# NDT of Steel Ropes with Magnetic Flaw Detectors: Documentation and Interpretation of Test Results

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Test result documentation and correct interpretation is an actual problem in various technologies of NDT: ultrasonic, eddy current, X-ray, magnetic etc. Most of current flaw detectors are provided by means of test data processing to get testing document. The document usually looks like a report or a protocol containing information on an object under test, test equipment and its adjustment, test procedure and conditions and so on.
The basic part of the report is used to be as a graphical representation of test data. This may be like visual image of whole object under test or its part (e.g. weld zone) or like schematic data representation (e.g. a strip-chart record, 2D or 3D printed traces of a flaw detector signal).

Test data are represented usually on strip-chart record or on 2D printed traces of signal by steel rope NDT. Most of present magnetic steel rope flaw detectors work as two-functional (two-channel) instruments: one channel for loss of metallic area (LMA) measurement of a rope and another for local faults (LF) detection. Record of the LMA channel represents LMA value in percents relative to a standard value of rope metallic area as a function of distance along the rope. The LF channel records sensor signals that appear due to LF like broken wires, local corrosion etc. along rope under test. A path signal generator used to get distance marks on the records.

Rejection criteria for ropes in use take into consideration limitations in LMA and LF as like as rope dimensions change and disturbance of rope structure.

Earlier rope flaw detectors used chart recording as base method of test data representation. Of course, chart record contains the most full information about rope condition. The information must be interpreted correctly to identify possible faults of a rope. Therefore inspectors must be skilful and experienced. Besides it takes much time because of usual big length of a record. Nevertheless, errors are inevitable since interpretation and identification processes are subjective. Another disadvantage of chart recorder use is fixed amplitude and distance scaling. Therefore it is difficult to interpret signal traces with wide range of signal magnitude, e.g. corresponding to location of rope metallic core broken or to place of rope splicing. One more disadvantage is the problem of interpretation when rope speed changes.

Inspection procedure by flaw detectors depends on purpose of a rope use and its positioning in equipment or construction. Thus, inspection procedures for mine hoist rope, for elevator rope and for stay rope (guy) are different. In particular, demand to minimize inspection time is actual when ropes of mine hoist or hot-metal crane are checked. Often it is necessary to get inspection data in real time to stop rope move and to inspect the rope section visually just after significant LF or LMA signals appear.

Another procedure is used to test guys. In this case a magnetic head of flaw detector moves along rope under test. Test data are transferred to an electronic unit by a cable and then are recorded or/and are loaded down to computer for processing.

The real time data recording procedure demands to perform it by high skilled expert who can quickly interpret a record. Of course, the inspection result is subjective.

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.

Documentation of testing result is important part of inspection. There are requirements for testing report in rules and instructions of many countries. According to these rules the report must include information of a rope under test (construction, dimensions, location, use etc.), of a flaw detector used and of its adjustment, of testing procedure, of inspection personnel. The more important part of the report is signal traces of LMA and LF channels.

The steel rope magnetic flaw detector INTROS designed and manufactured by INTRON PLUS, Ltd. can be applied for inspection using both the procedures mentioned. It consists of a universal electronic unit and different magnetic heads (Fig.1) to test ropes of various constructions and dimensions [1]. The microprocessor electronic unit is portable (not more than 0.8 kg) and is used as data logger with memory sufficient to save testing data of (2-12) km of rope in the LMA and LF channels simultaneously. The unit can be used as in-situ interpreter of test results for real-time inspection using its own LED display, light and sound alarm. A chart recorder can be connected to the INTROS electronic unit. Recording is possible as in real time (in-situ) simultaneously with data downloading to the unit storage so after testing by the data transfer from the storage. The scales of the record are set automatically during instrument calibration.

