LMA-300
TRIPPLE-FUNCTION
WIRE ROPE INSPECTION SYSTEM
Including CC-04-USB Signal Console

Operation and Maintenance Manual

NDT TECHNOLOGIES,Inc.
Wire Rope Nondestructive Evaluation
Know Your Ropes. Know What. Know Where. Know Why.

WARRANTY:

NDT Technologies, Inc. warrants products manufactured by NDT Technologies, Inc. against defects in material and workmanship and will provide parts (except batteries) and labor free of charge for a period of one year after date of shipment.

CAUTION:

Any attempt to disassemble the Sensor Head can cause severe damage and will void all warranties.

CAUTION:

Do not install rechargeable batteries with reversed voltage polarities. This will cause severe damage and will void all warranties.

Note:

NDT_CARE™ requires <u>Excel 2003</u> for proper operation.
(This is necessary because Mircosoft has removed some essential charting features from later versions of Excel.)

Note:

NDT_CARE™ Version 2.10 is now available. NDT_CARE1.06™ should be replaced by NDT_CARE 2.10™ after installation. NDT_CARE 2.10™ is included on a separate USB flash drive.

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APPLICATION

The LMA-300 Wire Rope Inspection System is used in the field to test for and measure loss of metallic cross-sectional area (LMA) caused by external and internal corrosion, wear, broken wires, broken cores and deformations in steel wire ropes. Our Patent Pending Wire Rope Roughness (WRR) Analysis method allows the quantitative characterization (measurement) of internal broken wire clusters and corrosion pitting. A conventional localized-flaw (LF) signal is also available, which can sometimes be useful for locating broken wires and corrosion pitting. However, please note that the LF Signal is unsuitable for determining the number broken wires in clusters.

The LMA-300 Rope Tester was developed as an accurate diagnostic tool for thorough rope inspections. Furthermore, the instrument is well suited for simple routine testing of wire ropes in mining, industrial and military applications where safety and hence the detection of wire rope anomalies is of paramount importance.

Because it can detect rope deterioration in its incipient stage, the LMA-300 Rope Tester is a powerful preventive maintenance tool. For example, the early detection of wear and corrosion allows immediate remedial action which can greatly extend the service life of a rope.

PRINCIPLES OF OPERATION

A section of the steel rope is magnetically saturated in the axial direction by strong permanent magnets. Discontinuities in the rope such as a broken wire, a broken core, corrosion or wear distort the axial magnetic flux, and flux leaks from the rope into the surrounding air space. Sensors, close to the rope, sense the leakage flux. The rope moves, which causes the leakage flux to intersect the sensors. The changing intersecting flux induces signals in the sensors. Electronic circuitry conditions and modifies the signals. Strip chart recorders display the signals visually.

Three different types of signals are available:

  (i) The <u>LOSS-OF-METALLIC-AREA (LMA) SIGNAL</u> gives a quantitative measure of the loss of metallic cross-sectional area of the rope caused by corrosion, wear, broken wires, etc.

  (ii) Using the NDT_CARE (**C**omputer **A**ssisted **R**ope **E**valuation) software, a <u>WIRE ROPE ROUGHNESS (WRR) ANALYSIS</u> of the LMA signal can be performed, which allows the accurate quantitative characterization (measurement) of internal broken wires (single and in clusters) and corrosion pitting.

  (iii) The <u>LOCALIZED-FLAW (LF) SIGNAL</u> can sometimes be useful for locating broken wires and corrosion pitting.

SYSTEM COMPONENTS

The LMA-300 Wire Rope Inspection System consists of the following items:

1 ea.   Sensor Head Assembly comprising
       1 ea.   Magnet Assembly
       1 ea.   Sensor Assembly
       1 ea.   Distance Counter Wheel Assembly

Rope Guides as required

1 ea.   Signal Console CC-04-USB, including Signal Conditioning Circuitry, Integrated Chart Recorder, USB Interface Module, Interface Circuitry and Connectors for external Chart Recorder and external Data Acquisition System.

1 ea.   Battery Charger

1 ea.   External Chart Recorder (optional)

1 ea.   Data Acquisition System (optional)

1 ea.   Connecting Cable, 25 feet long

2 ea.   Carrying Cases

1 ea.   LMA-300 Operation and Maintenance Manual

The Sensor Head Assembly, Signal Console, Battery Charger and other accessories are stored in two Carrying Cases.

In operation, the Sensor Head attaches to the rope by means of rope guides to detect flaws as the rope moves at rates from .03 m/sec (5 fpm) to high speeds of 3 m/sec (600 fpm). Signals are recorded by the integrated chart recorder and by a computer based USB Data Acquisition System. Different rope flaws are then identified from their characteristic chart patterns.

A bi-directional Rope Distance Counter indicates rope position, and a Speed Display shows the speed of the rope under test. Distance marker signals on the test chart indicate every 1 meter (or, optionally, every 1 yard), with emphasis on every 10 meter (or 10 yard), of the rope under test.

LMA-300 Sensor Head

Dimensions (LxWxH) (without handles)................. 13 in. x 5 in. x 10 in. (330 x 127 x 254mm)

Weight.. 75 lbs (34 kg)

CC-04 USB Signal Console

Dimensions (LxWxH) .... 18" x 14" x 7" (457 x 355 x 178 mm)
Weight.. 22 lbs (10 kg).
Batteries.. Rechargeable NiMH batteries.
8 hours of continuous operation.
External battery charger.

Performance

Rope Sizes.. Rope diameters up to 3¼ inch (83 mm)
Rope Speed .... 0.03 to 3 m/sec (0.5 to 600 feet per minute)
Test Signals .... LF and LMA signal, amplitudes
independent of rope speed.
Flaw Detection .... Loss of metallic cross-sectional area
(LMA): external and internal broken
wires, corrosion, wear, broken
cores, various changes of rope
structure.
Localized flaws (LF): broken wires,
corrosion pitting.
Flaw Detectability.. Flaw cross section:
0.1% of rope cross-sectional area.
Quantitative flaw identification of loss
of metallic cross-sectional area for
flaws longer than 2" (50 mm),
qualitative flaw identification for
localized flaws.

Environmental Conditions .... Dust proof, splash proof (oil and
water), humidity to 95%.
Sensor Head sealed with polyurethane coating.
Connectors waterproof to 30 m.
Operating temperature:
0°C to 55°C.
Storage temperature:
-40°C to 55°C.

