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

Memo on the Future of Wire Rope Examination/Evaluation (NDE) and Magnetic Rope Testing (MRT)

To: Members of the Wire Rope Community
From: Herbert R. Weischedel, NDT Technologies, Inc.
Date: November 16, 2018
Subject: Paradigm Shift in Wire Rope Retirement Philosophies and NDE Inspection Methods

Preface

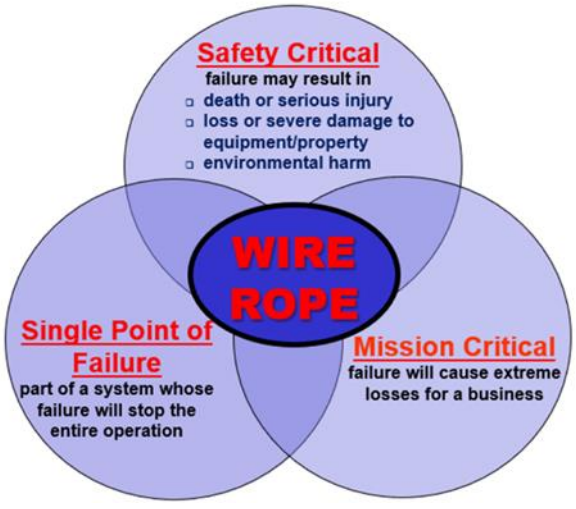
Wire ropes are both, **safety critical and mission critical.** This means that, if a rope fails, human lives and entire missions or even whole businesses are at stake. Wire ropes provide a lifeline for industry, often under hostile and demanding conditions.

Any person involved in the management of wire rope can be held accountable if and when it fails. Acceptance of second best is a risk that nobody can afford to take.

Therefore, if you are directly or indirectly responsible for maintenance, inspection, or the safe use of wire rope, it is your obligation to be fully informed, and this memo is a must-read.

The critical importance of wire ropes is illustrated in a nutshell 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.**



Please read on for a further discussion of this diagram

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 and single points of failure** – are unacceptable and must be avoided at all cost.

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.

Therefore, wire ropes are also **mission critical**. Here

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

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.”

Traditional preventative maintenance and replacement schedules 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.

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

A Major Paradigm Shift Will Change the Future of Wire Rope Nondestructive Evaluation/Examination (NDE)

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).
2. On the other hand, 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.

   However, straight Retirement-for-Cause policies are mistrusted and rarely used in the past and even at the present time for these reasons:

   - 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.

Today, we are at an inflection point, when Statutory Life Polices will be recognized and abandoned as inherently wasteful and/or dangerous.

Reliable and validated/verified MRT instruments are now available from NDT Technologies that – in the hands of well-qualified inspectors using rational retirement criteria – will guarantee the safe and economical use of wire ropes.

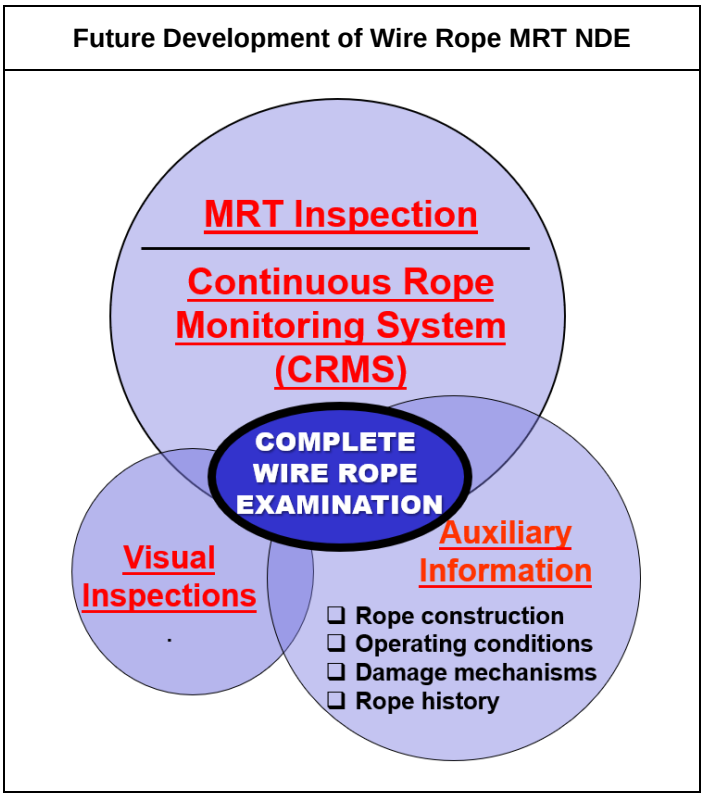
An early catalyst for this paradigm shift has been the Code of Federal Regulations 30 CFR § 77.1434, Wire Rope, Retirement Criteria, which – monitored by U.S. Mine Safety and Health Administration (MSHA) – has led to widespread use of magnetic NDE in the North American mining industry.

