STEEL ROPE NDT IN THE OFFSHORE INDUSTRY AND SHIPYARDS

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Abstract

Specific conditions by steel wire rope NDT at the offshore locations and at the ship synchrolift stipulate requirements for methods and instruments used. The INTROS magnetic flaw detector meets the requirements. The practice of its use is discussed.

Introduction

Steel wire rope NDT provides safe functioning different kind of equipment and constructions in which the ropes are used. On the other hand, NDT of the ropes saves money of owners of the equipment and constructions containing the ropes due to rope lifetime prolongation based on objective testing data.

Safe use of the rope as well as economical factors are very important in oil-gas offshore and shipbuilding industries. The ropes usually work there under impact of aggressive environment, like seawater first of all. This results in intensive rope wearing due to corrosion. Visual inspecting is helpful for the rope condition but it is informative relative to the surface wire condition and qualitatively only. Besides, it takes much working time of high skilled personnel. That is why the instrumental NDT of steel ropes is used as a main means of steel rope condition evaluation all over the world. Currently, the magnetic NDT instruments are most useful for steel rope inspection. There are dozen suppliers of the instruments in many countries (1). The great experience of the instruments use results in standards and rules (2, 3).

Rope testing output data usually are preformed in two channels: loss of metallic area (LMA) and local faults (LF) of the rope. The LMA is the characteristic of rope wear due to friction (abrasive wear) and corrosion. That is distributed (along a rope) fault defined in percents of the nominal value of rope metallic cross section area. The LF arises mainly as broken wires and pitting corrosion. The LF data are mostly qualitative and are interpreted by an expert. The rules establish rope discarded criteria based on the LMA and the broken wire number limits.

There is the third kind of rope faults: structural faults (SF) (1). The SF includes distortions of the rope structure like loose wires, deformation, mechanical damage and martensitic embrittlement occurs as a result of rope wires heating above a critical temperature (e.g. due to friction or electric discharge) and then rapid quenching by cold metal beneath. That condition can be formed on mooring ropes. The martensitic embrittlement leads to the fast and easy crack arising in rope wires. This type of the rope fault is not easy for the visual detection but is detectable by the magnetic NDT method.

The expert takes visual inspection data into consideration when he interprets output data of the flaw detector and prepares the final report on the rope under test condition.

Wire rope for offshore applications and their degradation

The main offshore applications of wire rope include crane ropes, diving bell lift ropes and mooring ropes (1).

Offshore crane ropes and diving bell hoist ropes usually have diameters of (25-35) mm and are multistrand types comprising two or more layers of strands. This type of rope construction limits axial rotation of the freely suspended rope under load. However, the multilayer ropes have a tendency to internal deterioration like broken wires in inner layers of the rope.

Mooring ropes for offshore structure are typically of a six-stranded construction with metallic wire core. The range of diameters is (70-127) mm. The ropes are long and expensive. Use of other rope types including large diameter multistrand ropes is the tendency in floating production platforms technology.

The reasons and mechanisms of offshore rope degradation are shown and analyzed by C.R.Chaplin and others in several publications, e.g. (1, 4). The rope deterioration usually occurs due to:

- abrasive wear of wires;
- corrosion;
- broken wires;
- loose wires;
- deformation and mechanical damage;
- martensitic embrittlement;
- combined failure modes.

All the damages can appear on both external and internal wires. Of course, internal damages are invisible and can be detected by rope flaw detectors only.

Method and instruments for rope NDT

Instrumental NDT methods use the magnetic principle of operation when the rope under test made of ferrous steel. The principle bases on rope section magnetization by permanent magnets including a magnetic flux along the section. Any anomaly of the rope under test causes a change of the magnetic flux as like as change of the leakage flux around the rope. The changes are measured by magneto-sensitive sensors (Hall sensors most often) or by inductive coils.

There is a number of the magnetic flaw detectors produced by different companies and offered on the world market (1, 5). The modern instruments demonstrate testing results close each other (1). Nevertheless they differ by specifications which are important for users, e.g. by mass and dimensions, by method of testing data storing, processing and presenting, by types and range of rope under test dimensions, etc.

