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# PERFORMANCE EVALUATION OF TRACK ROPES USING TWO NON DESTRUCTIVE TESTING INSTRUMENTS

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## ABSTRACT

Electromagnetic nondestructive evaluation/testing (NDE/NDT)of wire rope has been in use for over fifty years. Regular NDEinspections provide a powerful tool in monitoring the rate ofdegradation of a rope.Wirerope Defectograph/Rope Tester is being used for scanning of steel wire ropes in aerial ropeways. The effective technology for these devices depends on the magneticproperties of steel wire rope.An attempt has been made in this paper to evaluate the performance of four track ropes in a zigback passenger cable car installationin India using two nondestructive testing instruments.

**Keywords:** NDT, track ropes, aerial ropeways.

## INTRODUCTION

Wire rope is a vital machine element for transmitting tensile forces and motion. It consists of wires,strands and core. Carbon steel wire ropes are by farthe most abundant, due to their high strength and relativelylow cost.

Based on use, ropes are classified into two categories – (1) Standing ropes used as Guide ropes in shafts, Track ropes of aerial ropeways etc. and (2) Running ropes for Haulage, Hoisting etc. Based on construction, ropes are grouped into two categories – (1) Stranded ropes which are again divided into subgroups of round, multi, compound and flattened and (2) Non-stranded ropes which have sub-groups in half locked coil and full locked coil [1].

Track ropes are used solely for supporting carriers on an aerial ropeway. Cabins for passengers travel on wheels upon track ropes in a zig-back, *i.e.*to and fro, ropeway system. The track ropes are made in a single length between the anchored end and the end connected to the rope tensioning system. Helicoidal ropes with round outer wires are not recommended for track ropes [2]. Track ropes are full locked coil (FLC) ropes. They are made of a spiral strand as its main core and finally covered with one or more layers of shaped wires. The final cover layer is made of full locked sections of wires which interlock each other and present smooth surface. The outermost layer or cover is always laid in the opposite direction to the inner layers to make the rope "non-rotating" [3].

Steel wire ropes are most significant part of ropeways [4].Frequent inspection of wire ropes is required to attainmaximum service life avoiding costly, and possiblyinconvenient, replacement. It is necessary to observeexcessive wear on the outside wires resulting in markedreduction of rope diameter, broken wires, corrosion andpitting, state of lubrication, core condition, etc.

## INSTRUMENTS USED FOR INVESTIGATION

A wirerope defectograph instrument used for NDT of steel wire ropes, generally uses the "DC Magnetic method" (also known as permanent magnetic method) [5, 6] for magnetization of the rope with permanent magnets and detection of the changes of magnetic field around the rope and total magnetic flux.Location of sensors and various classes of defects in rope to be detected have been schematically shown inFig. 1. The sensors are divided into two types: (1) LF sensors, (2) LMA sensors. A broken wire or corrosion pit creates radial magnetic flux leakage and the LF sensor detects it as the rope passes through the sensor. This signal provides information about the presence of a local fault and also information about its magnitude to the extent required. The LMA sensor measures total axial magnetic flux in the rope as an absolute magnitude or variations in a steady magnitude of the magnetic field. This signal is proportional to the volume of steel or the change in steel cross-sectional area. It provides information about loss of steel due to missing wire, continuous corrosion or abrasion.

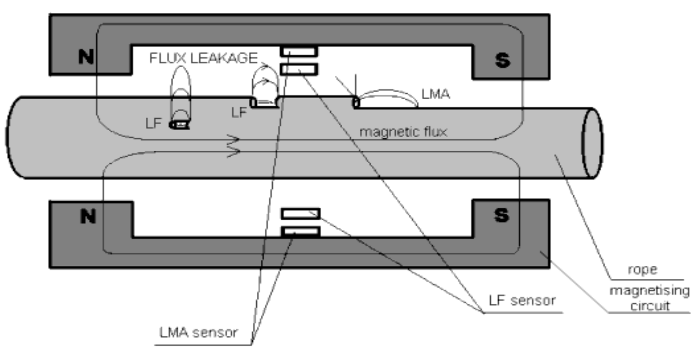



**Fig. 1.** Location of sensors and the detection of various classes of defects in rope

The Wirerope Defectograph has been calibrated each time by 80 sqmm and 20 sqmm rods for Hall Effect channel for comparison of metallic cross sectional area. Steel cross-sectional area has been assumed about 85% of the full (nominal) cross-sectional area. The Defectograph with its magnetic head 2-sh suitable for wire ropes of diameter varying from 20 to 60 mm, has been used. Average rope speed during investigation of haulage rope has been 1.0 m/sec. The internal and external (inner and outer) inductive sensor coils have registered the defects characterized by stepwise changes in rope cross-section implying broken wires i.e. localized flaws and the Hall effect sensor has registered the relative variation in loss in metallic cross-sectional area due to distributed flaws [7-11].