Readout and Recording

Rope Distance Counter... Digital panel readout.
Event markers indicating every 1 m
(or 1 yard), and emphasizing every 10 m
(or 10 yard) of rope inspected.

Strip Chart Recorder .... Integrated two channel thermal/digital recorder.
External chart recorder (optional).
Rope flaws indicated by characteristic chart
patterns. Signal amplitudes independent of
rope speed. Distance event marker indicating
every 1 m (or 1 yard) emphasizing every 10 m
(or 10 yard) of rope inspected..

USB Module..USB Port connects to any computer.
LED indicates status of USB connection.

Software...*NDT_CARE™ (Computer-Aided Rope
Evaluation)* including *Signal Foundry™*
software for data acquisition, data display,
printout, and chart evaluation.

CC-04 USB SIGNAL CONSOLE, Picture of Control Panel

FUNCTION OF CONTROLS AND CONNECTORS

Controls and Connectors are located on the CC-04 USB Control Panel. A picture of the control panel is shown on the previous page. The functions of the controls and connectors are as follows:

Power Controls

1. **POWER SWITSCH BUTTON** – Switches battery power.
2. **BATTERY CHARGER RECEPTACLE** - Allows charging of the rechargeable batteries from the separate Battery Charger.

Test Signal Reset Button

3. **LMA/LF RESET BUTTON** – Initializes LMA/LF circuits.

Test Signal Connectors

4. **INPUT CONNECTORS** - These connectors, on the Sensor Head and the Panel of the Signal Console, allow signal transmission between Sensor Head and Signal Console.

Rope Distance Counter Controls

5. **DIGITAL DISPLAY** - Indicates rope distance traveled in meters (or yard).
6. **RESET BUTTON** - Resets the rope distance count to zero.

Rope Speed and LMA Balance Controls

7. **SPEED (BALANCE) DISPLAY** - Displays Rope Speed in meters per second (or feet per minute). Alternatively, this display can be used as an indicator for testing the balance of the LMA amplifier circuit.
8. **BALANCE TEST BUTTON –** Used to check for balanced circuit operation.

Integrated Chart Recorder Controls

9. **CHART RECORDER ON-OFF POWER BUTTON** - Switches power for integrated chart recorder.
10. **CHART SPEED CONTROL PUSH BUTTONS** - Start chart recorder and determine chart speed.
11. **RESET PUSH BUTTON** - Stops chart recorder.
12. **LMA AND LF POSITION CONTROLS** - Set the position of LMA and LF traces on the chart.
13. **LMA AND LF GAIN SWITCHES** - Set gains of LMA and LF signals on the chart (coarse adjustment).
14. **LMA AND LF GAIN POTENTIOMETERS** - Set gains of LMA and LF signals on the chart (fine adjustment).
15. **AUTO START SWITSCH** – Allows automatic start or stop of the chart recorder when the rope under inspection starts moving or stops.

Note: The integrated Chart Recorder displays the rope distance indicator signal on the upper margin.

Data Acquisition System Interface

16. **DATA ACQUISITION OUTPUT JACK** - The combined LMA, LF and Event Marker Signals are available at this 37-pin female D-type connector. Using the proper cable, this connector allows an easy and convenient interface with a notebook computer via a PCMCIA card, if required. This output jack can also be used to connect to alternative recording devices such as an external strip chart recorder, etc.
17. **USB TERMINAL** (not visible on picture) – Allows connection to any computer via the USB port.
18. **USB INDICATOR LED** (not visible on picture) – Indicates proper USB connection and operation.

TESTING INSTALLED ROPES

The Electromagnetic Wire Rope Inspection System can perform a highly reliable and accurate diagnostic Loss-of-Metallic-Area/Wire Rope Roughness/Localized-Flaw (LMA/WRR/LF) Inspection. An LMA/WRR/LF Inspection gives a quantitative indication of loss of metallic cross-sectional area caused by abrasion, corrosion, broken wires and other rope deterioration.

1.   Using proper Rope Guides, mount Sensor Head on rope.
     Connect Sensor Head and Signal Console with the connecting cable. Turn on the instrument. Push the LMA/LF Reset Button and the Counter Reset Button.
     Connect the Signal Console with a computer, if required. This is done using the USB ports of the computer and the CC-04 console together with a USB cable.
     If desired, turn on the Auto Start/Stop feature of the built-in chart recorder. This operates the built-in chart recorder automatically as the rope under test moves or stops.

     Note: For sensor head mounting, the lever arm of the distance counter assembly can be retracted. The lever arm and the mounting fixture have one hole each. Note that the lever arm is held in the retracted position by sticking a pin (nail, screw driver, etc.) through the two aligned holes.
     Note: While usually not necessary, it is sometimes useful to perform the following magnetic homogenization procedure before the inspection.
          For an accurate inspection, the rope should be uniformly magnetized. To magnetically homogenize the rope, move it through the Test Head once over its full length. An inspection of the preliminary chart recording will show the presence of spurious rope magnetization, which has been removed. The rope is now uniformly magnetized and ready for LMA/WRR/LF inspection.

2.   Attach a calibration wire of known cross-sectional area (and consequently known percentage of the wire rope's cross-sectional area) to the wire rope under test. Make sure that the rope section with the attached calibration wire will run through the sensor head for each test. This way, the attached calibration wire will appear on chart recordings and in acquired computer data files. (The calibration process will be discussed below in a separate chapter.)
3.   Run approximately 1 m of rope through the Sensor Head, and then push the LMA/LF Reset Button again. It is not necessary to stop the rope while pushing the LMA/LF Reset Button.
5.   Perform LMA/WRR/LF inspection of the rope over its entire length. Inspection from two or more different positions is usually required to cover the entire active length of a rope.
6.   Inspect chart recordings and, if applicable, acquired test data files for LMA, WRR and LF. The exact nature and extent of rope deterioration can be diagnosed from the LMA, WRR and LF traces. Chart interpretation is discussed, among other subjects, in the papers of the Appendix.

In-Situ LMA CALIBRATION

An ***in-situ*** calibration procedure like the approach described in the following is the most accurate and direct method. For an additional discussion of calibration procedures, see the papers of the Appendix.

Calibrating the instrument allows a reading of a rope's loss of metallic cross-sectional area as a percentage of the rope's total metallic cross-sectional area.