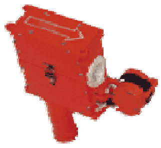
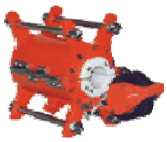
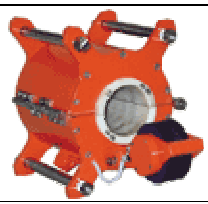
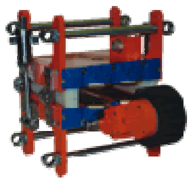
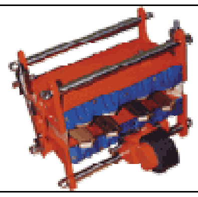
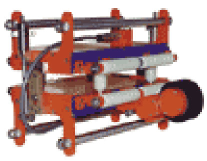
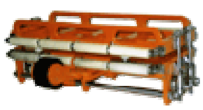
One of the most portable and light instruments, the INTROS, was described on the 7th ECNDT in Copenhagen (6) and on the 15th WCNDT in Rome (7).

The INTROS steel rope flaw detector consists of the portable basic electronic unit and the set of magnetic heads for various types of ropes and for the range of rope cross section dimensions (Table 1). The instrument is two-functional: it measures LMA value and detects LF.

There are two modes of INTROS use: real-time (operational) inspection and post process (remote) inspection.

By the first mode the electronic unit is used as in-situ interpreter of test data and stores the data in the unit storage simultaneously. Real-time interpretation of the data is possible by use of the unit LCD symbol display, light and sound alarm. A chart recorder can be connected to the electronic unit for LMA and LF traces recording.

Table 1. Electronic Unit and Magnetic Heads Specification

View		Ropes	Dimensions Weight	Main Application
Basic Unit		All types	230x85x35 mm 0.7 kg	With all magnetic heads
Magnetic Head MH 6-24		Round, 6...24 mm diameter	235x230x64 mm 3 kg	Ropes in cranes, elevators, drilling rigs, etc.
Magnetic Head MH 20-40		Round, 20...40 mm diameter	330x205x190 mm 8 kg	Mine hoist ropes; ropes in cranes, ship yards, aerial ropeways, etc.
Magnetic Head MH 24-64		Round, 24...64 mm	330x235x190 mm 15 kg	Mine hoist ropes; ropes on bridges, ship yards, roofs, offshore platforms, aerial ropeways, antenna towers, etc.
Magnetic Head MH 40-64		40...64 mm diameter		
Magnetic Head MH 124		Flat, up to 124 mm width	285x220x225 mm 9 kg	Tail balance ropes
Magnetic Head MH 233		Flat, up to 233 mm width	325x300x268 mm 23 kg	Tail balance ropes
Magnetic Head MH 233R		Steel-rubber flat, up to 233 mm width	367x350x336 mm 26 kg	Tail rubberized balance ropes
Magnetic Head MH 450R		Steel-rubber flat, up to 450 mm width	546x200x367 mm 35 kg	Tail rubberized balance ropes

The real-time mode is most useful for running rope testing when it is necessary to stop rope moving just after significant LMA or LF signals (over alarm level) appear. Then inspector checks the rope section under test visually to define the reason of the alarm.

When one need to inspect standing rope (e.g. guy rope) using the INTROS as a fully stand-alone instrument moving along the rope in the distance from an inspector, the second mode is used. By this mode the testing data are downloaded from the electronic unit storage into a computer and then are processed using the software WINTROS.

The WINTROS provides many of functions: different kinds of filtering, noise cutting-off, zero level displacing, rejecting and alarm levels setting, amplitude and distance scaling (zooming), auto-scaling, signal traces "lacing", aligning of some signal traces by distance and others. The last function is very helpful to follow rope condition within its lifetime. It is important to catch a moment when rope wearing speed increases dramatically, then time intervals between inspections must be decreased. Test data accumulation in electronic format allows creating databases for many ropes under test and to exchange data by modern communication means, e.g. by e-mail. The inspection report as a final document is filed and printed after test data processing. When the computer-oriented procedure is used then testing data are processed according to algorithms accumulated experience of many experts. Therefore the result is more objective. The both of the modes can be used in series by the same inspection.

Offshore ropes testing

Due to the simple handling and the low weight, INTROS rope test instruments are suitable for the examination of ropes at offshore locations. Several ropes at conveying platforms and on a crane ship were checked with the help of the INTROS within the last 2 years.

