Abstract
This article will inform the reader of a simple and reliable way to monitor the structural integrity of elevator suspension and governor ropes. Nondestructive testing (NDT) provides a means to locate degradation in a rope that may be impossible to detect visually. The author briefly describes the procedure for testing elevator ropes and shows results from the tests. It is shown that NDT, incorporated into a preventive maintenance program, reduces costs and improves safety.

Introduction
The Mine Safety and Health Administration has been involved in NDT of mine elevator suspension and governor ropes for ten years. NDT does not impair the future usefulness and serviceability of a rope. Through this means, it is possible to determine the type and magnitude of degradation on a rope. Broken wires, localized pitting-type corrosion and wear are detected. The American Society for Testing and Materials (ASTM) E1571, Standard Practice for Electromagnetic Examination of Ferromagnetic Steel Wire Rope, offers guidance to professionals involved with wire rope. Those who test ropes should follow these guidelines to assure reliable test results; the users of the ropes should be familiar with this standard, understand the NDT procedure followed and the test results provided by the testing company.

Principle of Operation
A test head encircles a rope. A constant flux magnetizes a length of rope as it passes through the test head (magnetizing circuit). Variations in a constant magnetic field are sensed and electronically processed to produce an output voltage proportional to the volume of steel or change in metallic cross-sectional area within the region of influence of the magnetizing circuit. Magnetic flux leakage created by a discontinuity in the rope, such as a broken wire or a pit in a wire from corrosion, is also sensed, processed and displayed. Thus, two channels of information may be displayed: (1) changes in metallic cross-sectional area and (2) localized conditions, such as broken wires, pits in the wires or inter-strand nicking. This information may be displayed on a two-channel strip chart recorder. Recent developments make it possible to store and view data on a laptop or notebook computer.

Testing Procedure
This agency uses a system consisting of a test head, a console and a two-channel strip chart recorder (Figure 1). The test head encircles the rope during the test. The rope moves through the test head at inspection speed or speeds up to 400 fpm. The test head contains strong permanent magnets that magnetize the rope sufficiently to detect anomalies inside, as well as outside, the rope. One of the two channels on the strip chart recorder displays a signal, calibrated to show percent change in metallic cross-sectional area (LMA) by studying the strip chart trace and comparing the degraded section(s) of the rope with the best section. The other channel displays local flaw (LF) indications. If LMA is indicated, a corresponding indication also must be displayed on the LF trace. Otherwise, the LMA indication may be erroneous. For example, relative movement between the test head and a nearby metallic object (other than the rope under test) may influence the LMA signal but will show no effect on the LF signal. If the test head is too close to the magnetic field produced by the elevator motor, the LMA signal may be affected but not the LF signal. Consequently, it is important to evaluate the data carefully and compare two consecutive test runs to check for repeatability. It is not possible to NDT the rope at the end termination (babbitt or wedge socket) with this system. This part of the rope, and the socket, must be inspected visually or by another NDT method for broken wires and cracks in the sockets. It is wise to reteterminate when there is more than one broken wire at the attachment.

Subtleties of Corrosion
Although it is probably true that mine elevators are generally subjected to a harsher environment than commercial elevators, some commercial elevators are subject to humid, corrosive atmospheres. If the corrosion is localized, it may be easily missed during a visual inspection, because it affects a relatively short length of a rope. Competent elevator inspectors have missed serious localized corrosion during their routine visual inspections. NDT is a reliable means to evaluate the condition of an elevator suspension and governor rope (excluding nonmagnetic stainless steel and bronze).
Baseline Test

Newly installed ropes should be nondestructively tested after construction stretch has occurred. If it is believed that light loading will cause minimal construction stretch, then the initial baseline test may be conducted shortly after rope installation. A baseline test is important for comparison with future tests. This makes it possible to locate and, possibly, remedy potential problems that may have developed during rope installation or later. The baseline test establishes a norm from which to compare future test results.

Field Test and Evaluations - Mismatched Ropes

A problem was found with one of seven suspension ropes at a coal mine. The elevator transported miners into and out of the mine. The ropes had been in service for only 2-3/4 years. The strip chart from a test (Figure 2) displayed significant corrosion. Note that degradation is displayed on both the LMA channel and the LF channel. The "hash" displayed on the LF channel, indicative of corrosion, was verified through a visual inspection of the rope. The other six ropes displayed no significant losses. It was learned that the rope showing the loss was bright (non-coated wires), and the other six ropes were galvanized (zinc-coated wires). American Society of Mechanical Engineers' Al 7.2.1-1993, Item 3.29.1 (a)(2) requires all the suspension ropes to be from the same manufacturer and of the same material, grade, construction and diameter - preferably cut from the same reel. The degradation experienced by the one rope is typical of mine elevator ropes exposed to fresh, moist air entering the intake shaft, which is traversed by the elevator. The parts of the ropes above the car are directly exposed to the moist air when the car is parked at the surface most of the
When corrosion is involved, it is impossible to “separate the trees from the forest.” If there are broken wires in the corroded part of the rope, they may not show above the hash on the LF channel. However, it is the authors belief (based on laboratory analyses of retired rope samples) that safety is more adversely affected by deterioration from corrosion pits in the wires than actual broken wires. Eventually, wires will break from corrosion. It is important to retire a governor rope or set of suspension ropes well before this happens. Based on laboratory analyses of wires that have been retired after the NDT evaluation indicated retirement, it is prudent to retire a rope that shows 10% loss of metallic cross-sectional area. Visual examinations have determined that pits are well-established. Quoting the wire Rope Users Manual, Third Edition, “Pitting of wires is cause for immediate rope removal.”

**Relative Versus Absolute Type of Test**

As mentioned earlier, the test for LMA is a relative type of test. After a complete test is conducted, a comparison is made between the best section and other deteriorated sections of the rope. It is assumed that the best section represents a new rope. The best section of a rope may be located where it does not travel over a sheave and is not exposed to a corrosive atmosphere. This is used as a zero-reference point, and losses at other points on the rope are determined relative to that point. In theory, absolute - rather than relative - losses may be determined with the instrumentation. However, this has not been proved from field tests. It is important to compare rope diameter caliper measurements over the life of the rope with baseline measurements to monitor rope stretch. The rope may represent a new rope except for reduction in diameter and may meet retirement criterion based on diameter reduction. Excessive rope stretch should not occur if the car is not overloaded.

**Problems With Elevator Maintenance Contracts**

In general, mine operators contract the elevator maintenance. The cost of the contract includes rope replacement and labor. The problem observed with this system is that ropes are not reviewed in a timely manner. It is very important to inspect and evaluate the elevator components, including the ropes, regularly. This is not done in all cases.

**Conclusions**

This article briefly describes how an NDT of elevator suspension and governor ropes complements a good preventive maintenance program, promoting the safe and economical operation of the elevator. It has probably raised questions and comments from readers who show a particular interest. For more detailed information on instrument setup, etc., contact the author. He will be happy to share his knowledge and experiences.

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