# Non-destructive testing of large diameter steel wire ropes with Intros instruments

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Magnetic non-destructive testing has become a standard method of condition monitoring at many different rope applications, such as ropeways, lifting ropes, cable-stayed structures [1]. This is reflected in modern industrial regulations and codes, for example, BS EN 12927-2004, ISO 4309:2010 and other. This technique was most widely applied for ropes of diameter up to 60 mm, because these ropes are mostly applied. Last time magnetic testing finds more often use for inspection of large diameter ropes, these ropes are from 60 mm to 120 mm and more. It concerns both ropes of lifting machines and ropes of cable-stayed structures. This technique also is being applied for off-shore applications by several companies, including Acergy Group.

Main object of non-destructive rope testing consists in measurement of loss of metalic area (LMA) and detection of local faults (LF). LMA indicates such faults as corrosion and abrasion. LF are caused typically by wire breaks, both outer and internal. All this rope faults lead to the loss of rope’s load-carrying capacity. While calculating wire rope residual load capacity one should take into consideration both deterioration factors – LMA and LF in their distribution over rope’s length. Figure 1 shows distribution of LMA and LF for one shaft lifting rope of 63 mm diameter during 3 consecutive inspections (blue – first inspection, orange – second inspection, red – third inspection), carried out with help of Intros instrument. Combination of distributed LMA and local wire breaks is to be seen on these diagrams. Effect of LF superposes over LMA and residual load capacity can be calculated as a characteristic of the weakest rope cross section. This calculation should take into consideration different rope parameters, such as rope construction, nominal load, material strength [2]. The result of the calculation can be presented in terms of safety factor as the main rope characteristic for a customer. Figure 2 depicts distribution of Safety Factor of the above mentioned shaft rope during 3 consecutive inspections. The construction of this rope is 6x25(1+6;6+12)+IWRC.

While estimating rope safety factor, location of wire breaks should be considered, because endurance of deteriorated wire ropes depends on wear location at the rope cross-section. Level of this dependency is different for diverse rope constructions. Two examples of this phenomenon are presented below.

