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

# Magnetic Wire Rope Testing (MRT) 2018: The State of the Art

**Herbert R. Weischedel**

## Summary


Wire ropes are both, **safety critical** **and** **single points of failure**. Because their failure always has very serious consequences – like loss of life, serious injury and/or – frequently huge – financial losses wire ropes are also **mission critical**. Therefore, wire rope failures are – or should be – unacceptable. They must be prevented at all cost.

Wire ropes are complex machines with a great many moving parts. They require attention, skilled operators, careful maintenance, inspection and lubrication.

And yet, in spite of their mission critical importance, wire ropes are frequently treated as and considered low-tech, uninteresting commodities. Failures are viewed and accepted as "inevitable."

Traditional preventative maintenance and replacement schedules – if followed at all – typically are based on some form of in-service visual inspection combined with a large amount of guesswork. MRT examinations are frequently performed with equipment of dubious pedigree by inspectors with inadequate skills.

While some 'best practice' rope examination methods, discard criteria and maintenance procedures are available, they are frequently not applied. Entire operations are jeopardized by an unexplained and sometimes perplexing reluctance to use existing wire rope safety procedures.

The above mentioned **systemic problems have caused a serious credibility crisis** for the entire MRT community.

On the other hand, over the past few years, NDT Technologies has undertaken a vigorous R&D effort. We have made tremendous progress that is unprecedented in the industry.

Our accurate and reliable MRT instrumentation together with our sophisticated rope evaluation algorithms/software will greatly alleviate the above mentioned systemic problems. They will finally make the **Retirement-for-Cause** and **Condition-Based Maintenance/Retirement** approaches for wire ropes feasible.

This paper discusses the following topics:

- Our 'New Generation' Magnetic Wire Rope Inspection (MRT) Systems for Ropes up to Φ 165 mm
- Our Continuous Wire Rope Monitoring System (CRMS)
- Systemic and Credibility Problems
- MRT Hardware/Software Performance Validation
- Inspector Training and Qualifications

# Preface

Wire ropes are both, **safety critical and single points of failure**. Here:

1. A **safety-critical system** or **life-critical system** is a system whose failure or malfunction may result in one (or more) of the following outcomes:
   - death or serious injury to people
   - loss or severe damage to equipment/property
   - environmental harm
2. A **single point of failure** (**SPOF**) is a part of a system that, if it fails, will stop the entire system from working. While SPOFs are undesirable in any system, high-value offshore and most other ropes are SPOFs that usually cannot be eliminated.

Failures of high-value offshore and most other ropes – which are both, **safety critical <u>and</u> single points of failure** – are unacceptable. Besides loss of life, they can cause catastrophic losses in the seven, eight or, maybe, even nine figures range. These huge losses can significantly affect the bottom line and the reputation of even giant corporations.

Wire ropes must also be considered as **mission critical**. Here

3. **Mission critical systems** or **business critical systems** are defined as systems whose failure will cause extreme losses for a business.

The above situation is illustrated by the following logical diagram that shows wire rope as a system component that is – at the same time

- ▷ **Safety Critical,**
- ▷ **a Single Point of Failure, and**
- ▷ **Mission critical.**


Wire ropes are complex machines with a great many moving parts. They require attention, skilled operators, careful maintenance, inspection and lubrication.

In spite of their mission critical importance, wire ropes are frequently treated as and considered low-tech commodities without much interest. Failures are frequently accepted as "inevitable."

All too many – usually serious – wire rope failures prove that present rope inspection methods, discard criteria and maintenance procedures leave a lot to be desired.

Traditional preventative maintenance and replacement schedules usually follow either one or both of two approaches:

1. ***Statutory Life Policy*** – i.e., rope retirement at certain prescribed intervals. (A *Statutory Life Policy* places a maximum on the time a rope can be in service).

   However, a Statutory Life Policy is inherently either wasteful or dangerous.

2. Therefore a ***Retirement-for-Cause*** or ***Condition-Based Retirement*** **Policy** is considered more desirable.

   This approach is typically associated with some form of in-service inspection – MRT (**M**agnetic **R**ope **T**esting) and/or visual procedure.

   Realistically, *Retirement for Cause* retirement policies could extend the life of wire ropes and especially high value ropes by several years, and possibly double their useful service life.

   Considering the actual replacement cost of very expensive high-value offshore ropes together with the true cost of a potential rope failure, their safe life extension offers considerable and obvious cost savings.

   However:

   - Since modern wire ropes typically deteriorate internally and/or are covered with grease visual inspections are notoriously unreliable.
   - MRT inspections, more often than not, are performed with instruments of dubious pedigree and/or by inspectors with lacking skills, usually supplemented and embellished by a large amount of educated or blind guesswork.

   Therefore, straight Retirement-for-Cause policies are mistrusted and rarely used.

The above considerations are of major concern to various safety authorities, government agencies, insurance companies and classification societies. This situation is also seriously considered by middle and upper level management, and by opinion leaders and decision makers in the wire rope community. Any person directly or indirectly responsible for maintenance, inspection, or the use of wire rope can be – more or less – held accountable if and when it fails.

