NONDESTRUCTIVE TESTING OF ELEVATOR SUSPENSION AND GOVERNOR ROPES

by Dennis N. Poffenroth

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.

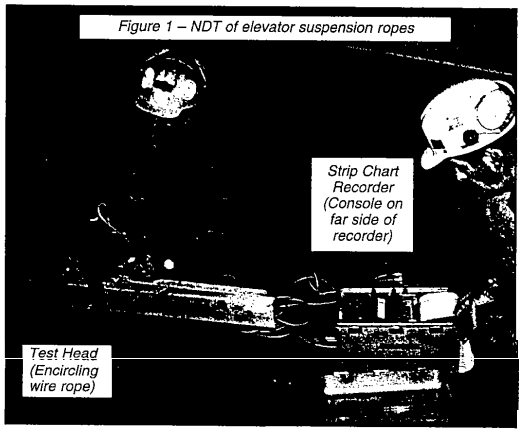

Figure 1 – NDT of elevator suspension ropes

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. This signal makes it possible to determine percent loss of 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 reterminate 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).

Continued ▶

NONDESTRUCTIVE TESTING OF ELEVATOR SUSPENSION AND GOVERNOR ROPES

Continued

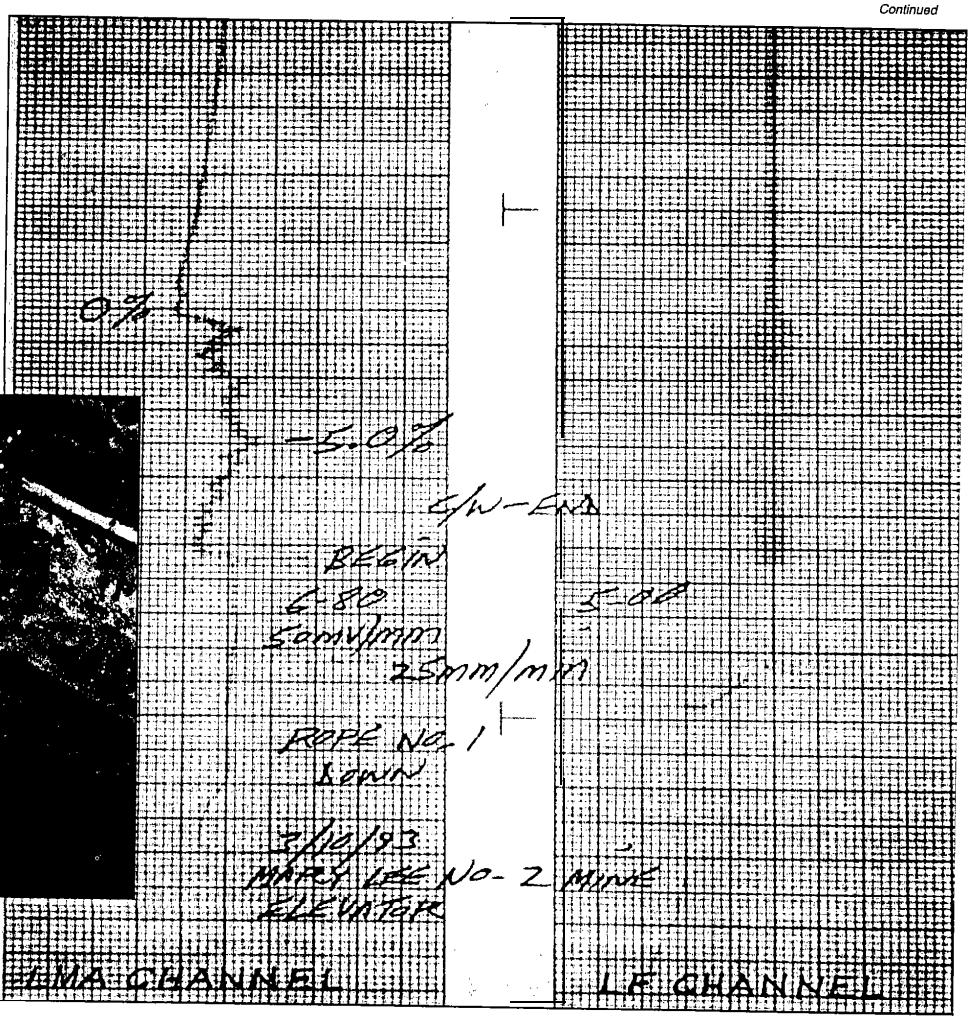

Figure 2 - Strip chart record of an elevator suspension rope test, Note: A recorder sensitivity of 5 mv/mm on the LMA channel (left trace) represents 2.5 mv per major division, which is equivalent to 2.5% change in metallic cross-sectional area. There are ten major divisions from left to right. As many as seven ropes have been analyzed by comparison of individual rope strip charts. ▶

A
Figure 3 - Corroded elevator ropes, illuminated with electronic flash

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

time. Eventually, galvanized ropes lose their protective coating and corrode, but this process takes much longer than with bright ropes.

Corrosion From Dripping Water

A set of six suspension ropes was tested at a coal preparation plant. The ropes were in service for 4-2/3 years. Alignment of the six strip charts revealed losses at the same locations on the LMA traces. The LF channel indicated, and a visual inspection (Figure 3) verified, corrosion. During the test in the machine room, water was observed dripping onto the ropes over the traction sheave. Water penetrated the ropes because the strands in each rope separated slightly as they rested over the sheave. Penetration occurred at different locations on the ropes as the car was parked at different landings. It was recommended that a guard be placed over the traction sheave. A NDT of ten-year-old ropes used at another, identical installation displayed minimal degradation. A guard was in place over the driving sheave-effective and inexpensive preventive maintenance!

Distinguishing Corrosion Pits From Broken Wires

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 ropes 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."

Frequency of Nondestructive Tests