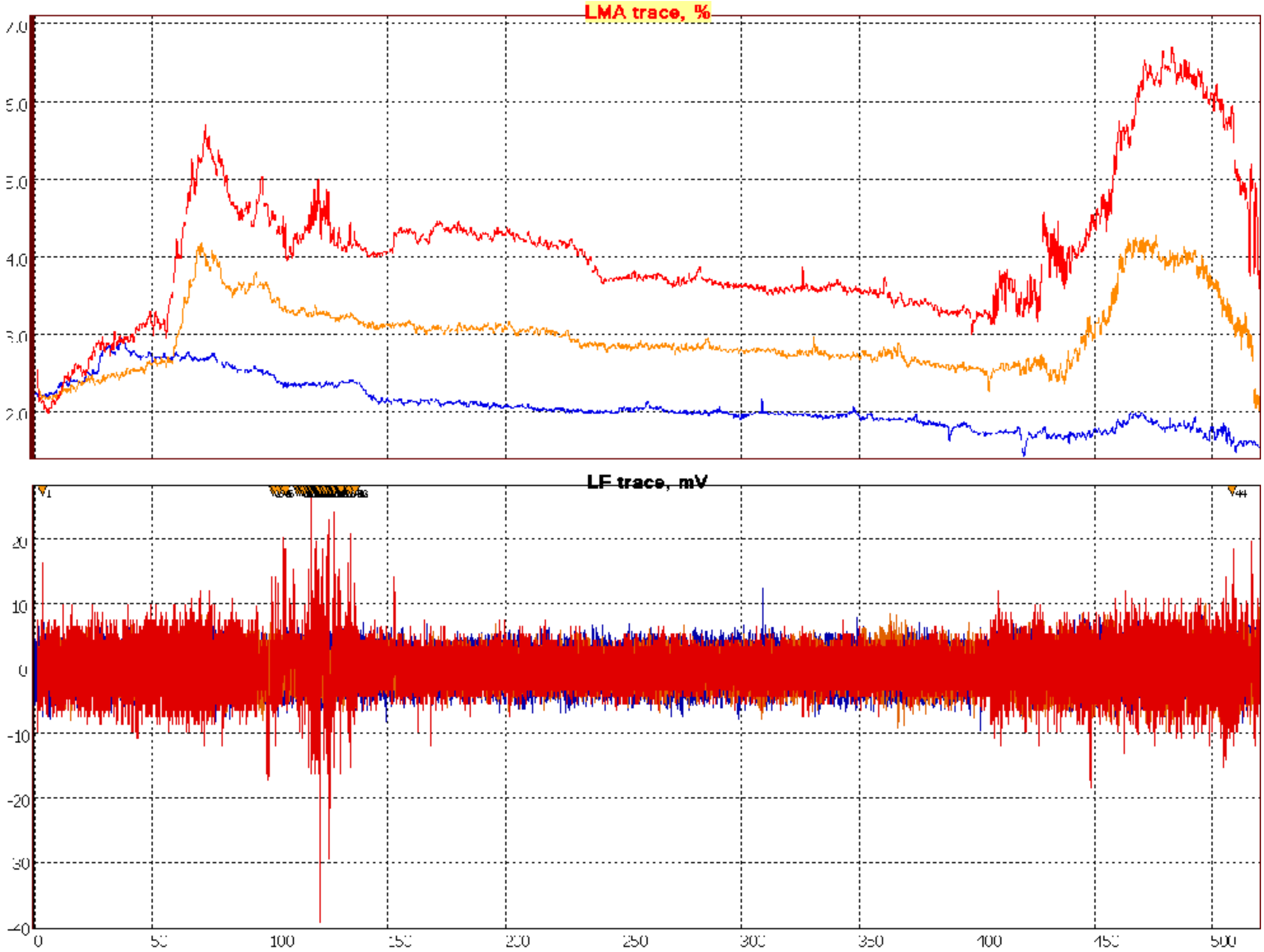



Figure 1. Distribution of LMA and LF of the shaft rope during 3 consecutive inspections.

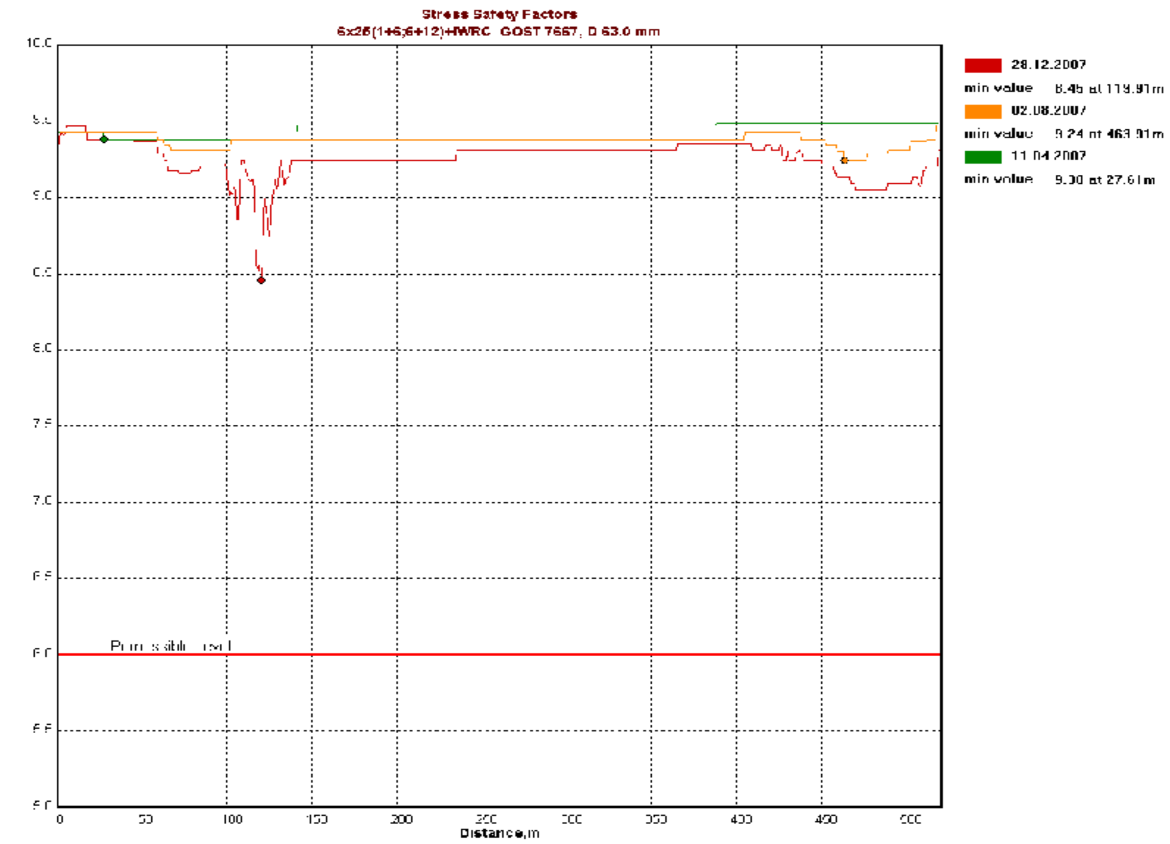
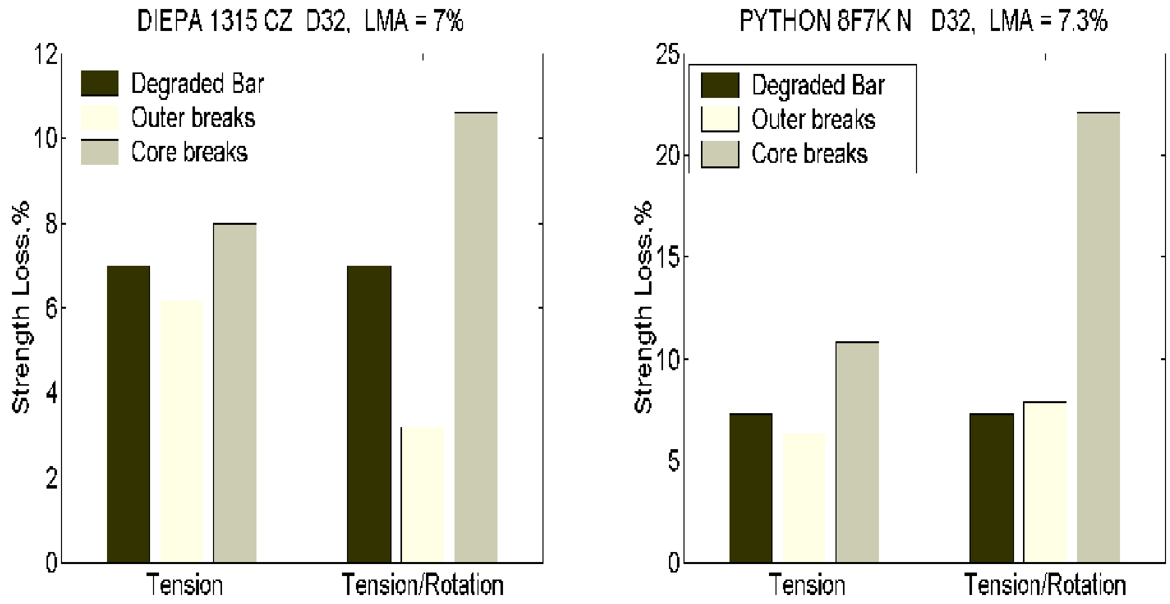