Calibration Procedure: *In-Situ* LMA Calibration

1.   The simplest and most direct method of calibrating the LMA output is by comparing the rope cross-sectional area to the known cross-sectional area of a piece of reference wire (or bundle of reference wires).
2.   Procure a piece of reference wire or bundle of reference wires, about 400 mm long or longer. Determine the wire cross-sectional area. Any wires made from ferromagnetic steel (e.g., florist wires, etc.) are suitable for this purpose.
3.   Determine the metallic cross-sectional area of the rope under test. The rope manufacturer can usually provide this information. Alternatively, the table below can be used to determine the rope cross-section.
4.   Compute the percentage change of the cross-sectional area caused by the reference wire(s). Typically, this percentage change could be about 1% to 5%.
5.   Attach the reference wire(s) to the rope under inspection with self-adhesive tape. Make sure that the rope section with the attached calibration wire will run through the sensor head for each test. This way, the attached calibration wire will appear on chart recordings and, if applicable, in acquired computer data files.
6.   Besides serving as a rope cross-section reference, the test wire also establishes a reference location along the length of the rope. This helps to locate the position of anomalies along the rope from corresponding indications on the chart recording.
7.   Run rope test as described above.
8.   Using the built-in chart recorder, the percentage loss of metallic cross-section along the rope under test can be determined by comparing the amplitudes caused by the test wire(s) to the rope anomaly indications on the chart recordings.
9.   Charts created on a computer with the **Signal Foundry™** program are approximately pre-calibrated. A detailed discussion of the **S**ignal Foundry computer program will be presented in a subsequent chapter.
10.   The **NDT_CARE™** (**C**omputer-**A**ided **R**ope **E**valuation) program allows easy and convenient rope evaluation (including calibration) with uncommon accuracy. This is discussed in one of the following chapters.

* Values given are based on 3% oversize because this is a common design "target." But, this figure often varies and is not to be considered a standard. Wire sizes in specific constructions also vary, thus the given values are approximate. They are, however, within the range of accuracy of the entire method that is, in itself, approximate.

It is necessary to know the metallic rope cross-sectional area in order to determine the percentage change of a rope's cross-sectional area.

For diameters other than 1 inch, multiply the area given in this table by the square of the nominal rope diameter.

Example:
Find the area of a 1/2" diameter
6 x 36 WS IWRC rope.
Answer:
Value from the table: .485
Diameter squared: $(1/2)^2 = 1/4$ or .5 x .5 = .25
Multiply table value by diameter squared:
Area: .25 x .485 = .121 inch^2

Example:
Find the area of a 1-1/4" diameter
6 x 25 FW FC rope.
Answer:
$(1.25)^2$ x .417 = 1.563 x .417 = .652 inch^2

Example:
Find the area of a 28 mm diameter
6 x 37 FW IWRC Rope.
Answer:
28^2 x .493 = 386 mm^2

APPROXIMATE METALLIC AREAS OF ONE-INCH ROPE OF VARIOUS CONSTRUCTIONS*			
Construction	Fiber Core	IWRC or WSC	Cable Laid
5 x 7	.390	.457	
6 x 6	.320	.386	
6 x 7	.384	.451	
6 x 12	.232		
6 x 19 12/7	.376	.442	
6 x 19 S	.404	.470	
6 x 19 W	.416	.482	
6 x 21 FW	.412	.478	
6 x 21 S	.411	.477	
6 x 24 15/9	.329		
6 x 25 FW	.417	.483	
6 x 26 WS	.409	.476	
6 x 29 FW	.420	.486	
6 x 31 12/19	.385	.452	
6 x 31 WS	.414	.481	
6 x 33 FW	.423	.490	
6 x 36 WS	.419	.485	
6 x 37 18/19 W	.393	.459	
6 x 37 FW	.427	.493	
6 x 41 SFW	.425	.491	
6 x 41 WS	.424	.490	
6 x 42 Tiller	.231		
6 x 43 FWS	.392	.458	
6 x 46 SFW	.425	.492	
6 x 46 WS	.426	.492	
6 x 61 FWS	.408	.474	
7x7		.471	
7 x 19 12/7		.466	
7 x 19 W		.505	
8 x 7	.343	.474	
8 x 19 S	.359	.472	
8 x 19 W	.366	.497	
8 x 25 FW	.368	.499	
8 x 19 FW	.366	.499	
18 x 7	.422		
19 x 7		.453	
6 x 3 x 19			.122
7 x 7 x 7			.343
7 x 7 x 19			.361

CHECK LMA BALANCE

1. To check for LMA balance of the system, connect Sensor Head and Signal Console with the Connector Cable (important!). Do not attach the Sensor Head to a rope and keep moving ferromagnetic objects away from the Sensor Head.
2. Turn on the Instrument.
3. Push the LMA/LF Reset Button.
4. Then push the Balance Test Button.
5. Observe the voltage on the Speed/Balance voltmeter. For a balanced condition, the Balance Sensor Signal should oscillate in a random fashion close to or around zero. This means that, over time, the Balance Voltmeter should show a very small voltage that irregularly oscillates.
6. Balance is lost if the Balance Voltmeter cannot be prevented from saturating. This indicates malfunction of the instrumentation. In this case contact NDT Technologies, Inc.

   Note: Discharged batteries can cause imbalance conditions. Before checking balance of the instrument, charge batteries.

Integrated Chart Recorder Operation

1. Turn on chart recorder power by pushing the RECORDER POWER button.
3. Set GAIN potentiometers to their calibrated settings. Adjust position of traces on the chart with the POSITION potentiometers. These settings are usually determined by trial and error and documented for use during subsequent inspections.
4. Push one of the SPEED buttons for recording at desired speed. The chart is stopped by pushing the RESET button.
5. Alternatively, with the Auto Start/Stop Switch on, the chart recorder will record and stop when the rope under test moves and stops, respectively.
5. The Distance Marker Signal indicating each meter of rope traveled is displayed on the upper margin of the chart, with an enhanced marker signal at ten meter intervals.
7. Turn off chart recorder power by pushing the RECORDER POWER button again.

BATTERY CHARGING

The batteries are recharged by the external Battery Charger via the Battery Charge Jack. Please use only the **<u>Smart Charger</u>** that comes with the equipment.

Connect the Smart Charger exactly as follows in the indicated order.