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 following logical diagram illustrates the above situation.

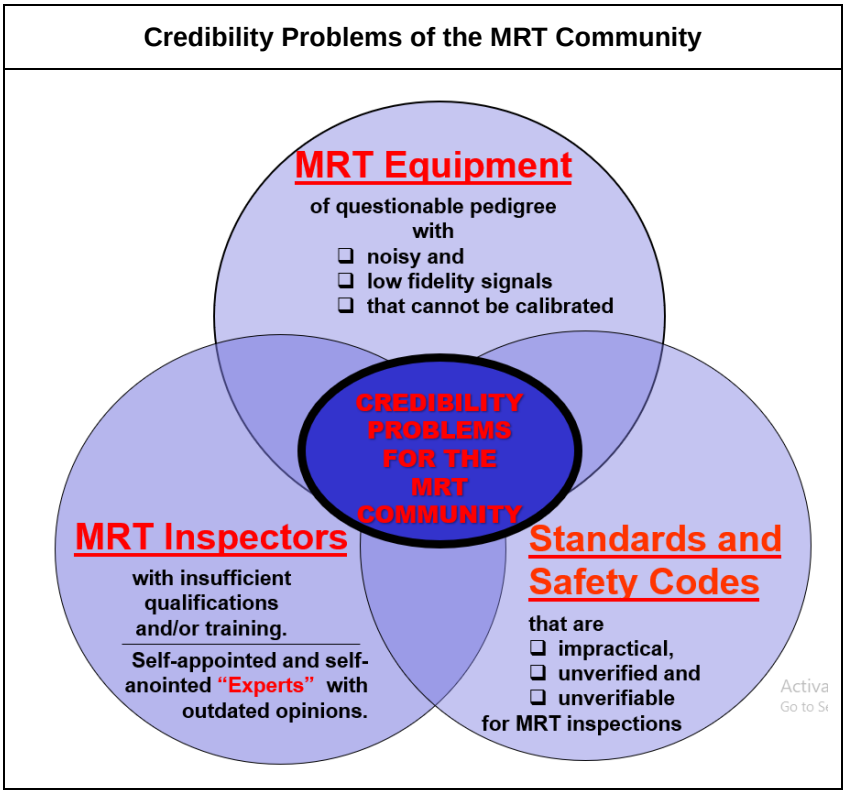
Future Development of Wire Rope MRT NDE



How to Choose Magnetic Wire Rope Test (MRT) Equipment

The wire rope community is 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 following logical diagram illustrates– at a glance – the root cause of the bad reputation of MRT equipment and MRT inspectors.



At NDT Technologies, we still believe in the old-fashioned slogan: **"An educated customer is our best customer."**

Therefore, if you are involved with – or just interested in – the safe and economical use of wire ropes, we encourage you to educate yourself – as objectively as possible – about the performance of all present MRT equipment.

To choose appropriate MRT equipment, you must well understand and carefully evaluate its performance – capabilities and limitations.

To assist you in your due diligence evaluation, we offer – upfront – as much objective information as we can.

Please note that compiling the following background information was a painstaking task. We carefully referenced and substantiated all details. All our claims are clickable. Please follow some or all of the links to check our sources. For the same reason, you should ask our competitors for equivalent well-corroborated details on their equipment.

Of course, if you require additional details, please contact me:

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The following table offers easy and compact access to information on our MRT equipment. Please refer to the following pages for more information on each item of the Table.

