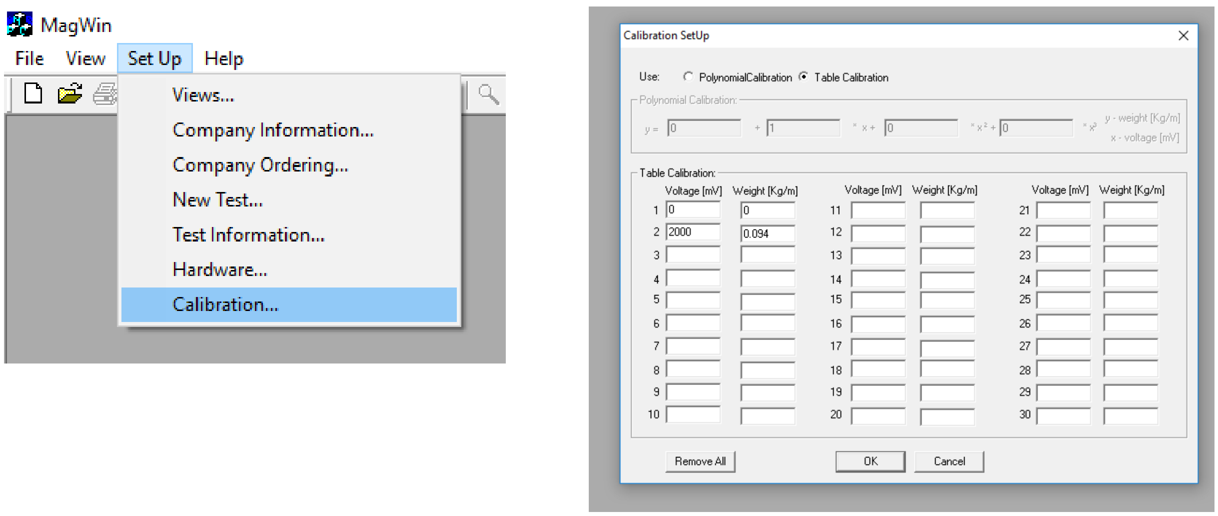

Figure 62 Scaling SetUp

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13.1 Perform a full head scaling (refer to Figure 63)

Step 1 Attach the head to the standalone using the MagSens cable. The standalone should be on battery power only.

Step 2 Boot up the laptop and turn on the standalone power.

Step 3 Open the Measurement and Automation program. Open test panels and verify you are looking at channel A1, Input Configuration 'RSE', Auto scale off (unchecked box), then click start.

NOTE

The head should be empty and closed at this point

Step 4 Turn the zero adjustment knob to approximately zero volts as the signal runs.

Step 5 Place the cable standard in the head and close it. Adjust potentiometer to 2000mV or close.

Step 6 Remove the test piece from the head, and close the head.

Step 7 Verify the voltage on channel 1 is close to Zero volts.