## Wire Rope Nondestructive Examination/Evaluation: The Future

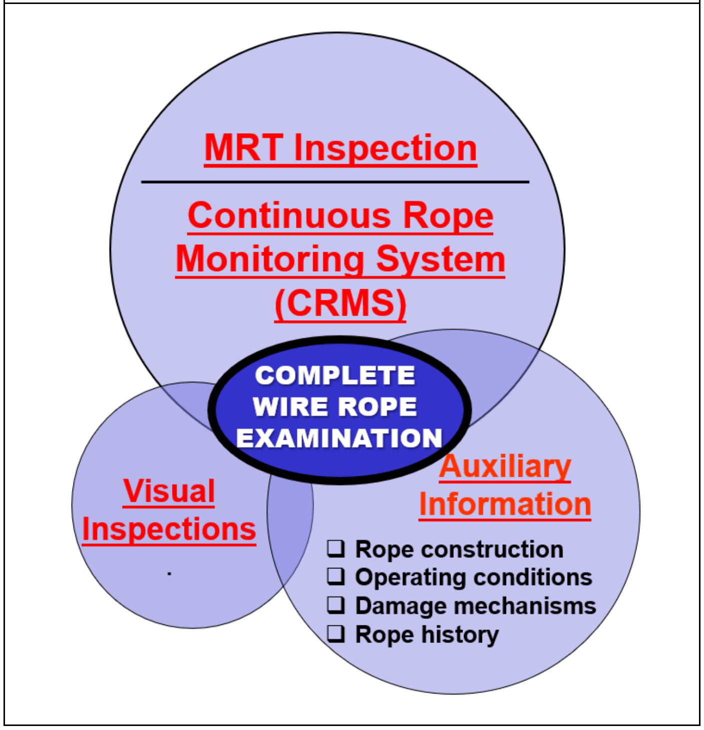
Considering the above situation, the practice of wire rope examination/evaluation will drastically change in the future.

1. MRT NDE will become the indispensable and primary wire rope inspection method. For high-value and extremely safety-critical special applications, continuous rope monitoring systems (CRMS) will become mandatory.
2. Visual Inspections will be a minor – albeit important – complement of MRT NDE.

3. Auxiliary information on rope construction, operating conditions, damage mechanisms and failure modes, rope history, etc. is an important component of a complete wire rope NDE.

The above situation is illustrated by the following logical diagram.

**Future Development of Wire Rope MRT NDE**




## Magnetic Wire Rope Testing (MRT): State of the Art


Over the past few years, NDT Technologies have undertaken a vigorous R&D effort. We have made tremendous progress that is unprecedented in the industry. Our accurate and reliable MRT instrumentation together with our sophisticated rope evaluation algorithms/software will finally make the ***Retirement for Cause*** or ***Condition-Based Retirement*** approach feasible.

Modern wire ropes usually deteriorate internally and/or are covered with grease. This tendency makes sole visual inspections ineffective and outright dangerous.

**Therefore, MRT will be the predominant wire rope NDE method in the future. It is bound to become mandatory in the industry, supplemented by visual inspections and other NDE procedures as feasible and necessary.**

NDT Technologies offers a complete toolbox for the MRT inspection of wire ropes, including:

- a high-accuracy LMA signal that can be precisely calibrated, including pre-calibration and post-calibration procedures,
- an inherently speed independent LF signal, that does not require an unreliable rotary encoder signal for speed compensation.

  Note that the LF signal cannot be calibrated and is not suitable for estimating the number of broken wires in clusters, interstrand nicking, and the severity of corrosion pitting.

Therefore, we have developed

- our WRR (Wire Rope Roughness) analysis method that allows the separate estimation of deterioration by various deterioration modes, such as internal and external
  - corrosion, corrosion pitting,
  - winding on drum damage,
  - broken wires including broken wires in clusters and interstrand nicking,
- a histogram analysis tool that gives an at-a-glance overview of the rope condition, including the identification of rope sections with inspector-specified deterioration levels.
- We have developed and installed a non-contacting Continuous Rope Monitoring System (CRMS) on a pipelay vessel as the only feasible approach to making the NDE inspection of densely packed high-value offshore ropes feasible.
  - Please note that conventional NDE for these ropes is time consuming and requires considerable and excessively expensive vessel downtime. Therefore, more often than not, NDE is ruled out, and it is considered cheaper to scrap a rope early. While this rope discard philosophy might be acceptable for smaller ropes, it is unjustifiably wasteful for large high-value ropes. Remarkably, CRMS inspections can be performed during normal vessel operations and do not require any downtime.

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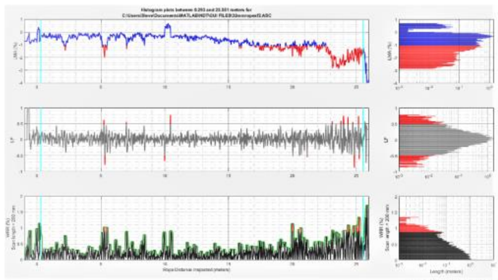
Our recently developed hardware and software tools offer powerful capabilities. They allow a rational interpretation of test results and will take the guesswork – educated or blind – out of rope retirement decisions. They will profoundly transform inspection procedures for high-value offshore ropes, and they will finally make *condition-based rope retirement* possible.

Our high-fidelity signals are noise and distortion free and require no filtering. The inspection accuracy and ease of operation of our MRT equipment stand head and shoulders above that of our competitors as illustrated by the following table.