Figure 1. Crane on offshore location (jib near the park position)

Each conveying platforms has 2 cranes with 4 ropes of the following dimensions (Fig.1):

- 1 rope for the main hoist (30 mm ∅, app. 340 m length),
- 1 rope for the auxiliary hoist (26 mm ∅, app. 125 m length),
- 2 ropes for the luffing winch (24 mm ∅, app. 250 m length).

The ropes are multistrand regular lay with steel core and preformed strands.

The cranes are used once a week for loading and/or unloading of supply ships. Also they are necessary for the heavy load transports on the platforms. The reason for the rope discarding is corrosion, because they are only low loaded ropes.

The discarding criteria were inferred from the Netherlands standard NEN 3233. In general this kind of ropes were checked only visually. A quantitative estimate of the damage (corrosion) condition by visual control is possible, however only with high skilled personnel. But these experts were not available always on the offshore locations. So the ropes were discarded after 2 and/or 3 operational years. With NDT systems, the service life of the crane ropes should be increased, without decreasing safety condition.

At first an examination of all ropes took place to determine the present condition. Training of the service personnel took place locally in handling of the INTROS instruments during this first examination. Recorded data will be helpful for attached visual inspections. Rope areas with remarkable indications can be checked afterwards more intensively by the visual examination. Rope damage development is better to estimate with the quantitatively determined data and periodic inspections. Using the results of the non-destructive examination rope segments, which are more strongly damaged by the unfavourable environmental influences, could be located better. Simultaneous the maintenance of these rope parts (e.g. relubrication) will be accomplished more purposefully. On the other hand the data from the NDT gave more additional information to define rope inspection periods.

Fig. 2 shows main hoist rope at the drum. The rope sections are well lubricated, but flight rust is visible on the lubricant layer.

Figure 2. Lubricated main hoist rope with flight rust on surface

A rope section above the crane hook (from main hoist) is represented in Fig.3. Surface of the outer wires is attacked (damaged) by corrosion. The measured LMA (loss of metallic cross-section area) is approx. 3 % (see Fig. 4).

Figure 3. Rope segment above the crane hook with corroded outer strands

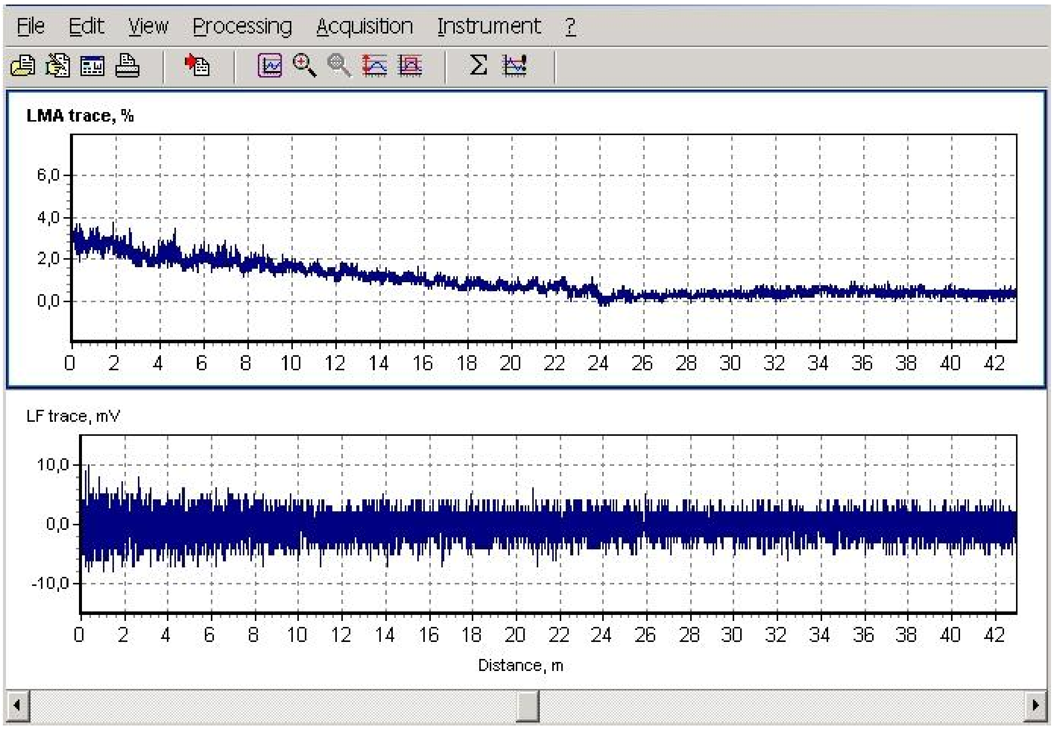


Figure 4. Data chart of the above mentioned rope (see Fig. 3)