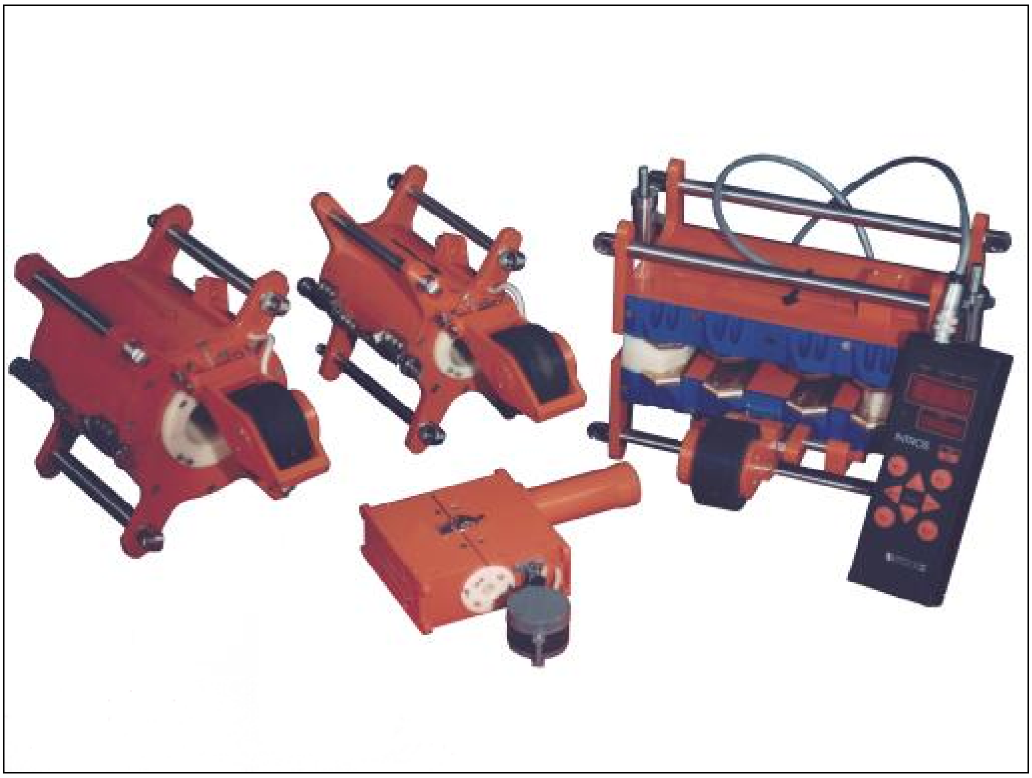

Fig.1

Due to portability and self-contained power supplying the electronic unit can be fixed at magnetic head to work as full independent instrument moving along rope under test far away from inspector. This is useful by guy of bridges or buildings inspection.

The software WINTROS is intended for test data processing after they are downloaded into a computer. The WINTROS provided 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 significantly. In this case time intervals between inspections must be decreased.

Test data accumulation in electronic format allows to create 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 (Fig.2). It consists of two parts: text one and graphical one. The graphical part includes diagrams representing compressed information about LMA (left) and LF (right). Height of the bar on the LF diagram represents the relative magnitude of the largest LF signals. Distance of the rope sections correlated to the signals is shown below. Two horizontal lines on the LMA diagram show the rejection (upper) and the alarm (under) levels of rope LMA.

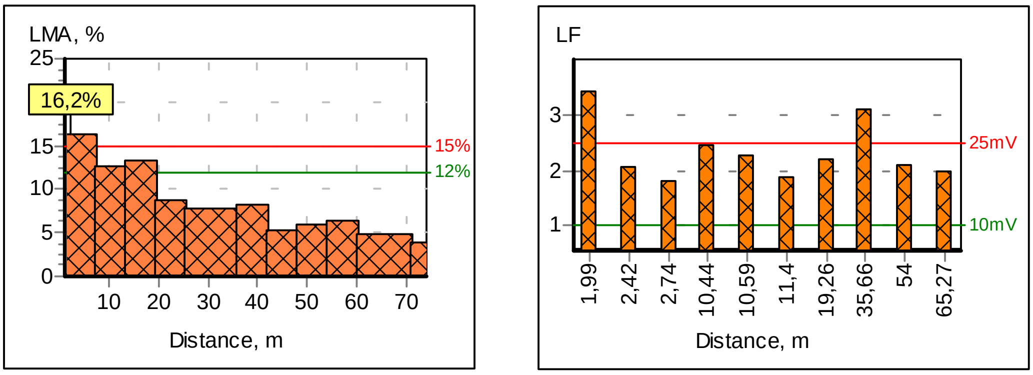


Fig. 2

The diagrams may be used as a basis for conclusion about a rope under test condition and its further use without detail analysis of signal traces. The traces are attached to the report in two versions: one is original and another is after processing fulfilled by an expert. Thus, the inspection report is an exhaustive document for the expert conclusion.