Frequency of the NDTs may vary from one installation to another, depending on ambient conditions and use. As an example, the first (baseline). NDT may be conducted shortly after the ropes are installed. The second test may follow in two years - earlier, if warranted. Known rope damage or a visual inspection may suggest earlier testing. The third test may follow in another couple of years. Eventually, deterioration may be displayed. Now, the frequency of inspection may be increased to one year, six months or more frequently as the ropes eventually approach retirement. Rate of deterioration will help in determining an appropriate frequency. Note: Any amount of corrosion other than simple surface oxidation is grounds for immediate retirement, since useful rope life can no longer be accurately predicted.

Higher strength ropes with independent wire rope cores are being used as suspension ropes in high-rise buildings. Wires will fatigue earlier than those in traction steel ropes with fiber cores. The NDT may be used to determine rate of increase in broken wires. Retirement may be judged on that factor. If the wires are broken on the surface of the rope (crown wires), the test head may be used to "zero-in" on the broken wires and visually determine how many there are in a given length. It is important to make sure that the frequency of inspection is adequate, to assure timely retirement of the ropes. This means that the frequency will increase as required by the changing condition of the ropes. Appropriate standards or regulations must be followed to assure timely retirement of the ropes. Based on information obtained from a wire rope manufacturer and personal experience, higher strength ropes may corrode at a faster rate.

Quality Assurance

To assure reliability of the test results, it is important to calibrate the instrumentation, assure repeatability in the tests and verify the anomalies visually, when possible. Confidence in the NDT system may be acquired by conducting laboratory analyses on retired rope samples and comparing the results with the NDT results.

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 retired 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. ❑

Dennis N. Poffenroth *is an electronics engineer in the Industrial and Electrical Safety Division at the*

Denver Safety and Health Technology Center - a part of the Mine Safety and Health Administration (MSHA). Since 1974, Poffenroth has directed the MSHA nondestructive testing program for mine hoist ropes and elevator ropes to ensure the safe use of wire rope used to transport mine personnel. included in his awards and accomplishments are: the U.S. Department, of Labor Secretary's Exceptional Achievement Award, chairman of the ASTM EO7.07 Electromagnetic Methods Subcommittee, past chairman of the Colorado Section of the American Society for Nondestructive Testing and author of many papers and artic/es on nondestructive testing.