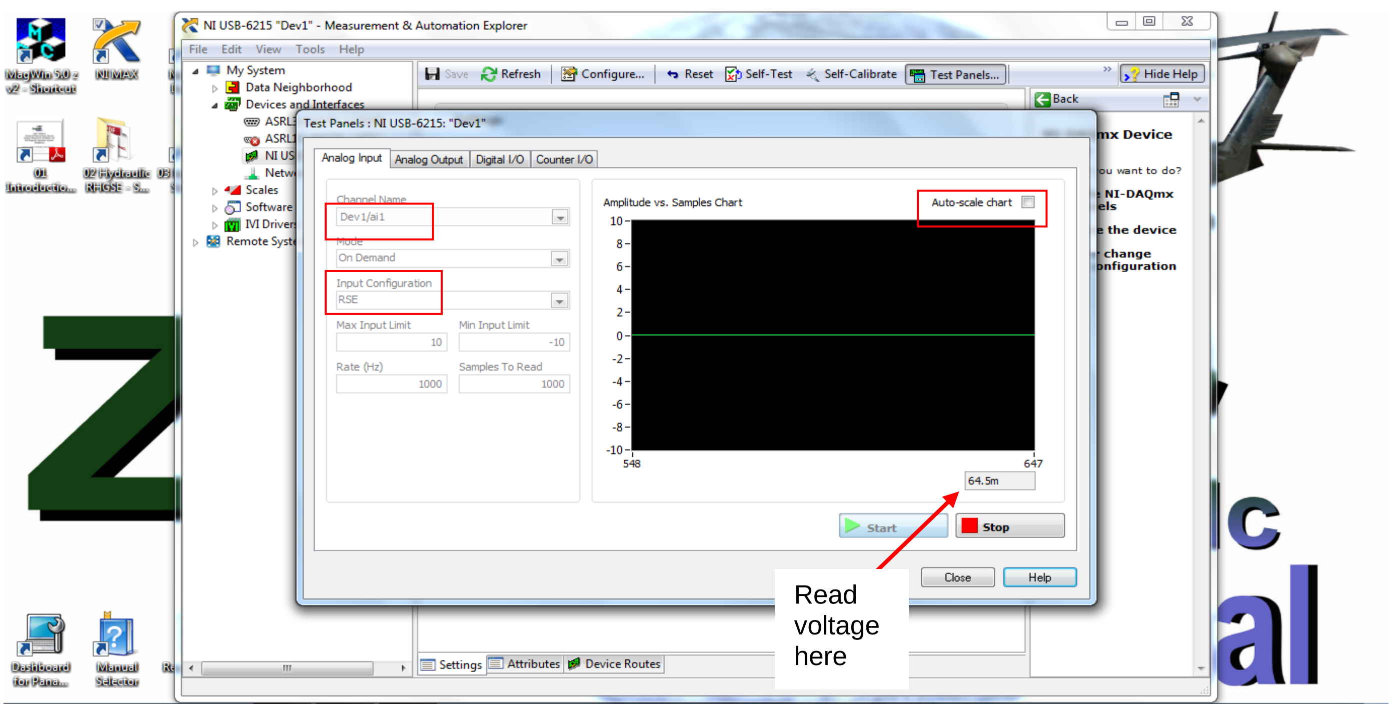
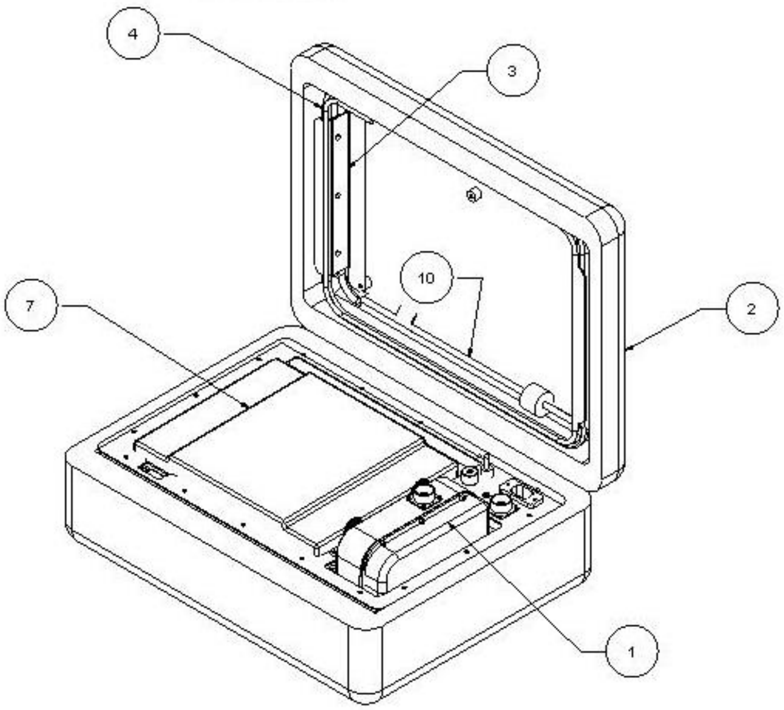