The INTROS instrument has being used for rope inspection at various equipment and installations in Russia, Ukraine and Kazakhstan for years and since 1998 – in Germany. Some examples of interpretation of test data are cited below.

Fig.3 and Fig.4 show LMA and LF signal traces before (Fig.3) and after (Fig.4) processing by the WINTROS. The LMA traces (Fig.3, upper) are low-pass filtered (Fig.4, upper) and the LF traces (Fig.3, bottom)) are filtered by an optimal filter and cut-off (Fig.4, bottom).

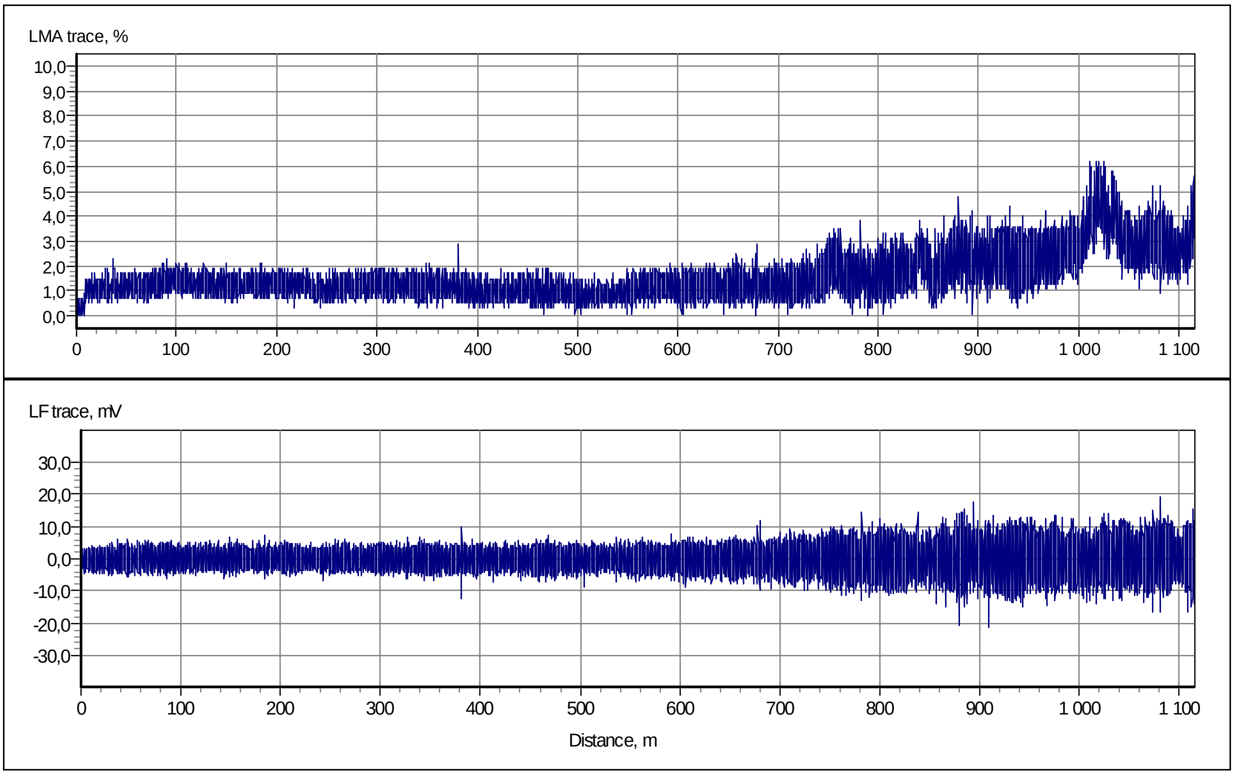


Fig.3.