1. Plug the Smart Charger into the "Charger" Jack.

2. Only then plug the Smart Charger into the AC power outlet.

3. Observe the LED Indicator Light while charging.

   a. *Red* light indicates *charging* of the batteries.

   b. *Green Flashing* light indicates *trickle charging*. This will happen after about 2 hours.

   c. *Green* light indicates *fully charged*.

Charge for approximately 3.6 hours at a 0.4 A current level setting of the charger.

Please note that nickel-metal hydride (NiMH) batteries have a tendency to discharge over time. Therefore, re-charge the batteries before each use.

BATTERY REPLACEMENT

Used batteries can be replaced by new *nickel-metal hydride* batteries.

Please contact NDT Technologies. Inc. for instructions.

EXCHANGE OF ROPE GUIDES AND USE OF END CLAMPS

1. The instrument comes with one or more Rope Guides made from UHMW polyethylene and/or an End Clamp Set consisting of aluminum end clamps and self-adhesive UHMW polyethylene wear tape. Note that all rope guides can be used for ropes with diameters smaller than the nominal rope guide diameter.
2. For testing, install appropriate plastic Rope Guides. Loosen the screws from sensor head pole pieces. After replacing guides, tighten screws.

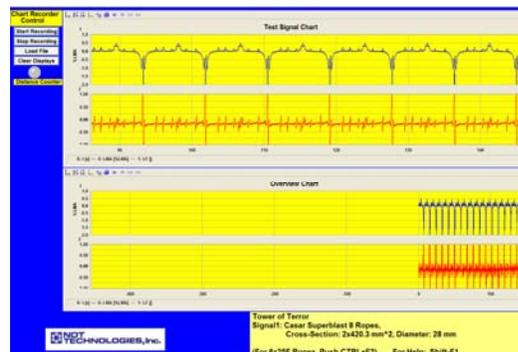**<u>Note:</u>**   Do not use instrument without rope guides!

<u>Note:</u>   Keep Sensor Head and Rope Guides clean. Sensor Head and Rope Guides can be cleaned with most cleaning compounds. Iron filings can be removed from Magnet Assembly by using self adhesive tape.

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Signal Foundry Version 1.06, Software - Instructions

1. Sensor Heads of different sizes require different versions of the Signal Foundry software. The LMA-300 Sensor Head is compatible with **LMA-300 Signal Foundry.**
2. The **Signal Foundry** data acquisition software allows pre-calibration of the acquired LMA signal. However, it is highly recommended to use the post-calibration procedure described on pp. 9 and 20 of this manual for a more accurate, reliable and error-free calibration of the test results.
3. Upon opening the program, the *Help* Panel will appear. It gives instructions for choosing the proper Chart Recorder Panel and chart recorder operation.

4. For proper operation, make sure that the LED of the USB Module (on top of the CC-04 console front plate) is turned on.
5. Ropes with different diameters and constructions can be inspected by selecting the appropriate panel. This can be done by pushing CTRL+F1 ….. CTRL+F5, respectively. The LMA signals for all panels are (approximately) pre-calibrated for their respective rope sizes and constructions, as indicated at the bottom of each panel. A typical Chart Recorder Panel is shown below. (This panel shows a laboratory recording of a rope test loop.)

6. Each Chart Recorder Panel displays two different charts: (a) the *Test Signal Chart*, which shows the LMA and LF traces in detail, and (b) the *Overview Chart*, which offers an overview of the overall rope condition.
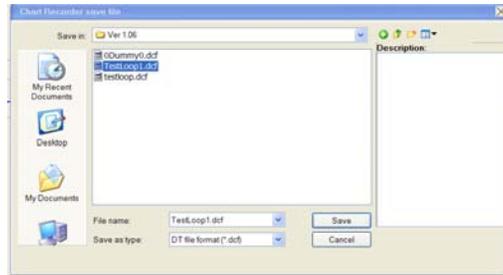
OPERATION

1. Both chart recorders in each panel are operated by the chart recorder controls as shown.

    Data acquisition is started, and both chart recorders in a panel are turned on by pushing the **Start Recording** button. Recording is stopped by pushing **Stop Recording**.

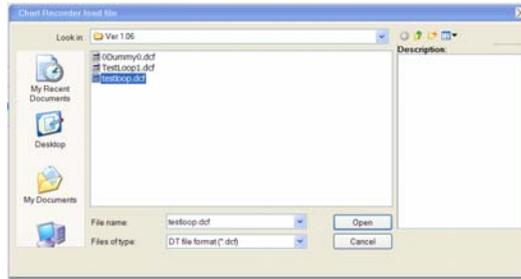   Upon pushing **Start Recording**, the following dialog box appears

    Specify a file where the data will be stored. Note that data is stored simultaneously as a binary (*.dcf) file and as an ASCII (*.txt) file. The ASCII file can be used for signal analysis by the NDT_Care™ (Computer Aided Rope Evaluation) program. Push the **Save** button to start the recording operation.

    These files contain 3 channels of information; Channel 1: LMA Trace, Channel 2: LF Trace, and Channel 3: Distance Counter Signal.

    Note that the chart recorders in each panel must be stopped before moving (i.e. by pushing CTRL+F1 or CTRL+F2) to another panel.

2. The **Distance Counter LED** flashes as the rope moves and turns the distance counter wheel of the sensor head. This allows suppression of the Distance Counter Signal in the chart recordings while still monitoring proper operation of the distance counter.

3. For **signal playback** push *Load File*. The following dialog box appears

4. Select a file, and push the *Open* button. The file will be displayed by the (upper) *Test Signal Chart* recorder. The (lower) *Overview Chart* recorder displays the most recently acquired signal. Note that each individual file can be displayed by only one chart recorder in all panels. To reset all chart recorders push *Clear Displays*.

5. *Click and Drag* to select and enlarge a chart section, as required.

The **Chart Recorder Toolbar** allows control of the chart display during recording and playback. For example, you can magnify and stretch sections of the charts, and the charts can be scrolled backward and forward for easier examination. Further, you can change the axis setup as required, and channels can be suppressed or made visible. You can print the charts with any printer. The Chart Recorder Toolbar is described in the following.

6. **Chart Recorder Toolbar**

The Chart Recorder panel allows you to record incoming data from one or more channels to a .DCF file and an ASCII data file.