Figure 2. Distribution of Safety Factor of the shaft rope during 3 consecutive inspections.

Consider first the rotation-resistant multi-stranded rope DIEPA 1315 CZ 15x7-6x26/6x7+IWRC (1x25) that is being in service in jib crane at offshore Sakhalin platform. Loss of metallic cross-sectional area (LMA) of 7 % is assumed to be a consequence either of outer wire breaks or of inner (core) wire breaks. The resulting strength reduction may be estimated by comparing the corresponding safety factors of damaged and new (undamaged) ropes subjected to the same loading [2]. The relative strength loss has been examined for two operating conditions: 1) rope is tensioned without torsional deformations and 2) tension is accompanied by moderate rotation of the rope swivel. Corresponding diagrams are presented in Figure 3a with reference to the 7-percent strength loss of the rope simulated as a homogeneous bar. In case the rope is not constrained from twisting the slight value of LMA in outer strands leads to more perfect torque balance. So the strength loss is even less than expected nominal value of 7 %. On the contrary, the same core LMA provokes the more torsional instability and gives rise to strength loss.




a) b)

Figure 3 Strength loss depending on failure location and operating condition

Another example is a non rotation-resistant hoisting rope PYTHON 8F7K N 8x25+IWRC (1x7+6x7) with LMA value of 7.3% due to wire breaks. The diagrams in Figure 3b show the strength of this kind of ropes is quite sensitive to lifting conditions and location of broken wires over cross-section. Strength loss increases greatly when rotation is not restricted. The normative rules do not permit to use such types of ropes in hoisting systems that enable any load rotation even if the twist compensators are available [3].

The scope of results in numerical form is presented in Table 1.

Table 1

| Rope | Loss of Metallic Area, % | Loss of Strength, % | | | |
|---|---|---|---|---|---|
| | | Tension | | Tension with Rotation | |
| | | Outer wires breaks | Core wires breaks | Outer wires breaks | Core wires breaks |
| DIEPA 1315 CZ 15x7-6x26/6x7+IWRC(1x25) | 7.0 | 6.2 | 8.0 | 3. 2 | 10.6 |
| PYTHON 8F7K N 8x25+IWRC(1x7+6x7) | 7.3 | 6.3 | 10.8 | 7.9 | 22.1 |

The inner faults seem to be more dangerous than comparable outer faults. Therefore a detailed modeling of rope failure is necessary if anyone wants to predict the rope residual strength and life-time using the magnetic testing data. This problem has been solved to a certain extent by NDT-mechanical approach in Wintros-RopeStrength application.