<table>
<tr><th></th><th>NDT Technologies</th><th>Competitor</th></tr>
<tr><td>Signal Noise</td><td>Clean, Noise Free Signals

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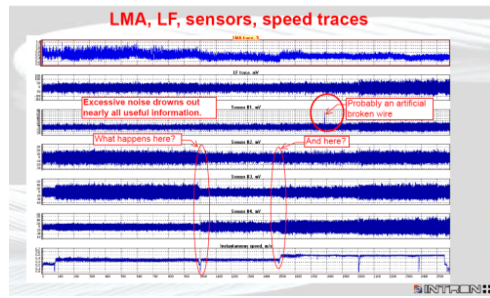

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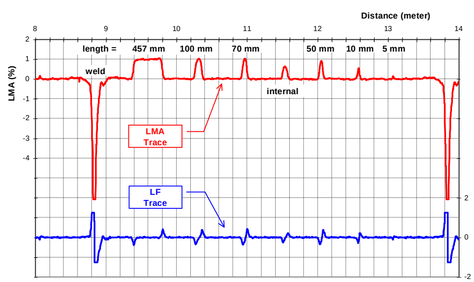
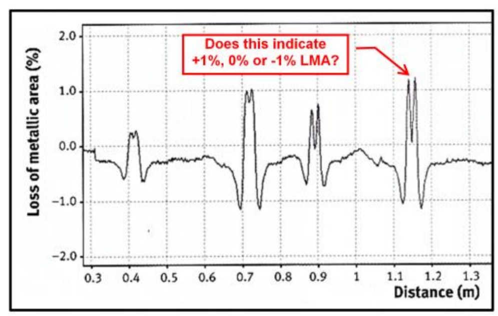
<tr><td>Signal Distortion</td><td>High Fidelity,<br>Distortion Free Signals


</td><td>Low Fidelity,<br>Distorted Signals


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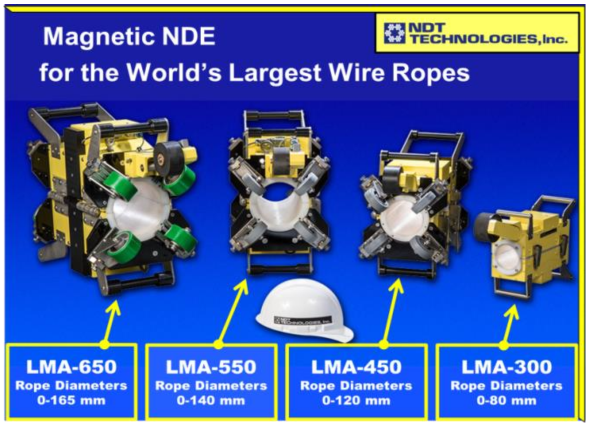
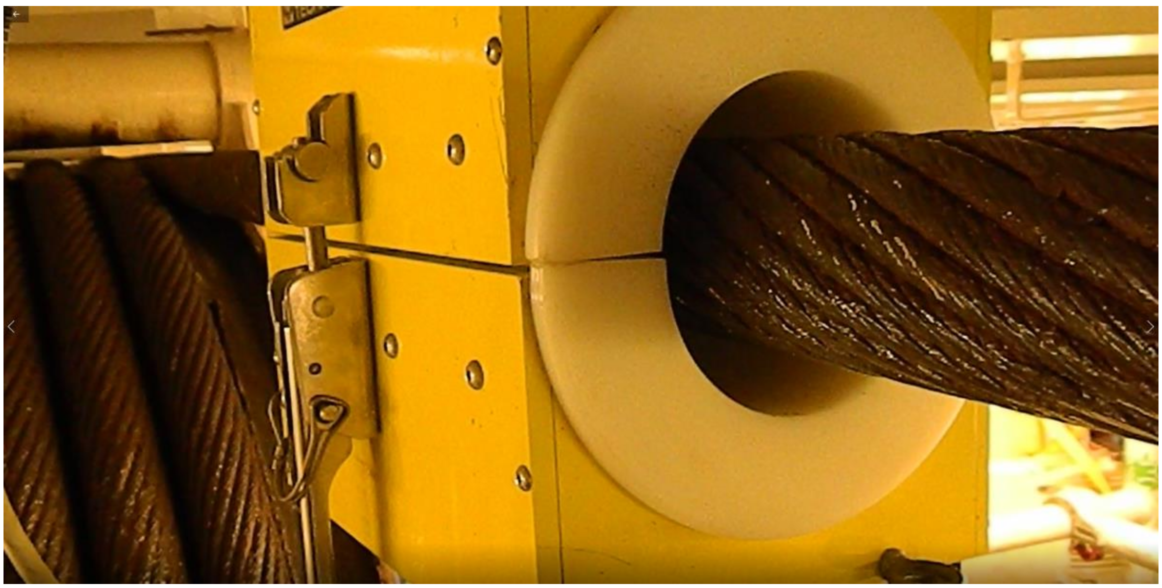
Here are some pictures of our New Generation MRT equipment that was specifically developed for the nondestructive examination (NDE) of high-value offshore ropes.

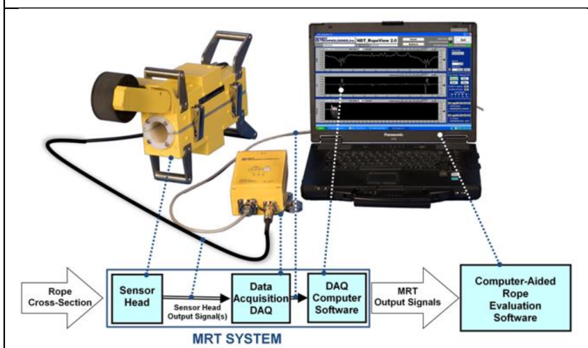
## New Generation
## Magnetic Wire Rope Inspection (MRT) Systems for Ropes up to Φ 165 mm




## Continuous Wire Rope Monitoring System (CRMS) (click picture to watch video)



## New Generation Data Acquisition (DAQ) System




## Magnetic Wire Rope Test (MRT) Systems for Wire Ropes Φ 0-120 mm

# MRT Market:
# Systemic Problems

The dictionary defines a **systemic problem** as a problem that is due to issues inherent in the overall system, rather than caused by a specific, individual, isolated factor.