Each Chart Recorder panel contains a toolbar, which lets you do the following:

Axis setup - Opens the Axis setup dialog box, which allows you to adjust the range of the   y-axis for each channel.

Autoscale - Adjusts the scale of the y-axis to the minimum and maximum values of the actual input signal(s). To set the scale of the y-axis back to the default range, click the Autoscale button again.

Capture scale - Sets the scale of the y-axis to the minimum and maximum values of the first input signal(s) in the buffer.

⊥ **Default scale** - Returns the scale of the y-axis to its default settings.

∿ **Cursor panel** - Shows/hides the reference cursors. (Not used for this application.)

🖨 **Print** - Prints the Chart Recorder panel data.

👁 **Channel visibilities** - Opens a dialog box that allows you to select which channels you want to display on the Chart Recorder panel.

H **Hold** - Stops the automatic update of the display when new data arrives. When you release the Hold button, the display jumps to the end of the data.

<< .and >> **Scroll backward and Scroll forward** - After you have loaded a file into the Chart Recorder panel, allows you to scroll through the data in the file.

NDT_CARE™ Software, Version 2.00 - Instructions

Note: NDT_CARE™ requires <u>Excel 2003</u> **for proper operation.**
(This is necessary because Mircosoft has removed some essential charting features from later versions of Excel.)

Note: NDT_CARE™ Version 2.00 is now available. NDT_CARE 1.06™ should be replaced by NDT_CARE 2.00™ after installation.

Note: Open **Template(Roughness).xls**. This will install an appropriate chart format into the Excel gallery. (This has to be done only once before using NDT_CARE 2.00.)

The **NDT_CARE 2.00** pull-down menu contains the following menu items:

1. The first step is to open a data file saved by the **NDT Signal Foundry** data acquisition program in the Excel compatible *.txt format. These files contain (3) channels of information; Channel 1: LMA Trace, Channel 2**:** LF Trace, and Channel 3: Distance Counter Signal. From the **NDT** pull-down menu select **Open File**. This pull-down includes .txt or ASCII (.asc) files acquired with two Data Acquisition software packages (*NDT Signal Foundry™* or DASYLab). It is also possible to download legacy Comma-Separated-Value (*.csv) files.
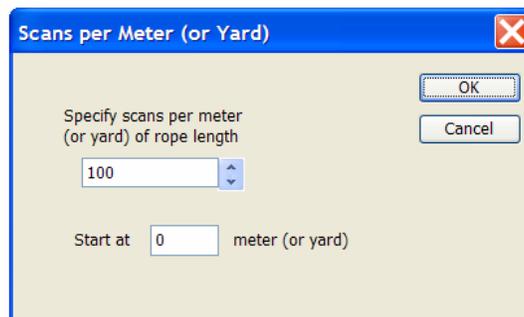
    Choose **Foundry (*txt)** in accordance with the **Signal Foundry** software package. An Open File dialog will appear. Find the directory where your file (for example, **testloop.txt**) is located and open it.

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2. After the file loads into Excel, the Status indicator will appear as follows showing the file that was opened, the directory information from which it came, the file size, the date and time the file was created, and the status. This status indicator, located on the File sheet, will keep a log of all operations performed throughout the use of the NDT_CARE™ software.

The **NDT_CARE™** software works with the understanding that there is a distance counter signal on the 3rd channel.

3. In the event you have a defective Distance Counter Signal, or are using a Sensor Head which does not have a distance counter, you can use the **Insert Time Markers (1sec)** feature from the **NDT_CARE** pull-down menu. After inserting time markers, all charting capabilities are available. However, the parameters used for **Signal Enhancement** (see Item 8 below) are now inspection speed dependent.

4. The next step is to display the file as a chart. From the **NDT_CARE** pull-down menu, select **LMA-LF Display**. The chart can be displayed in the **Forward** or **Reverse** direction.

You will then be asked to "Specify scans per Meter (or Yard) of rope length." The default is 100. By increasing or decreasing this number, the scaling of the distance axis increases or decreases. Increasing the number spreads out the chart. At this point, you can also choose where (distance) you want to begin drawing the chart.

5. An **LMA-LF Overview** (**Forward** or **Reverse**) chart can also be displayed, which will show the entire file of the wire rope under test on a single chart.

6. The **Synthetic LF** feature allows the user to digitally create an LF trace based on the LMA trace. This feature was developed for experimental purposes and is not used for regular inspections.

Note: Before proceeding to any of the charting enhancement features (**LMA Enhance, LMA Calibrate**, **LMA Level Adjust**, or **LMA Post-Calibrate**), all charts of interest must already be drawn. When any of these enhancements are called upon, all drawn charts – and only all drawn charts – will be affected.

Note: It is advisable to use the following **LMA Enhance** feature next, before proceeding.

7. A distinctive element of the NDT_CARE™ software is **signal enhancement**. This unique feature allows LMA measurements with unprecedented accuracy and resolution. From the NDT pull-down menu, select **LMA Enhance**.
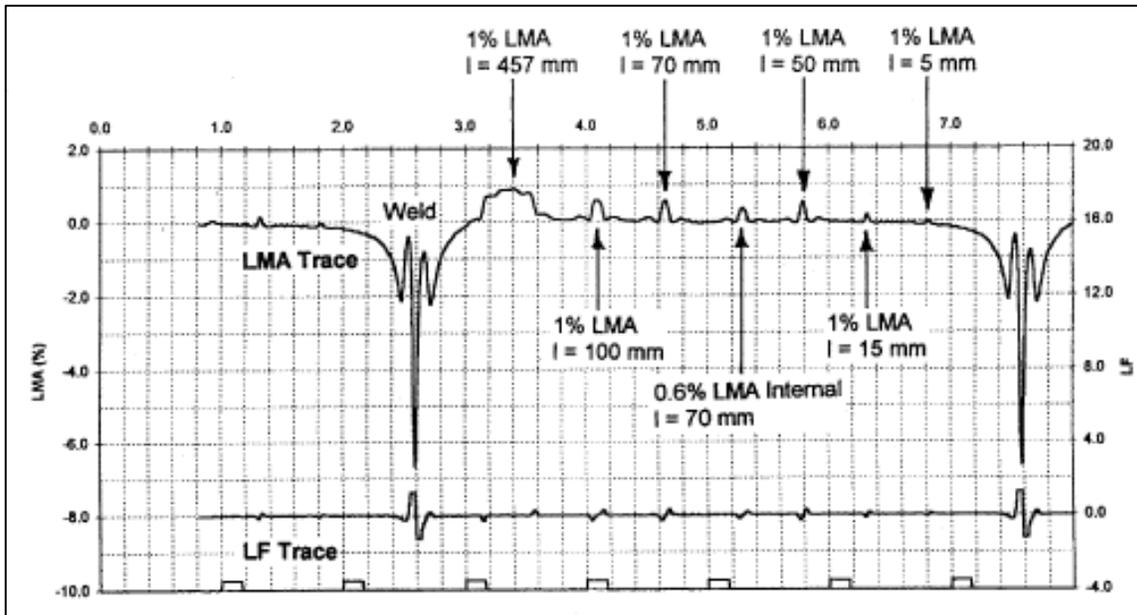The following dialog box will appear