Fig.4 consists of two traces got with 10-weeks interval for the same rope. All the traces relate to inspection of 30.5mm diameter brake rope at the cargo/man-riding two-deck cage of the “Scalistaja” shaft of “Norilsky nickel” mining enterprise. The traces show that the most worn section is located at the distance of (800-1100) m from the ground surface. LMA increased here from 6.5% to 8.8% within 10 weeks. There is significant corrosion damage of the section too as it can be seen at the LF traces. That is why inspector ordered to test the rope monthly and when LMA attained 10% then the rope was removed. Investigation confirmed the INTROS testing data.

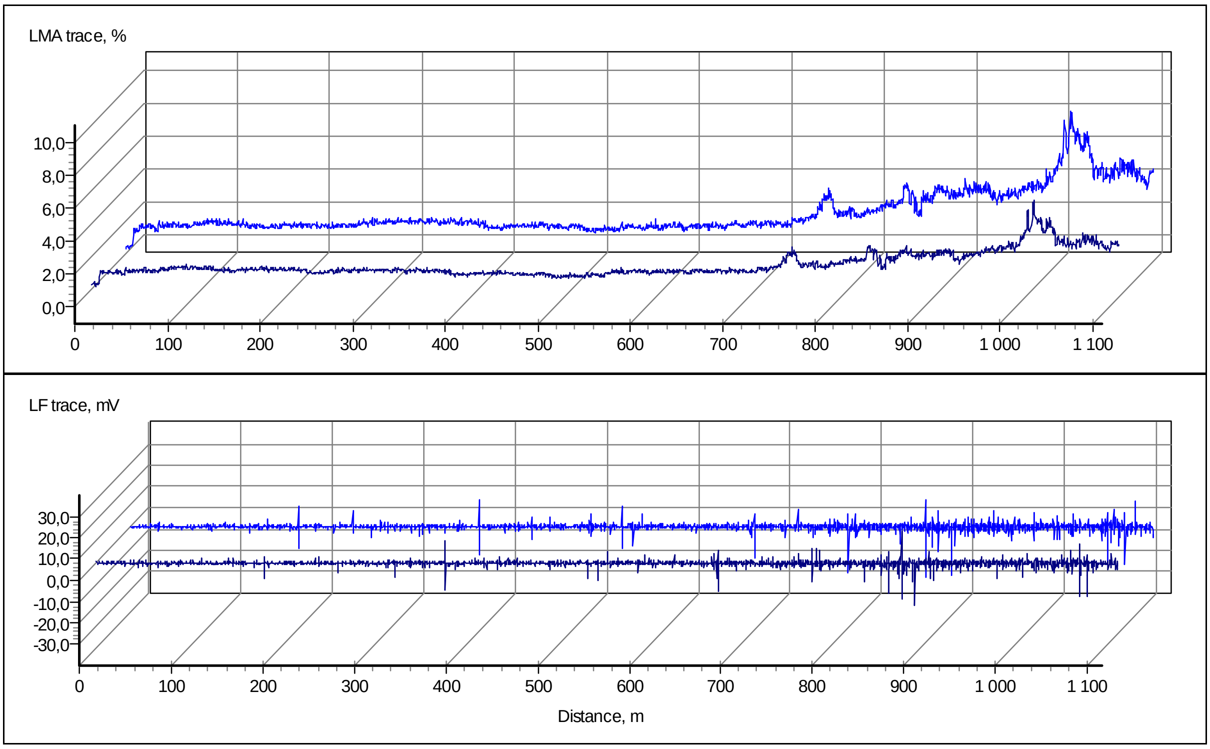


Fig.4

Fig.5 illustrates the INTROS signal traces of rope inspection of the hot-metal overhead travelling crane at “Severstal” steel plant. The LMA traces recorded with 1-week interval show 6 most worn sections concentrated in the rope part nearest to a hot-metal ladle. There are 3 high LMA peaks and 3 lower ones between them. It appears during investigation of the traces that the first 3 peaks relate to the rope sections, which are located on hoisting blocks (approached to the