Here is my perspective.


Just like other markets, the offshore MRT marketplace is a tangled web of obfuscation, confusion, human inertia, and divergent and conflicting commercial and personal agendas, including an overabundance of *Self-Appointed Self-Anointed Experts* brimming with "advice" and doctrinaire, simplistic edicts – with no rational explanations whatsoever.

Furthermore, all too many inspections – Let's call them ***Voodoo inspections***! – are performed haphazardly with second rate instrumentation by unqualified and untrained inspectors.

Juxtapose this to the fact that wire ropes in general, and high-value offshore ropes in particular, are safety critical and single points of failure. Rope failures – many of them catastrophic – are all too frequent.

Question: Is it really more important to protect commercial and personal interests and sensitivities, rather than prevent the loss of lives and avoid losses of potentially millions of dollars?

The human factor root causes of wire rope failures are multifaceted and can range from ignorance to criminal negligence.

Please consider this:

All MRT equipment is based on conceptually simple and easy to understand magnetic flux leakage principles. Furthermore, information on magnetic wire rope test equipment has been readily available in the patent and technical literature.

This deceptively easy access to the technology has led many a budding inventor-entrepreneur to see an easy business opportunity.

Here is how it's done.

1. Just slap some magnets and sensors together (typically Hall sensors, because they are easy to use), and you will get some sort of signals. Get a patent. Add specmanship, hype, a slick website, tenacious marketing, and – voilà – you have a business.

2. Call some signal "LMA Signal" (Loss of Metallic cross-sectional Area Signal), and then apply some procedure to it that you call "Calibration."

   However, these types of Pseudo-LMA signals do not at all measure loss of metallic cross-section, and they cannot be calibrated. Pseudo-LMA signals are not quantitative and useless for estimating a rope's loss of metallic cross-section. They do not allow a rational interpretation, with inspectors having to resort to guessing – educated or blind. Therefore, these signals cannot be used for making rope retirement decisions.

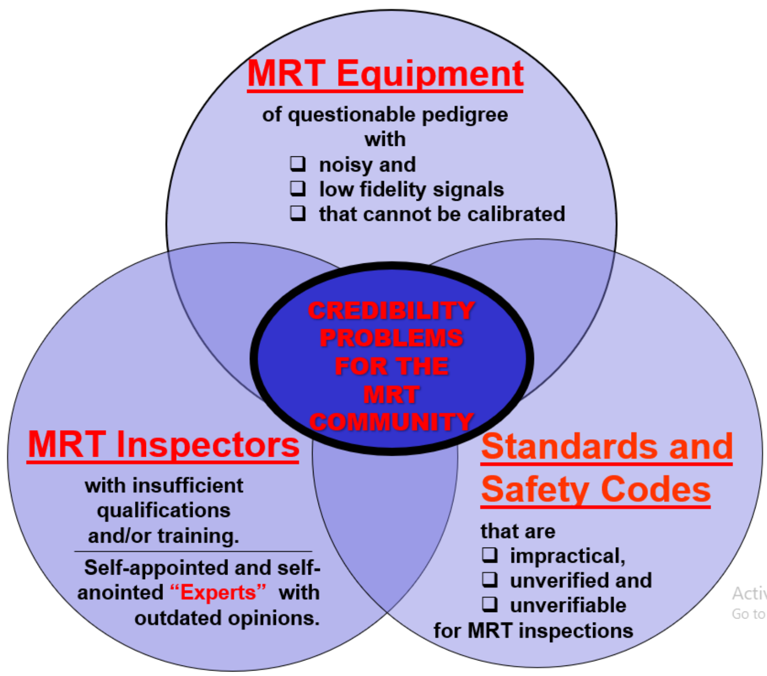
4. Add a pair of saddle coils – a century old, antiquated, and easily implemented MRT device – in order to produce the so-called LF Signal (localized flaw signal).

   As an aside, this is the same identical approach that I took some 35 years ago for my first MRT experiments. Note that saddle coils have been around for some 80 years and are still widely used by our competitors because they are so easy to use. I, for one, progressed to develop better inspection methods.

   Our competitors claim that the LF signal can be used to detect and count broken wires. However, it has been convincingly demonstrated by independent Round Robin tests (see below) that LF signals are useless for estimating the number of broken wires, single and in clusters, of interstrand nicking, or for assessing the severity of corrosion pitting.

The wire rope community is – understandably – distrustful of MRT equipment, as every supplier claims "that his device is the one you should use." We completely understand this skepticism because the credibility of the MRT market place is low. The root cause for the bad reputation of MRT equipment and MRT inspectors is illustrated by the following logical diagram.

**Credibility Problems of the MRT Community**



# Choosing MRT Equipment Hardware and Software


To be able to choose appropriate MRT equipment, its performance, capabilities and limitations must be understood and *validated*. In addition, the training requirements for the inspectors must be established.