The parameters "Tau" and "Alpha" are selected to get the optimum inspection accuracy of the enhanced charts. Each sensor head has its own set of values. The values of "Tau" and "Alpha" shown are for an LMA-175 Sensor Head. Other Sensor Heads will have their own values.

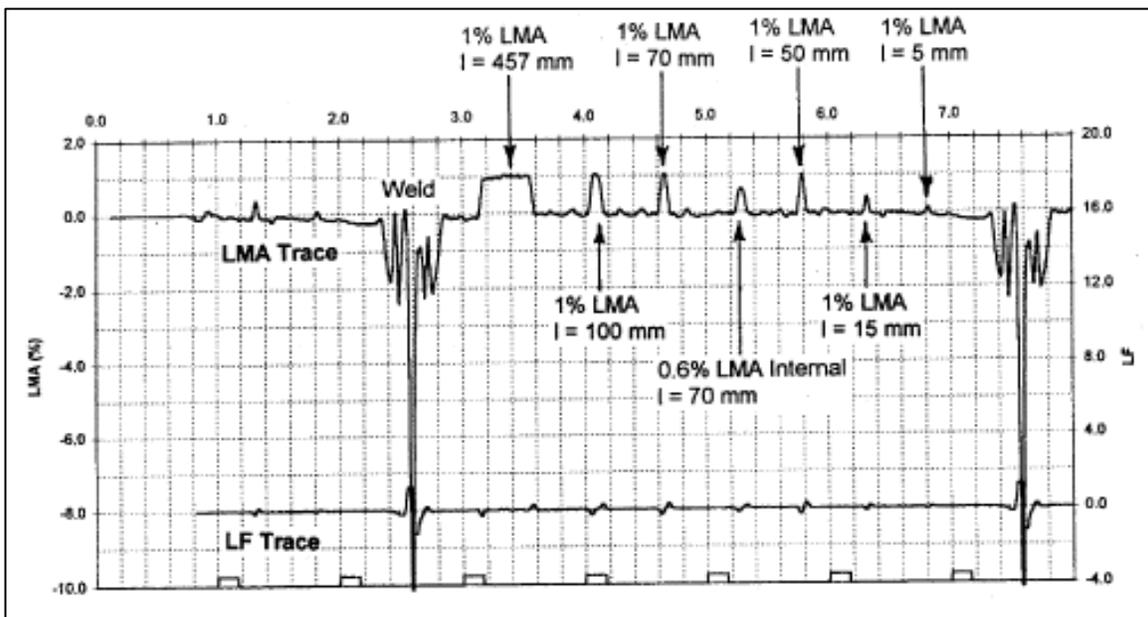| LMA Sensor Head	"Tau"	"Alpha"
LMA-125	0.13	0.25
LMA-175L	0.155	0.19
LMA-175	0.13	0.25
LMA-250/300	0.20	0.25
For other Sensor Head settings, please contact NDT Technologies.		

You may want to experiment with these values a bit in order to fine tune your results. The Signal Enhancement procedure is illustrated by the following charts.

For a further discussion of the Signal Enhancement process please refer to the Appendix.
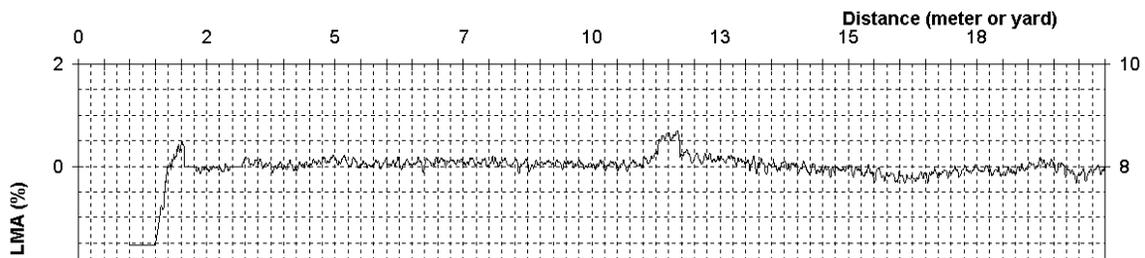
Before Enhancement

After Enhancement

8. Another useful feature is **LMA Post-Calibrate**. This feature can be used to calibrate the LMA Trace with increased accuracy. In this case, the inspector attaches a calibration wire of known cross-sectional area (and consequently known percentage of the wire rope's cross-sectional area) to the wire rope under test. The attached calibration wire will then appear in the acquired data file. To Post-Calibrate, click once on the LMA Trace to highlight it, click once again on the top of the calibration wire signal, and click and drag that point to its corresponding LMA percentage value
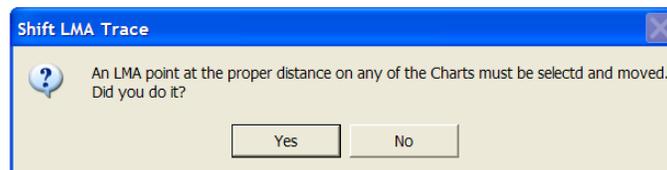
along the LMA % axis. As before, a little "tick mark" will appear on the LMA % axis to help get it just right. Next, select **LMA Post-Calibrate** from the NDT pull-down menu. A dialog will appear asking if you adjusted a point on any of the Charts. When you click "Yes," all drawn charts will reflect the new calibration.