Figure 63 Full head scaling

14.0 Illustrated Parts List

ZGS-15000-3 v1



Item Number	Quantity	Part Number	Part Name	Revision	Comment
1	1	ZGS-10200-2	MagSens 2		
2	1	1500	Case 1500		
3	2	ZGS-10402-1	Cable Retainer Assy		
4	1	PF51518C13120N	Power Cable		
5	1	RR-ABR01-XXG	USB Cable end 1		
6	1	ZGS-10386-1	Panel Subassembly		
7	1	W8	Laptop		
8	1	ZGS-10408-1	Rear Laptop Stop		
9	1		16 V Jack		
10	1	ZGS-10387-1	MagSens 2 Cable		

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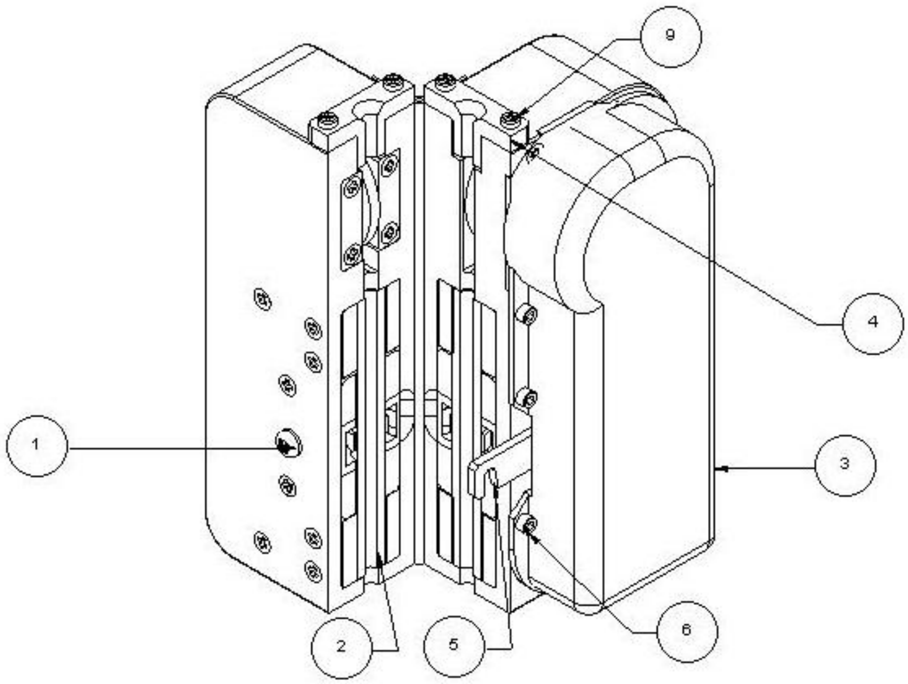
14.1 ZGS-10200-2 repair parts

No other parts can be replaced in the field.



Item Number	Quantity	Part Number	Part Name	Revision	Comment
1	2	ANSI B18.6.3	10-32 x .38 Pan Head Machine Sc		
2	2	ZGS-10235-1	Wire Guide		
3	1	ZGS-10208-1	Cover, Preamp		
4	2	ZGS-10126-1	Lubridryer Bushing		
5	1	ZGS-10051-1	Oiler Latch		
6	6	6-32 SHCS 3/8 Long	6-32 SHCS .375 long		

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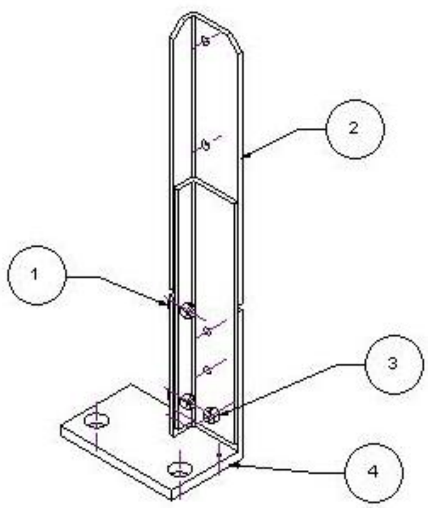
14.2 Upper Upright Extension



Item Number	Quantity	Part Number	Part Name	Revision	Comment
1	3	1/4-20 x .75"	.25 x .75 cap screw		
2	1	ZGS-10245-1	Upright Upper assembly		
3	3	1/4 -20 nut	.25 Locknut		
4	1	ZGS-10085-1	Upright Bracket		

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