When a company offers some *do-it-yourself validation* by claiming that their MRT equipment meets some impractical and unworkable, unverified and unverifiable standards, like ISO 4309:2017 or EN 12927-8, you should take a step back. Be skeptical! Think of it as naïve and unsubstantiated marketing hyperbole! Dig deeper! Don't get bamboozled!

# Validation/Verification

As part of your *due diligence*, ask for ***validation/verification*** of MRT equipment by competent, independent and completely unbiased third parties.

The process of MRT equipment validation consists of compiling theoretical and practical evidence to demonstrate that the instrumentation can meet its required objectives.

MRT equipment validation is the formal method for gaining confidence that your MRT instrumentation can meet its objectives and will detect the flaws you really need to find, and convincing your management and regulators that wire ropes are *fit for purpose*.


The process should also consider the entire MRT inspection by examining individually and in combination the elements of equipment hardware, software algorithms, and personnel.

The purpose ***of MRT Equipment (Hardware and Software) Validation*** is to

- **Determine the relationship (correlation) between MRT inspection results and the actual condition of the *Rope under Inspection (RUT).* This process is performed in two steps:**
  - i. The ***Manufacturer*** makes claims about the ***Performance*** **of his** MRT Equipment.
  - **ii.** A completely impartial and ***Independent Third Party*** evaluates and validates the MRT equipment using ***Rational MRT Equipment Performance Criteria*.**

This **validation process** can be illustrated as follows:


The above described validation process is necessary for performing reliable inspections because

- The ***Customer*** must have dependable and validated information about **the *Performance of the*** MRT Equipment used for inspections. This is necessary for making rational ***Rope Maintenance and Retirement Decisions*** that are, at the same time, safe and economical.

One of the key aspects of the validation process is that it

- relates the damage or degradation to the inspection outputs,

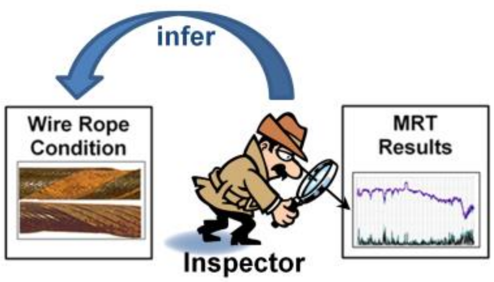
and, conversely,

- also relates the inspection outputs to the damage or degradation.

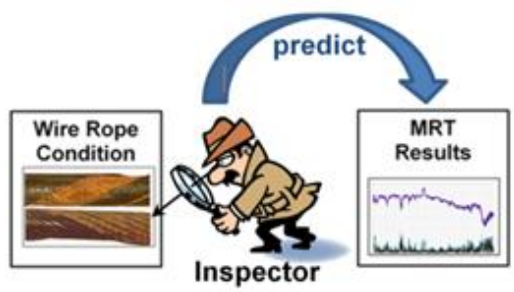
In other words,

**Correlation of test results, as required for validation, is a two-way process. This means that a (hypothetical) perfectly qualified – i.e., 100% efficient – inspector can**

- ▷ **infer, more or less accurately, the rope condition from the MRT data**




- ▷ **predict, more or less accurately, MRT results from the actual rope condition**




**The 'perfect' inspector's Inferences and Predictions depend exclusively on the accuracy of his MRT equipment. Therefore, his findings can be directly used as a performance measure of the MRT equipment that is under his evaluation.**

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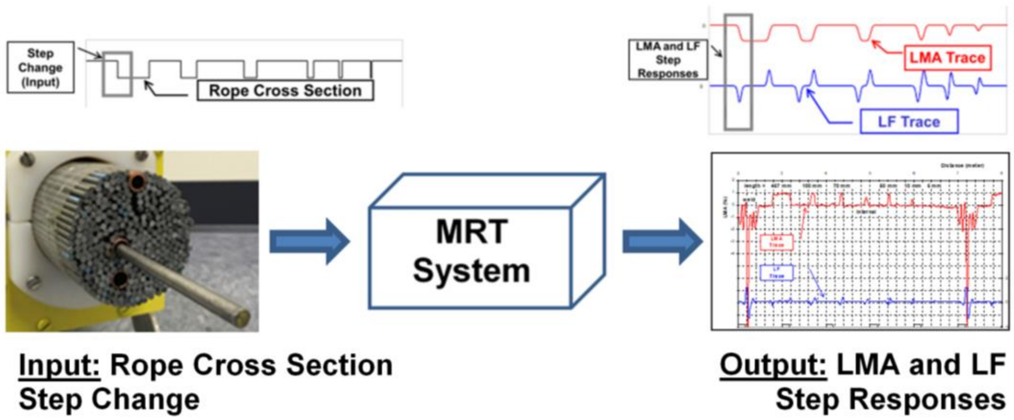
The MRT validation process must include practical trials. Preferably, it includes

1. **<u>Simple experiments that consist of inserting and removing steel rods into and from the sensor head, respectively.</u>**

   These tests are described in a paper titled "**Performance Evaluation of Magnetic Rope Testing (MRT) Instruments"** (https://www.dropbox.com/s/ptpc2hxyc9lywu1/Performance%20Evaluation%20for%20Magnetic%20Rope%20Test%20%28MRT%29%20Instruments%20%28final-2018-9-11%29.pdf?dl=0).