The methodic of rope's residual strength calculation developed in INTRON PLUS is based on the automated processing of magnetic traces (LMA and LF) taken with Intros instrument. Results of this data processing together with rope parameters are used in rope strength calculation, which enables analysis of rope degradation history and prediction of its technical condition. Figure 4 depicts degradation of rope safety factor with a time vs. loading cycles (black points) and prediction of safety factor in nearest future (green points).

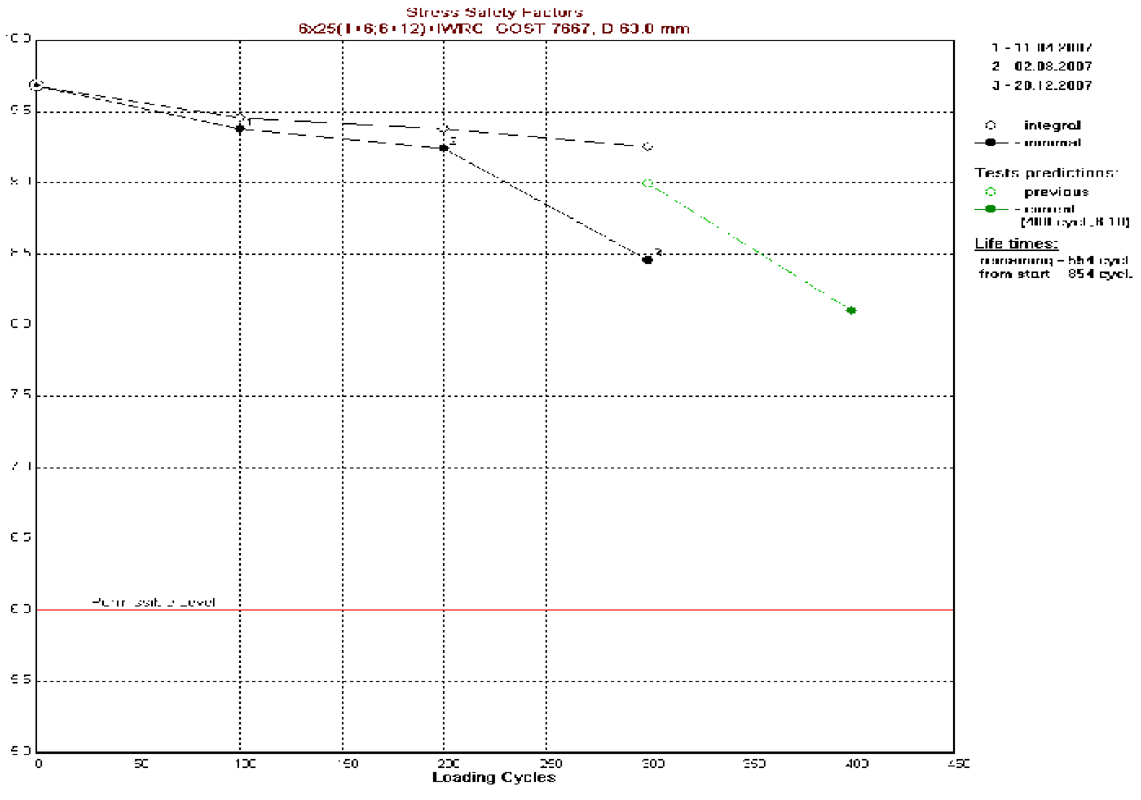



Figure 4. Degradation of Safety Factor of the shaft rope with a time.

Modern magnetic rope testing instruments such as Intros enable detection of outer and internal wire breaks (LF) simultaneously with LMA measurement on steel wire ropes of large diameter. This underlies calculation of rope residual strength and prediction of its technical condition. Some technical characteristics of Intros instruments are given in the Table 2.

Table 2

| | |
|---|---|
| Range of rope diameters, mm | 60 – 85<br>80 – 120<br>100 – 150 |
| Speed of rope under inspection, m/s | 0.2 – 1.5 |
| Precision of LMA measurement, % | 2.0 |
| Sensitivity limit to an outer broken wire, % (relative to cross-section area) | 0.12 |

These instruments are specially designed for inspection of large diameter steel wire ropes of different types – multistrand ropes, spiral strand ropes, locked coil ropes.

## References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2. A.Vorontsov, V.Volokhovsky, J.Halonen, J.Sunio. Prediction of operating time of steel wire ropes using magnetic NDT data. OIPEEC Conference, Johannesburg, 2007, p. 145-154.
3. ISO 4309:2010: Cranes – Wire ropes – Care, maintenance, installation, examination and discard, Beuth Verlag, Berlin, 2010-08, 60 pp.