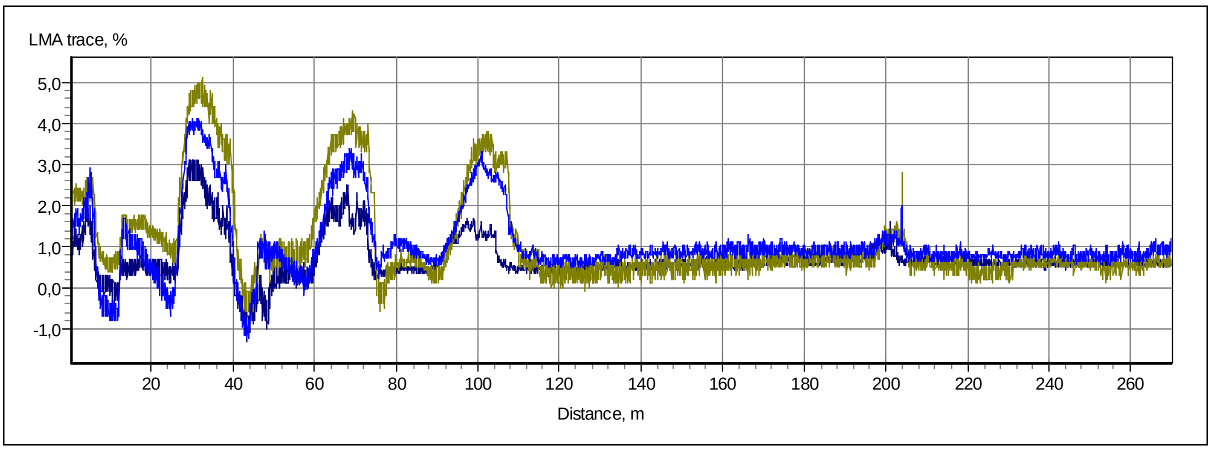


Fig.5



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ladle for 3 m) when the ladle is loaded or unloaded by hot metal. The sections are exposed by dynamic load and high temperature simultaneously. Therefore the rope sections wires are damaged mechanically and are lost strength due to metal structure change. The change influences on the INTROS output due to wire metal magnetic condition change.

The lower 3 peaks correlate to tackle blocks of the crane, which are located at least in about 15m from the ladle and are not exposed by high temperature. There is only mechanical damage of wires here, without structural change.

The LMA increases in all peaks during rope lifetime. The highest one increases approximately from 3% to 5% for 2 weeks.

The DMT TesTec Division (earlier WBK-Rope-Testing-Institute) has long experience with the inspection of steel ropes for more than 100 years. For many years steel ropes used in coal mines have been inspecting by the company. Today the company is involved in inspection of wider range of ropes: ropes for the potash and salt mines, crane ropes, bridge ropes and guy ropes of broadcast towers, etc.

The magneto-inductive devices used for these purposes utilize sensor coils. Four differential coils, which enclosed the rope as half-coils in two planes, detect the stray fields (4 LF signals). Usage of 4 coils system and special location of that coils makes possible detection of broken wires. The magnetic flux is determined by a measuring coil that encloses the rope. The magnitude of the magnetic flux is proportional to the meaning of metallic cross-section of the rope (LMA signal).

The electronic device RTI has a chart recorder integrated, which presents the rope charts during test. Test data are stored into a PCMCIA-Memory card for further evaluation. Special software developed for test data evaluation is able to determine the maximum of wire breaks per reference length along the rope and to determine the section with maximum loss of metallic area along the rope. Both the maximum wire breaks per reference length (caused by fatigue fractures) and the maximum loss of metallic area (caused corrosion and wear) are decisive criteria for the determination of the point of discarding or the specification of inspection cycles for ropes.