   Easy and very inexpensive, tests can be performed as table top experiments. They help the inspector to grasp the very basic principles of 'step change', 'step response' and 'linear superposition'.




**Step-Change/Step-Response Experiments**

This fundamental knowledge gives the inspector a deep and intuitive insight into the MRT signal generation process and serves as the foundation for a rational, lucid and reliable MRT signal interpretation.

The above described experiments introduce the concepts of **step change, step response** and **linear superposition**, principles that are universally used in electronic engineering and control theory and can be easily adapted for the performance characterization of MRT systems.

For MRT, a step change input is conveniently represented by a missing wire, or alternatively, by a steel wire or rod that is inserted and/or removed into or from the sensor head, respectively.

These experiments can be performed with a simulated, or dummy, rope – consisting of steel rods, pipes etc. – placed inside the sensor head or – equivalently – even with an empty sensor head.

This conceptually simple approach offers repeatability and simple and inexpensive implementation. It can be performed by instrument manufacturers and users alike – usually by desktop experiments.

Furthermore, it has been demonstrated that MRT is essentially a linear process. Therefore, the concept of linear superposition applies as described in the following:

a) It is easy to see that any Change of Metallic Cross-Sectional Area (CMA) can be represented -- with any desired degree of accuracy -- as the sum of appropriately scaled and spaced metallic cross-section *step changes*.

b) Then the output signals caused by this CMA can be – with any desired degree of accuracy – represented as the sum of the corresponding Step Responses.

This means that the signal output of an MRT instrument for any CMA can be predicted – from its step response – by using the principles of linear superposition.

## 2. MRT on used ropes and validation of test results by correlating acquired test data with the actual rope condition.

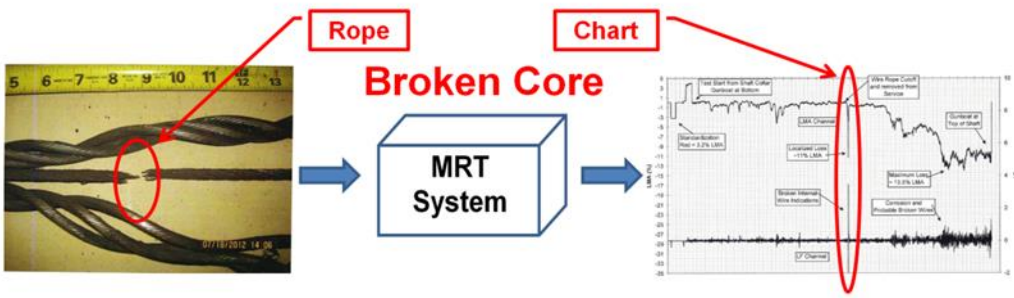
This type of tests requires a major effort and is always very expensive. To be credible, tests must be performed by completely trustworthy and unbiased third parties. The competence and integrity of test personnel must be beyond reproach as agreed by all interested parties. These are very high standards that are not easy to achieve.

On the other hand, our MRT equipment has been evaluated on a considerable number of deteriorated ropes by completely impartial government and semi-government agencies such as

- ▷ MSHA – Mine Safety and Health Administration (USA)
- ▷ SIMRAC – Safety in Mines Research Advisory Committee (South Africa)
- ▷ HSE – Health and Safety Executive (UK)

These investigations are well documented in a paper titled '**Magnetic Wire Rope Testing (MRT): Validation of Test Results'** that can be downloaded from this link: https://www.dropbox.com/s/a4st24asrpmebzo/Validation%20%282018-9-13%29.pdf?dl=0

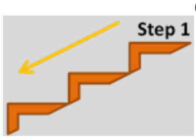
For MRT instrumentation from NDT Technologies, the validation studies confirm excellent correlation between acquired data and the actual deterioration of the ropes under inspection.




**Validation of Test Results by Correlating Acquired Test Data with the Actual Rope Condition**

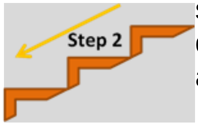
These trials and the subsequent analysis of the test data were carried out in three steps.

**Step 1:** Test data were acquired by using nondestructive wire rope inspection equipment.



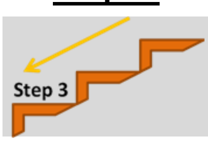

- ▷ **For the MSHA tests**, MRT was performed *in situ* (on site), usually in mines.
- ▷ **For the SIMRAC Round Robin tests**, a number of deteriorated ropes were set up at a rope test facility in Bochum, Germany for trials with substantially all major MRT instruments available at the time.
- ▷ **For the HSE Round Robin tests**, MRT was performed at the Health & Safety Laboratory in Sheffield, UK for trials with substantially all major MRT instruments available at the time.

**Step 2:** The ropes under test were destranded after their examination, and the state of their deterioration was verified visually and recorded in great detail. These reports are in the public domain, and they are readily available.