Further rope tests with INTROS were carried out on a heavy lift vessel (HLV). 2 cranes are installed on this ship, which are intended for building of offshore locations or large bridges.

Contrary to the crane ropes on the above mentioned offshore platforms these ropes have larger dimensions as follows:

- 4 ropes for the main hoist (61 mm ∅, app. 2955 m length),
- 1 rope for the auxiliary hoist (61 mm ∅, app. 2955 m length),
- 1 rope for the whip hoist (61 mm ∅, app. 2955 m length),
- 2 ropes for the boom hoist (61 mm ∅, app. 3645 m length).

The construction of the ropes are 6 x 47 WS + CRW and 6 x 36 WS +CRW.

In general these ropes were also checked only visually, because the HLV is in use worldwide and rope experts were not available at any time. The main reason for discarding is generally wire breaks, due to wear. The influence of corrosion is minimised by the use of a special lubricant. The wear is caused by up and off drums at the contact points of external wires. By decreasing of a critical wire size it comes to wire breaks.

The wear of the external wires is however differently strongly trained around the rope periphery. The measured value for the LMA cannot be distributed in equal parts on the external wires. The discarding criteria cannot be determined only by use of the LMA value. In this case it must be considered, that the breaking load reduction of a rope is substantially higher than the determined value of cross section reduction. By this reason an additional visual inspection is required to determine of the breaking load reduction of the ropes.

Fig. 5 represents a part of the stored data (boom hoist rope). In the centre are 2 wire breaks lying next to each other. Two additional wire breaks are beside on the left and right side.

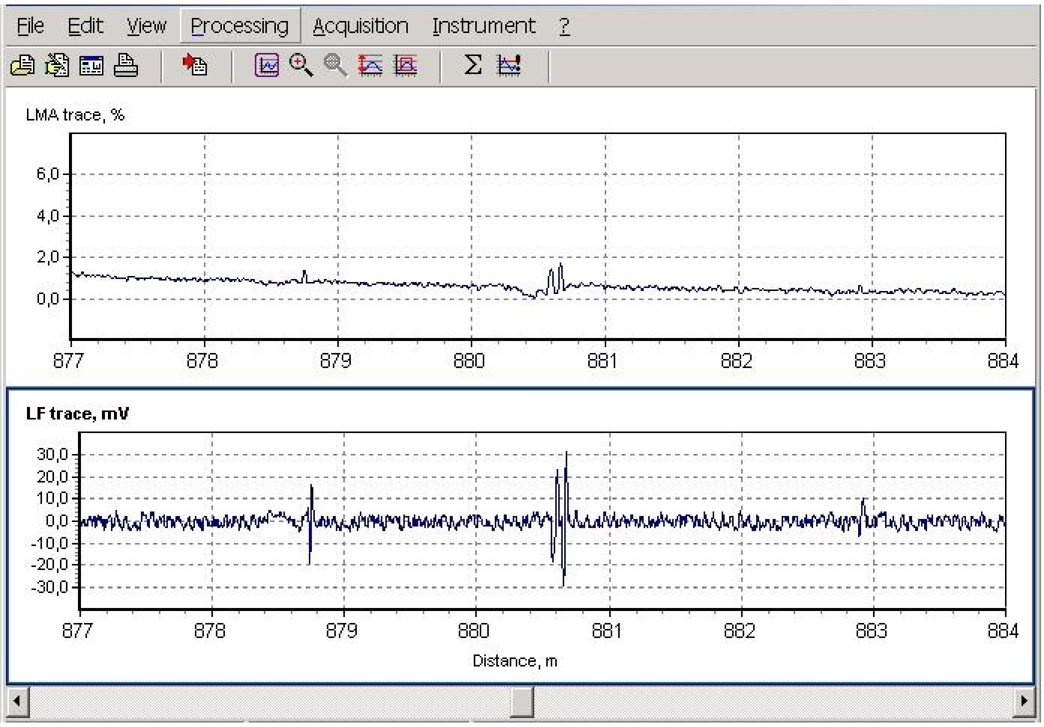


Figure 5. Part of data chart with 1+2+1 broken wires

In relation to a pure visual examination the use of the magnetic rope tester INTROS can improve the evaluation of ropes. However without experiences of the personnel this advantage cannot be used fully.