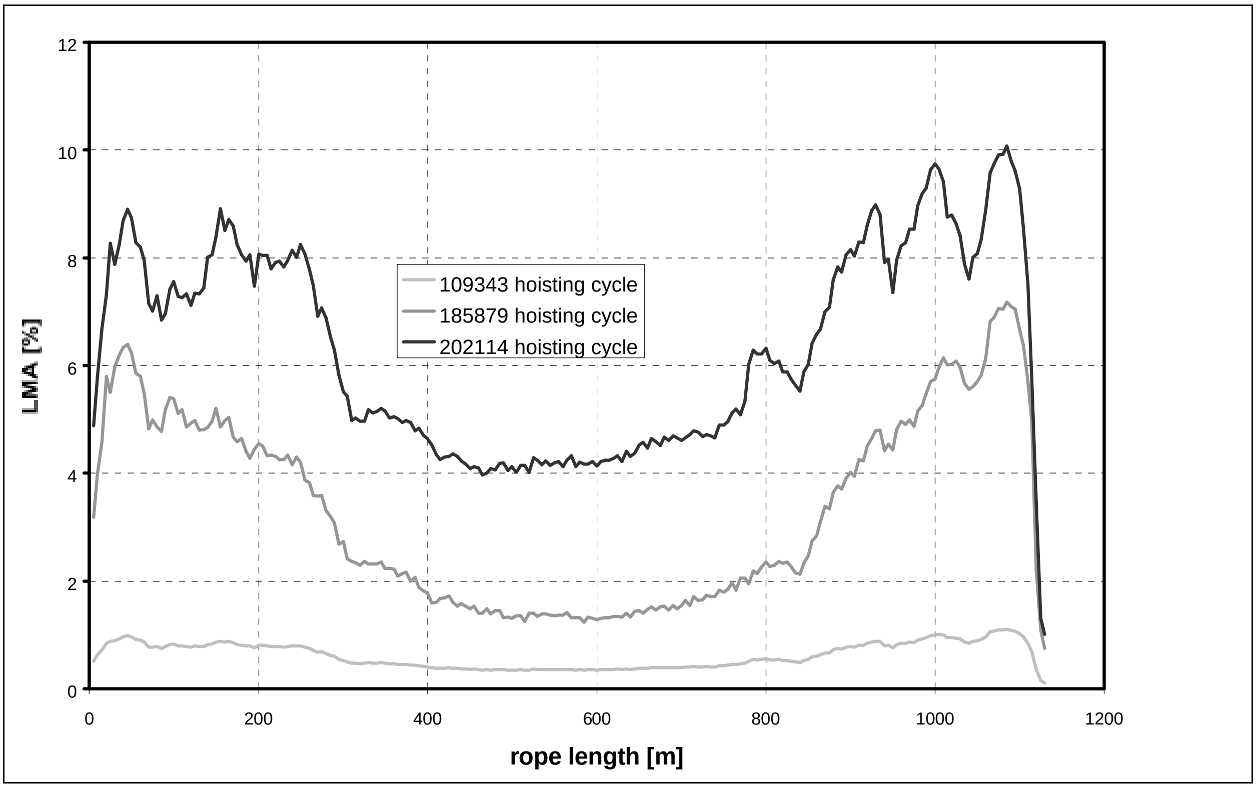


Fig.6



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The use of coils causes a more extensive electronics as well as an increased handling of the system. Therefore the ranges of application of the rope test instrument INTROS based on Hall-sensors were checked since 1998. A good agreement of the results at the determination of the metallic cross section was observed between both rope test instruments. The RTI device shows clearly more distinctive amplitudes at the recognition of wire breaks. The wire break signals were however also recognized at the INTROS device with the help of the LMA trace. The software developed for the RTI device was brought into line for the INTROS device.
An example for the determination of the loss of metallic area during the life time is represented in Fig. 6. These results are obtained from Koepe hoist shaft of the main haulage plant of the DSK (German hard coal industry). The conditions in the shaft are very damp and the ropes reached their point of discarding because of corrosion and wear. The area of the maximum damage is within the acceleration section for these hoisting ropes.

References

[1] V.Sukhorukov. Steel Wire Rope Inspection: New Instruments. – The 7th ECNDT, Copenhagen, May, 26-29, 1998.

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