- **For the MSHA tests**, deteriorated rope sections, identified by MRT, where removed for analysis in the laboratory. The findings, including photographs, are described in comprehensive reports that are electronically available in their entirety from the above referenced paper. This documentation shows excellent correlation between test results and the actual deterioration of the ropes under inspection
- **For the SIMRAC Round Robin tests**, the ropes were subsequently returned to South Africa. After destranding, their physical condition was visually determined and analyzed. These findings were published in a report titled '**An evaluation of international and local magnetic rope testing instrument defect detection capabilities and resolution, particularly in respect of low rotation, multi-layer rope constructions'** (download from http://www.mhsc.org.za/sites/default/files/gap503.pdf). A very detailed visual examination of the destranded ropes, including number and location of broken wires in clusters was undertaken and a record is available as an appendix to the report, albeit only in paper form.
- **For the HSE Round Robin tests**, the ropes were subsequently destranded and their physical condition was visually determined and analyzed. Results were published in a report titled **'Evaluation of instruments for the Non-Destructive Testing of wire ropes'. Unfortunately, an electronic copy of the report is presently not available.** Overall, a general description of inspection results was presented with select details and pictures of interesting chart and rope sections. Our own summary of these Round Robin test results titled '**Discussion of Experimental Electromagnetic Wire Rope Inspections Performed at the Health and Safety Laboratory in Sheffield England'** can be downloaded from here: https://www.dropbox.com/s/slmwmuga90wl3fd/Discussion%20of%20Sheffield%20Tests%2C%20All.pdf?dl=0.

**Step 3:** More recently, a Wire Rope Roughness (WRR) analysis of the test data was performed. (The WRR method was developed for quantitatively estimating the number of external and internal broken wires in clusters, the extent of interstrand nicking, and/or the severity of corrosion pitting. Conversely, it has been convincingly demonstrated – by the SIMRAC Round Robin tests – that the LF signal is qualitative only and ineffective for this purpose.)




- **Results of the SIMRAC and HSE Round Robin tests** were used as examples for illustrating the WRR analysis method. The results were presented in a paper titled '**Wire Rope Roughness (WRR), a new indicator for the Quantitative characterization of wire rope deterioration'** (download from https://www.dropbox.com/s/wierndgws2rgjho/Paper%20Oxford%20%2810-19-2012-1%29.pdf?dl=0.)

The correlation of the WRR Analysis results with the actual condition of the ropes under test shows a very close correspondence. This proves the feasibility and the value of the proposed methods.

**5. <u>Performance Evaluation Criteria</u>**

To compare the performance of MRT instrumentation from different manufacturers, a wide variety of performance criteria should be considered. Here are some important attributes that can be expected from state-of-the-art equipment.

a. Noise-free signals,
b. High-fidelity signals,
c. High quantitative resolution (short averaging – or scan – length)
d. Easy and reliable calibration,
e. Rational signal interpretation (minimize uncertainty, risk, complexity and ambiguity),
f. Etc.

For a further discussion of these issues please download and refer to the paper titled '**Performance Evaluation of Magnetic Rope Testing (MRT) Instruments**'.

# Inspector Training

We are acutely aware of the fact that an MRT can be only as good as the inspector.

Therefore, we consider operator training an essential element to ensure that our equipment is used correctly. This is true especially in the beginning, when our equipment is first introduced.

We offer training at our facilities at no extra charge with the purchase of our equipment. Training on customer premises is available.

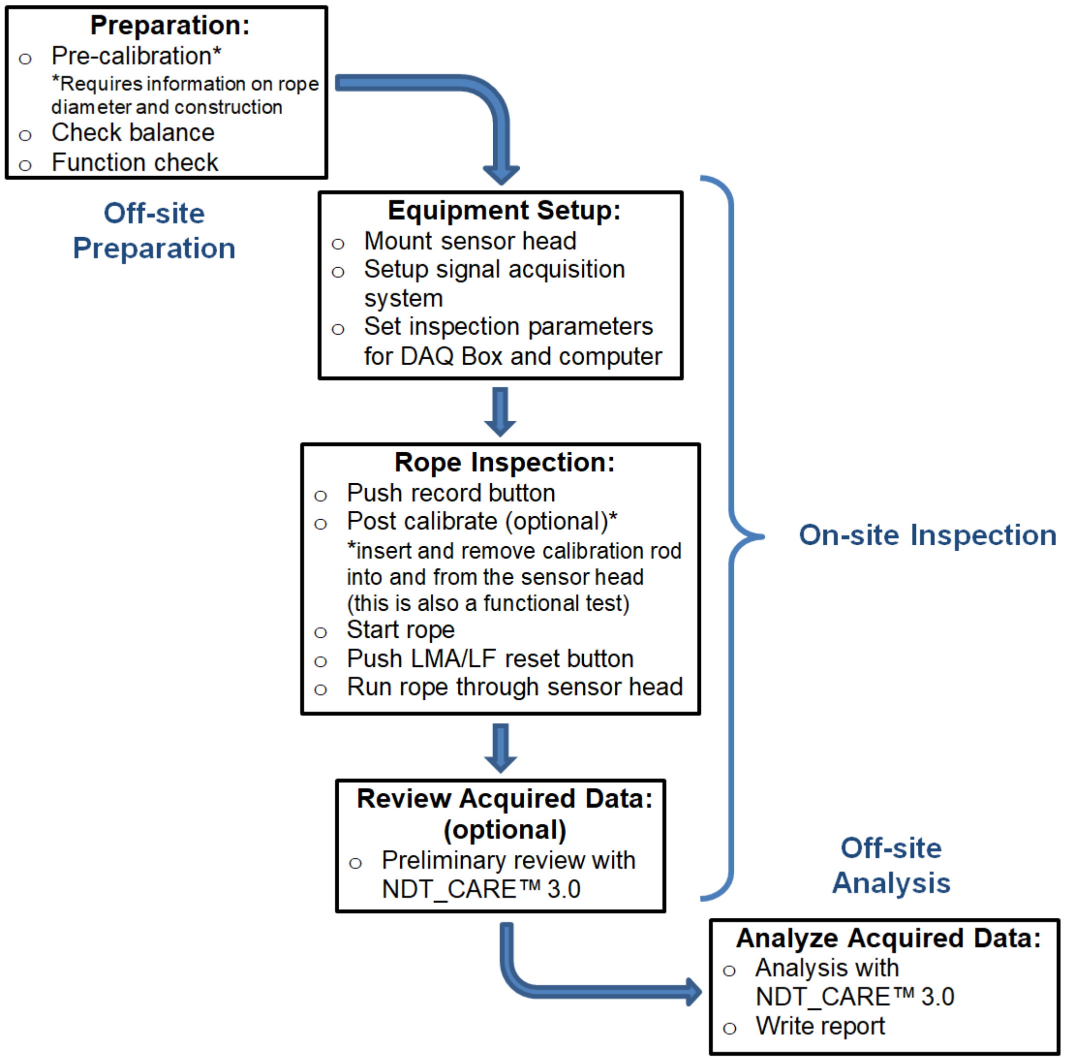
In support of our training efforts we have produced and are producing a series of tutorial videos that can be used as step-by-step guidance for the entire MRT process.