Testing ropes of the shipyard synchrolift

Malaysian Shipbuilding and Engineering, located in Johor Bahru, Malaysia has the largest, of its type, synchronized ship lift system in the world with a 50.000 dwt lifting capacity. A ship lift is actually, a large elevator used to lift ships out of and into the water.

Figure 6. Scheme of the ship synchrolift

From the deck of the ship lift, the ship is moved on a transportable system to other dry land areas for repair work.

The wire rope used in this ship lift is then exposed to both seawater and air that is a condition that most rapidly leads to corrosion. Therefore, a very stringent system of greasing the rope to prevent that corrosion is very important. The diameter of the rope is 35 mm and it contains 262 wires and is very heavily coated with grease. That is a strong detriment to relying on a visual inspection alone to determine the ropes condition. The failure of any one rope, could, under the worst case conditions, lead to a “cascade” type failure which would topple the ship onto its side causing an immense amount of damage.

When Malaysian Shipbuilding and Engineering (MSE) decided that their wire ropes were in need of a better inspection method, the contacted several companies to provide the Magnetic Flux Leakage of the rope. The criteria was that the company providing the system have the following:

1. A system that was acceptable to both themselves and Lloyds Registry of Shipping, who was their certifying agent. That meant the system had to prove its ability to detect a minimum of 0.5% LMA and to be able to find 5 broken wires in any one location or 10 broken wires in one strand lay. In addition, it had to have the ability to produce an easily readable record of the inspection.

2. The company had to have personnel certified to ASNT Level II in eddy current inspection, an acceptable ASNT Written practice for the certification of their personnel and an established procedure for doing the inspection.

After asking those companies in this region who could provide this service, they chose CITS Services Sdn. Bhd. who uses the INTROS wire rope inspection system provided they could prove out their personnel, procedures and equipment in trial tests which were to be witnessed by both MSE and Lloyds.

Samples of wire rope from the same reels as the rope in use were prepared. The outer layers were unwound, the central (King) core was ground to simulate internal corrosion, a know number of wires cut on the underside of some of the strands and a known number of wires cut on the outside of some strands. At the direction of CITS, a calibration rope standard was created. 10 wires (3.8% LMA) and 5 wires (1.9% LMA) cut on the inside of one strand. Using this rope as a calibration standard, we were able to detect 3 broken wires and 2% LMA with no problems.

The synchrolift cycles at one cycle every 1.5 hours. That is to say, it takes it 1.5 hours to go from fully up, to full down and back again. Due to the nature of the pulley system, each rope has to be inspected with the sensor head at two locations to get 100% coverage. That means it takes 3-hours/winch minimum inspection time. Since each winch only has 553 feet of rope, it is easily seen that this is a very slow, tedious job. Human nature being what it is, it is impossible to expect a technician to watch the indications on the data logger unit to detect defects as they may occur. Therefore, the ability to fully depend on the recording reliability of the data recorder is of paramount importance.

With the INTROS system data recorders ability to store up to 8 km of data at a time, the ability to "set and forget" the system and let it do the work as the rope travels through it is then possible. All the technician has to do is to record the data at the end of each segment, start it recording the next segment and so on. The uniqueness of this particular inspection is the very slow speeds the wire travels and the full dependence on the recording reliability of the data logger.

We have inspected 66 of the 110 winches that are inspected at the rate of 33 per year for an ongoing preventative maintenance inspection program with no indications of any LMA or LF problems even coming near the rope replacement limits.

Conclusion

NDT is important for safe use and well-timed discarding of steel wire ropes in various complicate constructions and installations working in offshore and shipbuilding industries. There is practical experience of the rope NDT by using the INTROS magnetic flaw detector in different countries. The experience shows importance of the human (expert) and instrumental capability proper combination for the best result achievement.

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