Another rope testing instrument INTROS make rope tester has also been used for non-destructive in-situ inspection of steel wire ropes in aerial ropeways, mine winders and other similar applications. The instrument quantitatively measures the loss of metallic cross-section area (**LMA**) and detects discontinuities such as broken wires or localized changes in rope structure (localized faults - **LF**).

Instrument utilizes the magnetic principle of operation. **Magnetic head** magnetically saturates section of a rope under test. While the rope is passing through magnetic head, the instrument inspects the rope. Any changes in rope cross-sectional area as well as discontinuities, like broken wires or strands, pits of corrosion etc., causes changes in leakage flux of magnetic field. These changes are detected by magneto-sensitive sensors, which are placed close to the rope midway between the pole pieces of magnetic head. Signals from sensors supply the **basic unit** where they are processed and displayed. The schematic diagram of INTROS make Rope Tester is shown in Fig. 2.

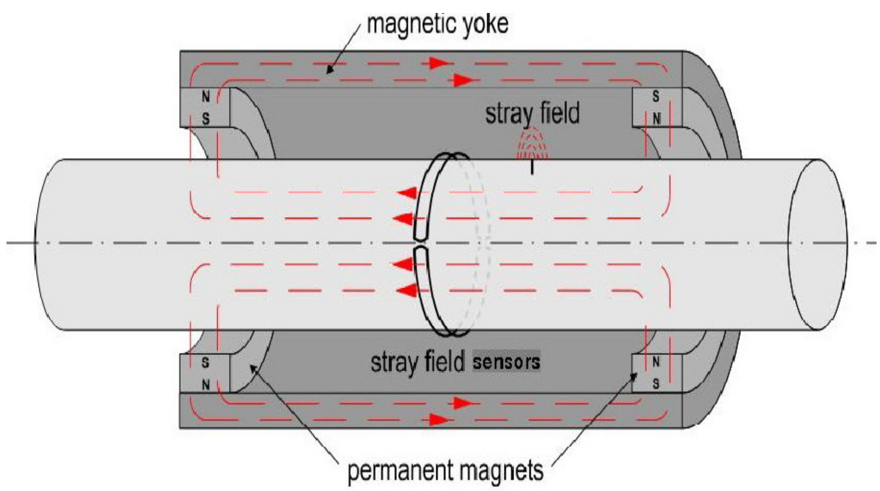
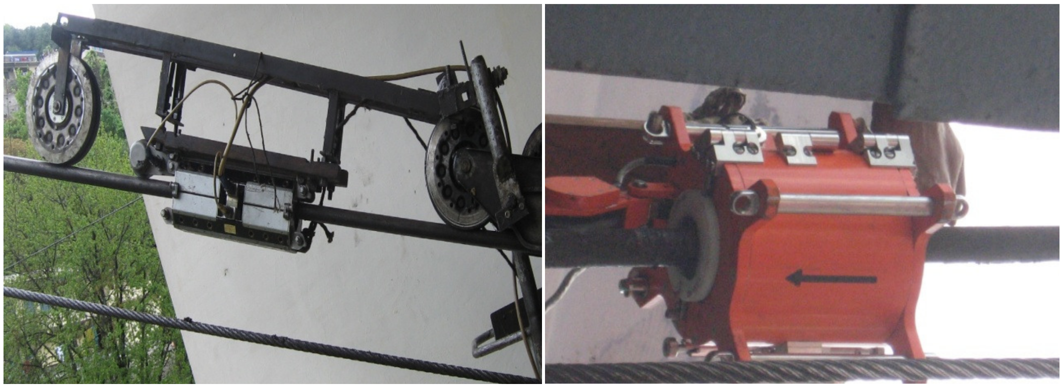



**Fig. 2. Schematic diagram of INTROS Rope Tester**

The instrument is to be adjusted in accordance with a special procedure and can be used in indoor and outdoor conditions. The rope is properly prepared before inspection. Magnetic head is installed around the rope. The rope is inspected by moving the head or the rope. Relevant signals can be recorded on a suitable media, such as a computer for the purpose of analysis[12].

The magnetic head of the defectograph/rope tester is fitted with separate special arrangement with pulleys on the track rope over thecabin in such a way that, as the cabin moves, the instrument passes along thecabin with the track rope sensed through the sensors of the instrument. In contrast to evaluation of haulageand winder ropes where ropes are allowed to pass through the instrument, here the instrument (defectograph/rope tester) movesalong the rope during assessment. The magnetic head placed over the cabin with the special arrangementis opened while crossing the tower and closed after passing the tower. The arrangement is shown in Fig. 3.Usually therope is assessed only between the towers where two side accesses to the rope are possible. It is advised todisplace the rope along periodically [7].



