Abstract

Magnetic rope testing (MRT) is becoming an essential mean to provide safe operation of steel wire ropes onshore and offshore. With consideration of advanced hardware, software and procedures to carry MRT, relevant standards ISO 4309, ASTM E1571, EN 12927-8 have been recently revised in order to help the users to effectively operate MRT equipment and interpret inspection data. At present, MRT is common to inspect guided structures (flare stacks, masts, antennas), drilling rigs, ropes of lifting equipment, including heavy lifting operations, cableways, civil structures, etc. There are different suppliers of MRT equipment available on the market, and customers should have basic knowledge to make a right choice. The presentation contains information on principles of operation of MRT equipment, description of different applications, inspection procedures, limitations of MRT, analysis of relevant norms and standards, requirements for the personnel carrying MRT, conception of rope monitoring. The presentation is based on over 20 years of experience in MRT.

Keywords: Rope, magnetic testing, rope monitoring, standards.
Magnetic Rope Testing: relevant applications and standards

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Wire ropes are one of the most frequently used parts in different industries.

Offshore & Onshore drilling rigs

Offshore heavy lifting

Onshore cranes

Mining

Civil engineering

Aerial cableways

Guided structures
Unlike many other industrial parts wire rope has complicated design. Wires are generally produced from carbon steel and covered with lubricant.
Steel wire ropes produced in number of constructions
Ropes deteriorate during storage and operation breaking strength may decrease dramatically

- Corrosion internal and external due to humidity causes loss of metallic area - LMA
- External and internal abrasion due to interaction between surface and drum/sheave and internal wires causes LMA
- Fatigue due to repetitive bending over drum/sheave and overloading causes broken wires – LF
- Excessive heat due to frequent bending on the sheaves or accidental fire causes LF
Every rope will fail one day if not discarded in time.

When the rope should be discarded?

When the rope is dangerous for operation?

How to know when the rope is dangerous for operation?

Inspect the rope properly.
Traditional visual external examination
All norms require visual examination during rope life time

- Inner wires are not inspected
- Half of outer wires are not inspected
- Core is not inspected
- LMA is not measured

Caution! Worn rope may remain in service resulting the accident
Traditional visual external examination
All norms require visual examination during rope life time

Caution! Worn rope may remain in service resulting the accident
Traditional visual external examination
All norms require visual examination during rope life time

Plastic coated ropes

Caution! Worn rope may remain in service resulting the accident
Limitations

- No tension to the rope allowed
- Not allowed at all by ASME B30.5
- Only small rope portion is inspected
- Ineffective for rotation-resistant ropes
Magnetic rope testing (MRT)
The only practical method to inspect wire ropes
Key issues to remember when prepare for MRT

1. Proper MRT equipment
2. Qualification of the personnel
3. Data interpretation

International standards and guidelines, that clarify above issues

1. ASTM E1571. Standard practice for electromagnetic examination of ferromagnetic steel wire rope
2. ISO 4309. Cranes-Wire ropes-Care and maintenance, inspection and discard
3. EN 12927-8. Safety requirements for cableway installations designed to carry persons-Ropes-Part 8: Magnetic rope testing (MRT)
4. IMCA IMCA LR 004, IMCA HSSE 023. Guidance on Examination of Steel Wire Rope Through Magnetic Rope Testing (MRT)
5. IMCA M 194. Wire rope integrity managements for vessels in the offshore industry
Magnetic saturation of rope is important

8.1.2 The energizing unit shall be capable of magnetically saturating the range (size and construction) of ropes for which it was designed.
5.1 Magnetisation

The MRT system establishes a magnetic circuit, which needs to magnetise the metallic cross section of the rope up to its saturation level. As a reference, EN 12927 states that the magnetising unit has to be able to create a magnetic flux density of between 1.9 and 2.3 Tesla in a rope (or a metallic test piece for reasons of calibration). A strong and homogenous magnetization of the rope cross-section in the monitored zone is necessary to obtain a high defect detection rate over the whole rope cross-section, in particular to reliably detect wire breaks within the rope, especially in the core. The magnetic and mechanical dimensions of the MRT device should be chosen so that a variety of defects can be interpreted optimally within the range of rope diameters which are to be inspected with the device (see also section 7).

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IMCA LR 004, IMCA HSSE 023, IMCA M 197 Rev. I
October 2018
Proper MRT equipment must magnetically saturate the rope

Annex B
(informative)

Magnetic flux density

The magnetizing unit has to be able to create a magnetic flux density $B$ between 1.9 and 2.3 Tesla in a rope (or a metallic test piece for reasons of calibration) having a maximum metallic cross section $A_{\text{max}}$ not exceeding the designed one over an axial extension of 0.5 times maximum rope diameter $d_{\text{max}}$. 
Proper MRT equipment must magnetically saturate the rope

2.2 Instrumentation

2.2.1 Function and operational principles of magnetic flux leakage instruments

MRT instruments are designed to operate on the magnetic flux leakage principle.