Again, we encourage you to contact our competitors in order to request all complementary information necessary for your due diligence evaluation. For your convenience, please find some of our competitors' contact information in Row 10 of the Table.

MRT Instrument Performance Evaluation

	Manufacturer	NDT Technologies	Intron	LRM-NDE	Universität Stuttgart
1	**LMA Signal**	True LMA Signal (high fidelity, noise-free, can be calibrated)	Pseudo-LMA Signal (low fidelity, low signal-to-noise ratio, cannot be calibrated)		No
2	**LF Signal**	Yes (limited use, calibration not possible)	Yes (limited use, calibration not possible)		
3	**Wire Rope Roughness (WRR) Signal**	Yes (for the reliable assessment of external/internal broken wires in clusters, interstrand nicking, and corrosion pitting)	No		
4	**Quantitative Data**	Yes (allows rational retirement decisions)	No (retirement decisions depend on intuition and guesstimating)		
5	**Digital Signal Acquisition** (Hardware and Software)	Yes (download **Information** including **Tutorial Video**)	Inquire from Manufacturer		
6	**Signal Analysis** (Algorithms and Software)	NDT_CARE™ (**C**omputer-**A**ided **R**ope **E**valuation) (download **Tutorial Videos**)			
7	**Equipment Validation/ Verification**	For details please download: **Validation/Verification Process** and **Validation Case Study**			
8	**Inspector Training**	Training at our or our customers' facilities ---------- Complete Library of Tutorial Videos			
9	**IP Rating**	IP65 (All Components IP67)			
10	Contact	info@ndttech.com	info@intron-plus.com	lrm-nde@lrm-nde.com	info@mesomatic.de

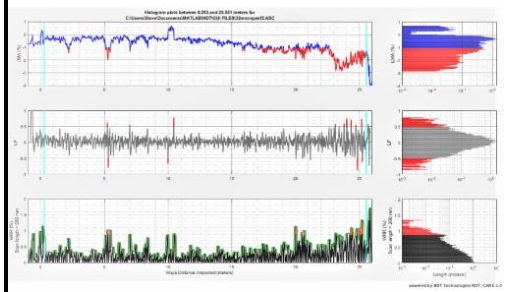
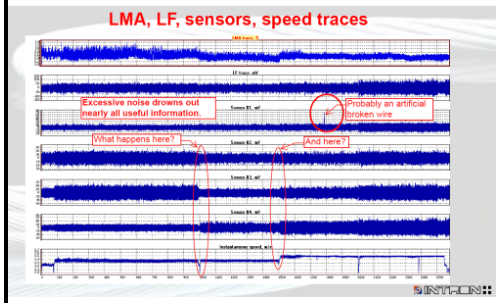
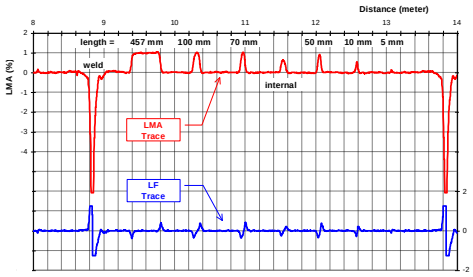
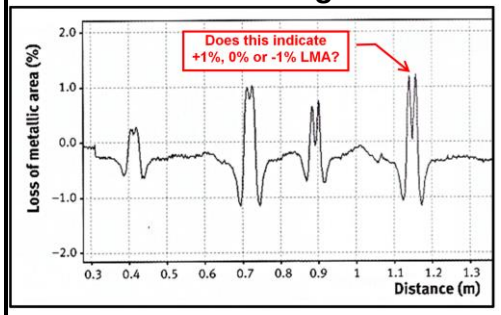
Additional Information on Table Contents

(Please refer to row numbers of the Table)

1

LMA Signals

The difference between our “True LMA Signals” and our competitors’ “Pseudo LMA Signals” is illustrated by this table:

	NDT Technologies	Competitor
Signal Noise	**Clean, Noise Free Signals** 	**Noisy Signals** 
Signal Distortion	**High Fidelity, Distortion Free Signals** 	**Low Fidelity, Distorted Signals** 

2 & 3

LF Signals vs. WRR (Wire Rope Roughness) Signals

Independent Round Robin tests performed by the **Safety in Mines Research Advisory Committee (SIMRAC)** have convincingly demonstrated that the LF signal is not useful for estimating the number of broken wires, single and in clusters, of interstrand nicking, or for assessing the severity of corrosion pitting. In order to remedy this situation NDT Technologies has developed its **Wire Rope Roughness (WRR)** method.