9. To adjust the baseline of the trace of the charts to another position (away from zero, for example), the **LMA Level Adjust** feature from the NDT pull-down menu is used. This is useful if the inspection was started on a deteriorated rope section. Prior to selecting **LMA Level Adjust**, you must select a point on any of the drawn charts in the same manner as during the calibration process. First, click once on the LMA trace to highlight it, and then click once again on the trace to select a point that you will be moving. Finally, click and drag the point to a place upward or downward where you want to establish the new baseline. As before, a little "tick mark" will appear on the LMA % axis to help get it just right. After this is done, select **LMA Level Adjust** from the NDT pull-down menu. A dialog asking if you adjusted a point on any of the charts (as described above) will appear. When you click "Yes," all drawn charts will reflect this new baseline.

10. The Distance Offset feature allows the user to eliminate an unwanted portion of the LMA and LF traces at the beginning of an inspection. The following illustrates this feature.
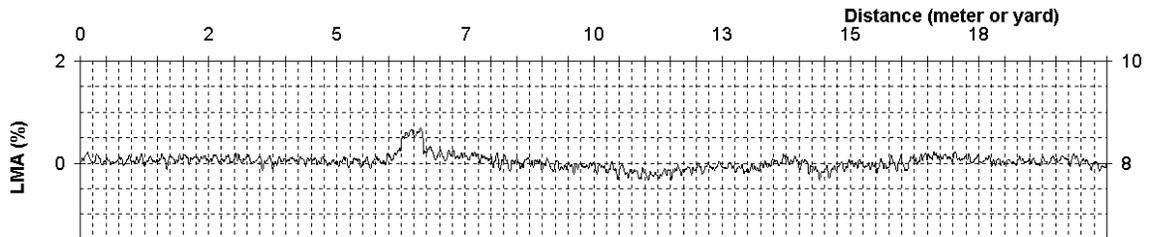

On the chart above, the user can eliminate the LMA trace up to the 5 meter part (and consequently have the new chart start at the point where 5 meters is now).
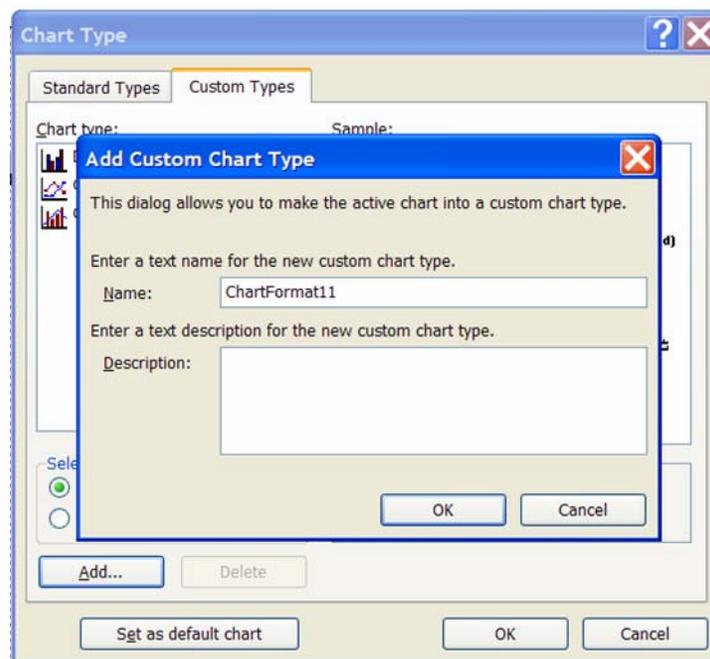
a. To accomplish this, click on the LMA Trace once, then choose (on the trace) where you want the new chart to start (in this case 5 meters), and click and drag upward or downward a bit to establish that point.

b. Select Distance **Offset** from the NDT_CARE menu. The following dialog will appear:

c. After selecting "Yes," the user will be asked to specify scans per meter (as above). A new chart will then be drawn as shown below. Note that the new "0" point is where the old "5 meter" point was.
    Note: This feature does not work for a chart drawn with "Overview".

12. The next option is the ability to modify how the charts look and to be able to store your settings. All charts use a user-defined template called **ChartFormat11**. If you want to change how this default template draws charts, you would make your changes as follows:

   a. Use one of the charts to create the chart appearance you desire, (for example you can change the color of the LMA Trace to red). Then from the **Excel** menu bar (Excel 2003), select the **Chart** pull-down menu. Next, select **Chart Type**. On the next screen, choose the **Custom Types** tab button then select the **User-Defined** radio button and click the **Add** button. The following screen will appear.

   b. Now, you must choose **ChartFormat11** as the Format Name. This name must be spelled exactly as indicated (with upper and lower case letters) because the software looks for **ChartFormat11** when it draws charts. You will be replacing the original (default) **ChartFormat11** when you do this. (You do not have to enter a Description.) Click OK, and a dialog will ask if you want to replace the existing user-defined format. Choose OK, and then close the next screen.
   c. Finally, select **Redraw All LMA_LF Charts** from the **NDT_CARE** pull-down menu. When you do, your new chart format will be reflected in all (and future) drawn charts.

13. The **Print LMA-LF Charts** does what it implies, and when selected from the NDT_CARE pull-down menu will print all drawn charts.

14. The **Undo All** feature allows the user to undo all the Calibrate and Enhancement operations on all drawn charts. The charts themselves will still remain and have their original appearance.

Note that the LF signal gives only a qualitative indication of broken wires and corrosion pitting. It cannot be calibrated or used to determine the severity of the rope damage. Therefore, it cannot be used for making rope retirement decisions.

A new feature introduced to NDT_CARE™ 2.00 is its ability to estimate and quantitatively characterize **Wire Rope Roughness (WRR)**. Because it is a quantitative signal, WRR can be calibrated and used for making rope retirement decisions.

> Here, **Wire Rope Roughness (WRR)** is defined as the combined surface roughness of all external and internal wires in a rope.

Typically, WRR is caused by corrosion pitting, interstrand nicking, and by broken wires and clusters of broken wires. The WRR feature allows you to estimate the severity of this type of rope deterioration.

In the absence of corrosion pitting, this feature can be used to estimate and quantitatively characterize the number of internal and external broken wires – single and in clusters – per unit of rope length.