Broken wires and corrosion can be detected by using a magnetic flux leakage instrument.

Magnetisation unit, magnetically saturates a length of rope as it passes through the instrument (magnetising circuit). The magnetising may be provided by electromagnetic or permanent magnets instrument.
Proper MRT equipment must magnetically saturate the rope.

2.2 Magnetization
With a rope in place an MRT system establishes a magnetic circuit which needs to magnetize the metallic cross section of the rope up to its saturation level of 2.1 Tesla for steel wire. A strong and homogenous magnetization of the rope cross-section in the monitored zone is necessary to obtain a high defect detection rate over the whole rope cross-section, especially to detect reliably wire breaks in the rope interior. The magnetic and mechanical dimensions of the
Strong magnetization

1. High repeatability
2. High sensitivity to outer and inner broken wires
3. Directly measure LMA in percentage with high accuracy

Weak magnetization

1. Low repeatability
2. Low LF sensitivity to inner broken wires (not possible to reveal)
3. LMA is not measured due to physical principle
Qualification of the personnel

7.2 Personnel

7.2.1 General

The personnel shall have basic knowledge about the rope types, the procedure of rope determination and about the splice method.

An individual carrying out MRT in accordance with this standard shall be classified in one of two levels depending upon his respective qualification.

Part 8: Magnetic rope testing (MRT)
9 Competence and Training

The operator carrying out the MRT should be trained in both visual wire rope inspection and use of MRT techniques and should be certified as medically fit.

- The operator should be trained in the use of the MRT machine, following the manufacturer’s instructions;
- Training requirements for interpretation of the MRT inspection traces are considered separately;
- MRT inspections should be carried out by personnel of Levels 1, 2 or 3.
7.3.2 Interpretation of results

The interpretation of results shall be carried out by a person classified as level 2 in accordance with 7.2.2.

The special defects referred to in this standard shall also be taken into account.

Wherever possible, the test results shall be correlated with previous test results of the same rope.

The whole of these results shall be included in the test report drafted by the above mentioned person with a conclusion on the wire rope condition with reference to discard criteria specified in EN 12927-6.

Part 8: Magnetic rope testing (MRT)
10 Interpretation of Data

The interpretation of MRT traces requires an understanding of MRT equipment operation, the application in which the wire rope is used, wire rope deterioration modes, and the circumstances under which the traces were taken. It is essential, where the person doing the interpretation was not present during the data collection, that an event log as detailed below be sent with the trace.

- The interpretation of results should be carried out by a person classified as level 2 minimum (see section 9.2);
Data interpretation

Annex C
(informative)

Discard criteria for MRT

C.1 Local fault (LF)

For the calculation of the loss of metallic area resulting from wire breaks, the actual diameter of the broken wires should be determined. If this is not possible, the maximum wire diameter of the wires in the rope excluding filler wires may be taken into account for the calculation. The loss of metallic area resulting from LF is determined independently of the rope construction. The discard values for loss of metallic area can be read over a length of 6d or over a length of 30d.

Table C.1 — LF-MRT discard criteria — Maximum permissible loss of metallic area for all rope constructions

<table>
<thead>
<tr>
<th>Loss of metallic area</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over a length of 6d</td>
<td>6</td>
</tr>
<tr>
<td>Over a length of 30d</td>
<td>10</td>
</tr>
</tbody>
</table>

The calculation for determining the maximum number of broken wires based on 6% loss of metallic area is as follows:

Max. no. broken wires = \( \frac{\varphi \cdot A}{(\delta_{max} \cdot 2)} \)

where:

- \( \varphi \) is the maximum allowable total loss of metallic area (6% over 6d);
- \( A \) is the metallic cross-sectional area of rope (from test certificate);
- \( \delta_{max} \) is the diameter of maximum diameter wire.

EXAMPLE For rotation-resistant rope — RN: 23-2 with a metallic area of 240 mm² and a max. wire diameter of 1.05 mm, then the maximum number of allowable broken wires for \( 6d = 9 \).

NOTE If the actual metallic cross-sectional area value for the rope is not known, it can be calculated by use of the metallic cross-sectional area factors listed in ISO 2400.

C.2 Loss of metallic area (LMA)

For the determination of the discard due to LMA the whole metallic rope cross-section is used. The loss of metallic area read from MRT measuring system is determined independently of the rope construction. The maximum discard values for loss of metallic area over a length of 30d are given in Table C.2.
MRT equipment INTROS with strong magnetization
MRT equipment INTROS with strong magnetization

The smallest magnetic head

Data Logger

The biggest magnetic head
MRT of syncrolift and onboard vessel
Inspection of flare stack guy ropes by using slings and winch or manpower
Inspection of flare stack guy ropes by using the climber
Inspection bridge rope
Thank you for your attention!

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