(a) MD 120B Wirerope Defectograph (b) INTRON Rope Tester

**Fig. 3.** Arrangement of magnetic head during study

**Case Study**

Four nos. of track ropeseach of 30 mm dia., full locked coil construction, of an Aerial ropewayinstallation at Parwanoo, H.P., INDIA, have been studied over two years. The total length of rope scanned is approximately 1672 meters. Two investigations have been carried out by two different nondestructive instruments. Comparative study of the number of flaws, diameter, lay length and relative % loss in metallic cross-sectional area of the track ropes have been shown in Table 1 [13].

**Table – 1.** Observations for the track ropes for cabin-1

| | MD 120B Wirerope Defectograph | | | | | Intron Rope Tester | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time (age of rope) | Distance of flaws (in meter) | Diameter (mm) | Laylength (mm) | Relative loss in cross-sectional area | Time (age of rope) | Distance of flaws (in meter) | Diameter (mm) | Laylength (mm) | Relative loss in cross-sectional area |
| Track Rope-1for cabin1 | 6 years | 108 m<br>140 m<br>160 m<br>350 m<br>530 m<br>1240 m<br>1403 m | 29.75 | 237 | Negligible | 7 years 1 month | 108 m<br>153 m<br>188 m<br>378 m<br>645 m<br>1320 m<br>1428 m<br>1531 m | 29.73 | 238 | 0.81% |
| Track Rope-2 for cabin 1 | 6 years | 131 m<br>195 m<br>293 m<br>348 m<br>359 m<br>372 m<br>447 m<br>486 m<br>1429 m<br>1477 m | 29.75 | 242 | Negligible | 7 years 1 month | 40 m<br>175 m<br>235 m<br>366 m<br>407 m<br>436 m<br>476 m<br>556 m<br>1155 m<br>1433 m<br>1525 m | 29.73 | 241 | 1.62% |

Important findings from the above observations are:

1. Number of flaws noticed in INTRON Rope Tester is more than that of MD 120B Wirerope Defectograph. Distance of flaws has been measured from the LTP (Lower Terminal Point).
2. Relative loss in metallic cross-sectional area is negligiblecompared to a healthy portion of rope as observed in Defectograph whereas in the INTRON Rope Tester, maximum relative loss in cross-sectional area of a flaw locationis shown as 1.62 % for Track rope 2 for cabin 1.
3. The length scanned by INTRON Rope Tester is more than that by MD 120 B Wire rope Defectograph.
4. Increase in the lay lengths of rope 1has been noticed.

**Table – 2.** Observations for the track ropes for cabin-2

| | MD 120B Wirerope Defectograph | | | | | Intron Rope Tester | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time (age of rope) | Distance of flaws (in meter) | Diameter (mm) | Laylength (mm) | Relative loss in cross-sectional area | Time (age of rope) | Distance of flaws (in meter | Diameter (mm) | Laylength (mm) | Relative loss in cross-sectional area |
| Track Rope-3 for cabin 2 | 5 years | 412 m | 30.0 | 231 | Negligible | 6 years 1 month | 460 m<br>731 m | 29.98 | 236 | 0.2% |
| Track Rope-4 for cabin 2 | 5years | 887 m | 29.97 | 230 | Negligible | 6 years 1 month | 908 m<br>1532 m | 29.96 | 233 | 0.8 % |

Important findings from the above observations are:

1. Number of flaws observed in INTRON Rope Tester is 2(two)and is more than that in MD 120B Wirerope Defectograph for rope 3 and rope 4. Distance of flaws has been measured from the LTP (Lower Terminal Point).
2. Relative loss in metallic cross-sectional area is negligible compared to a healthy portion of rope as observed in Defectograph. But using INTRON Rope Tester, maximum relative loss in cross-sectional area of a flaw location has been observed as 0.2% and 0.8% for both the ropes respectively.
3. The length scanned by INTRON Rope Tester is more than that by MD 120 B Wire rope Defectograph.
4. Increase in the lay lengths of rope 3and rope 4 has been noticed.

## CONCLUSION

Nondestructive testing (NDT) has direct impact on aerial ropeways. It can prevent accidents, save lives, protect the environment and avoid economic loss. The main faults of the track ropes are broken wires and disturbances of rope structure because of rather significant bending load on towers. This nondestructive investigation on track ropes does not include the aspect of fatigue which may develop in ropes in course of time. It is advisable to compare readings with a signature trace taken when the rope was new or first installed and then subsequent traces, to assess more accurately any degradation developed in the rope at the time of evaluation [14]. Outcome of the study will be useful for continuous monitoring of rope condition of aerial ropeway installation.

All wire ropes wear out eventually, gradually losing work capability throughout its useful life making periodic inspections, lubrication, and tensioning necessary [15]. It is important that the wire surface be sufficiently clean so that the broken wires are visible. The study depicts the present condition of ropes only. The measurements are intended to identify rope wear and other deterioration so that a wire is removed from service before it becomes hazardous to use. Application of nondestructive evaluation procedures makes it possible to improve the reliability of detecting broken wires over the available rope length for evaluation.

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