Note: The WRR charts are created by using the corresponding LMA-LF charts. They reflect all modifications of their associated LMA-LF charts. For example, if the LMA-LF charts have been calibrated, the corresponding WRR charts will also be calibrated, etc.
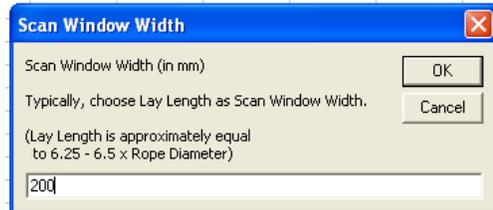
Hence, before proceeding to creating the WRR charts, all of the above LMA-LF charts should be established in their desired form.

Using NDT_CARE™, you should take the above steps in the following order.

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1. Open File.
2. Display LMA-LF Charts. Forward or Reverse
3. Display LMA-LF Overview Charts. Forward or Reverse. Optional
4. LMA Enhance. Optional.   (Recommended before proceeding further)
5. LMA Calibrate. Optional.
6. LMA Level Adjust. Optional.
7. Distance Offset. Optional.
8. Display Rope Roughness Charts. Requires established LMA-LF charts.

15. <u>Please Remember:</u> Before proceeding to the WRR section of the pull-down menu, make sure that all desired adjustments – like calibration, etc. – have been made in the LMA-LF section of NDT_CARE™.

    Then, on the pull-down menu, click **Rope Roughness Charts** to create the WRR charts. The following dialog box will appear.

    This dialog box asks for the width of the sliding window on the rope that is used to scan the LMA trace along the entire length of the rope in order to determine the WRR. Typically, the rope's lay length can be used as window width. However, other values are possible. You might want to experiment a little bit.
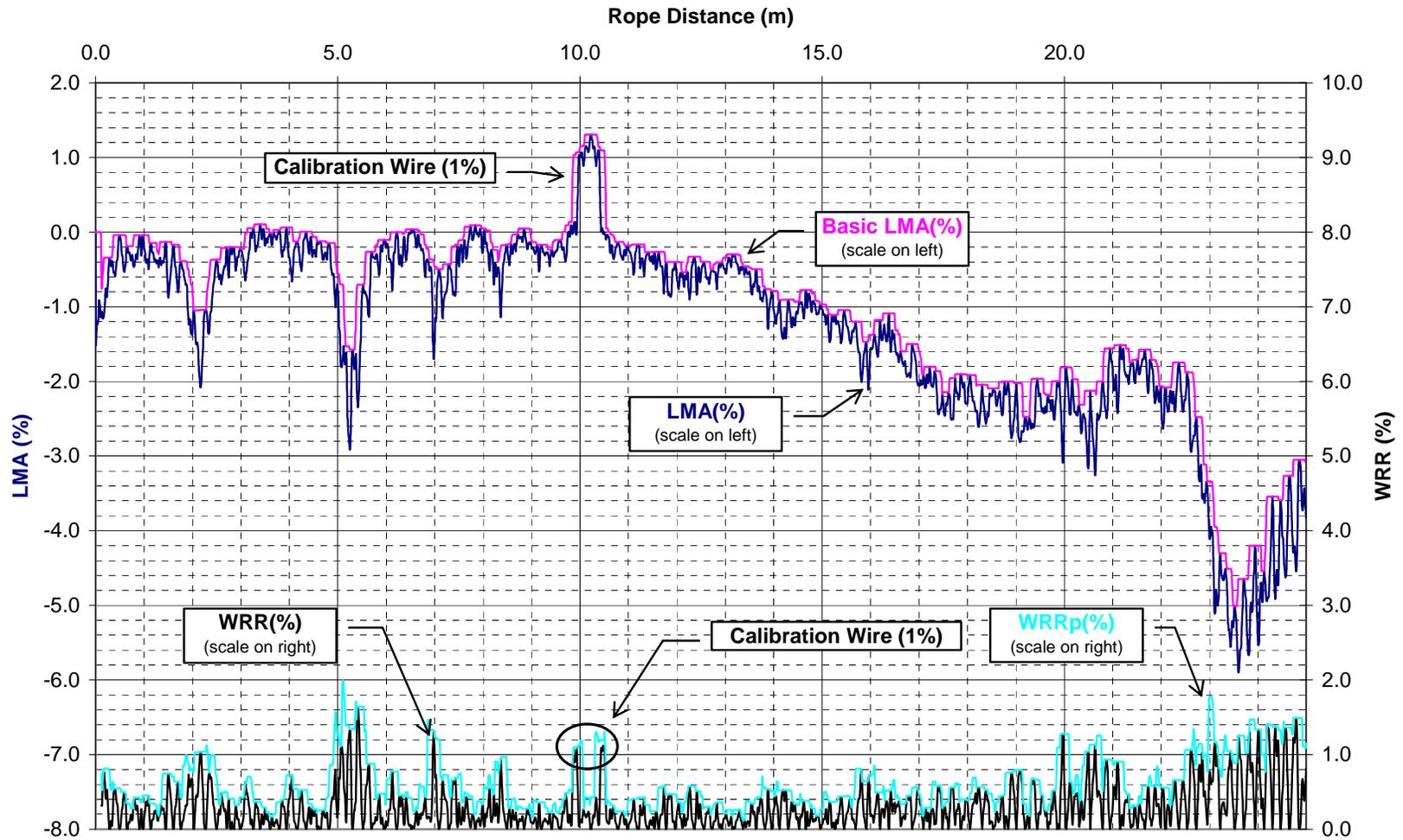
    The program will then proceed to create the LMA-WRR charts. The appearance of a typical LMA-WRR chart is shown on the following page.

    This chart shows four traces as follows.

    i.   LMA(%) – The original LMA trace after modification as indicated in the chart title.

    ii. Basic LMA(%) – The idealized LMA trace without the effects of corrosion pitting and broken wires.

    iii. WRR(%) (Wire Rope Roughness) – A quantitative indication of corrosion pitting and broken wires.

    iv. WRRp (Peak Values of WRR) – An alternative representation of WRR.

16. Menu items **Print Rope Roughness Charts** and **Redraw Rope Roughness Charts** do exactly what their names imply.

    Note that all WRR Charts use a user-defined template called **ChartFormat(Roughness)** that is stored in the Excel Gallery. You can change this template just as you would change the LMA-LF Chart template (ChartFormat11) as described in Item 12 above.

17. Menu item **Modify Rope Roughness Charts** is experimental only at this point.

C:\Documents and Settings\Herbert Weischedel\My Documents\Dropbox\Public\Quantitative LF\32mmropexf2.ASC
/Rope Roughness

Appendix