To illustrate, please have a look at this report:

Dohm, M. "An evaluation of international and local magnetic rope testing instrument defect detection capabilities and resolution, particularly in respect to low rotation, multilayer rope constructions". Safety in Mines Research Advisory Committee (Johannesburg, South Africa, 1999)

The following table summarizes the results.

Summary of some Round Robin Test Results			
Manufacturer	Signal	% of Broken Wires Detected	Page # in Report
DMT[1]	LF	14%	43 - 45
NDT Technologies	WRR[2]	104%	46 - 51
University of Stuttgart	LF	7%	51 - 53
Meraster (Zawada)[3]	LF	3%	56 -57
Intron[4]	LF	--	--
LRM NDE[4]	LF	--	--

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[1] The Round Robin tests were performed at the facilities of DMT in Bochum, Germany with the assistance of DMT personnel.

(DMT is responsible for the NDE of all mine hoisting ropes in Germany. DMT uses primarily Intron instruments. In the past, they have also developed their own instrumentation.)

[2]A preliminary version of NDT Technologies' WRR signal was used for these tests.

[3]Similar to LRM-NDE.

[4]Not invited. Did not participate.

All our competitors tried to use their LF signal for estimating the number of broken wires. They failed, some of them miserably.

In contrast, our WRR signal proved to be highly effective. For further details, please refer to the paper "**Wire Rope Roughness (WRR), a new indicator for the quantitative characterization of wire rope deterioration**."

4

Quantitative Data

All rational retirement criteria that are based on destructive and/or nondestructive testing must be quantitative (for example: number of broken wires per unit of rope length, percentage loss of rope diameter or loss of rope strength, etc.). The following table illustrates this.

Rope Evaluation Method	Retirement Criteria
Break Tests	Use retirement criteria based on the percentage loss of breaking strength (LBS)
Visual inspection	Use retirement criteria based on number of surface broken wires, rope diameter changes, change of lay length, etc.
Magnetic NDE **Loss of Metallic Cross-sectional Area (LMA) Signal**	Use retirement criteria based on wire rope loss of metallic cross-sectional area (LMA). The LMA signal can be used for the (quantitative) measurement of LMA caused by wear and corrosion.
Magnetic NDE **Wire Rope Roughness (WRR) Signal**	Use retirement criteria based on wire rope roughness (WRR). The WRR signal can be used for the quantitative characterization of the effects of interstrand nicking, number of external and internal broken wires in clusters, corrosion pitting, etc.).
Magnetic NDE **Localized Flaw (LF) Signal**	Retirement criteria based on the LF signal are not feasible and not available. The LF signal might be somewhat useful for the (qualitative) detection of surface or near surface broken wires, and corrosion pitting.
Reference: **Wire Rope Nondestructive Evaluation (NDE) Procedures, Retirement Criteria and Lifetime Prediction Methods for the Safe and Economical Use of Wire Ropes**	

5

Digital Signal Acquisition

Download **Information** including **Tutorial Video**

6

Signal Analysis

Please download **Tutorial Videos** on our NDT_CARE™ (**C**omputer-**A**ided **R**ope **E**valuation)

7

Equipment Validation/Verification

To be able to choose appropriate MRT equipment, its performance, capabilities and limitations must be well 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!

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

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

For details please download:
Validation/Verification Process and **Validation Case Study**

8	**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. 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. 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. Please download **Tutorial Videos** on our RopeView and NDT_CARE™ (Computer-**A**ided **R**ope **E**valuation) Software.

9	**IP Rating** Our Sensor Heads are overall rated IP 65 (Dust tight, splash proof – powerful water jets) All components, including connectors and sensors, are rated IP 67 (Dust tight, immersion proof – up to 1 m depth). Higher ratings available on request.