It is our opinion that any inspector familiar with visual wire rope inspections can reasonably acquire the additional skills necessary for MRT examinations with NDT Technologies equipment.

Please read on.

The following MRT Flow Chart illustrates the MRT inspection process.

**MRT Flow Chart**



As illustrated by the MRT flow Chart, the inspection process is performed in 3 steps.

1. **Preparation** is usually performed off-site at the home base.
   It consists primarily of Pre-Calibration, which requires advance knowledge of diameters and construction of the *Rope(s) under Test (RUT)*. LMA pre-calibration and LF balancing are performed by inserting and removing a calibration rod into and from the sensor head. LF balancing can be manual or automatic at the push of a button. LMA calibration is intuitive by setting two markers on the computer screen and then pushing the 'Calibrate' button. The pre-calibration process is illustrated by this video:
   **https://www.dropbox.com/s/jfb4fkajxumg12b/Calibration%20and%20Equalization%20-%20Take2.wmv?dl=0**
   Set-up including calibration parameters for various RUTs are stored in individual configuration files for use during on-site inspections. Pre-calibration represents, at the same time, a functional check and an LMA/LF balance check.

2. **On-Site Inspection** consists of

   a. Equipment setup
      i. Mount sensor head on rope
      ii. Set up signal acquisition system: Load appropriate configuration file to set inspection parameters for computer and DAQ box
   **b.** Rope inspection, optionally including post-calibration

3. **Analyze inspection results**

   Our recently developed *NDT_CARE™ 3.0 (Computer Aided Rope Evaluation) Software* allows the accurate and reliable analysis of inspection results. Our Wire Rope Roughness (WRR) analysis method together with our 'Echo Cancelation' algorithm allows highly accurate and reliable quantitative identification and discrimination of external and internal clusters of broken wires, interstrand nicking, and corrosion including corrosion pitting. Our use of Histograms greatly facilitates identification and pinpointing and highlighting the location of rope sections with various pre-specified degrees of deterioration. Histograms indicate at one glance the condition of the entire RUT on one or two diagrams.

   The software is purposely designed to be intuitive and guides the user step by step through the analysis process. To illustrate please watch these videos:
   **https://youtu.be/H3Cf37xEYoE** and
   **https://www.dropbox.com/s/l18vl7smrdc2ip3/14%20NDT%20CARE%203_0%20Stationary%20Calibration%20and%20Speed%20Signal.mp4?dl=0**

   Note that the example inspection discussed in the video is well documented in several papers that you can download as follows:
   **Wire Rope Roughness (WRR), a new indicator for the quantitative characterization of wire rope deterioration** and **here**.

   The basic NDT_CARE™ 3.0 software comes with several add-ins. One of these – very sophisticated – extensions, NDT_CARE™ 3.0 "3D" allows simultaneous plotting of results from consecutive MRTs in one 3-dimensional chart to illustrate the progression of rope deterioration over time.

Another add-in, **NDT_CARE™ (Computer Aided Rope Evaluation) 3.0 "VISTA"** **https://www.dropbox.com/s/xmeunabpn8g58fb/16_NDT_CARE_VISTA.mp4?dl=0** allows the comprehensive documentation of potentially very complex wire rope evaluation procedures involving, for example, combined MRT and visual inspections, including frequent rope stops and reversals.

NDT_CARE VISTA gives a complete record of an entire, possible very complex, rope examination, including

1. LMA, LF and WRR signals
2. Inspection time, distance along rope, total length of rope inspected, rope speed, and start-stop operation.

For example, this software can be used for monitoring the rope condition, distance and speed, and time during complex rope maneuvers like

1. A&R operations of pipelay vessels,
2. Deep sea lifts.
3. Combined visual and MRT inspections when the rope is stopped during an MRT inspection and moved back forth for a visual examination, etc.

Shown in the video are

1. An experimental inspection performed on a test rope at NDT Technologies' facilities. Here, the ends of the rope are welded together to form an infinite loop. The rope is exactly 5 m long. The weld shows clearly on the LMA/LF traces, and it can be used as a 5 m distance marker.
2. Spooling of a Φ 78 mm A&R winch rope that is 3.2 km long and lasted about 10 hours with numerous lengthy stops for repositioning of the pipelay vessel and the supply barge.

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