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ELEVATOR WIRE ROPE MAINTENANCE

By

Executive Committee for the American Standard Safety Code for Elevators, Dumbwaiters, and Escalators

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As these bulletins are not intended for legal adoption or enforcement they have not been given the status of an American Standards Association project but have been prepared quite informally by the Executive Committee as its contribution toward elevator safety during the emergency.

It is the hope of the Executive Committee that these bulletins may be of real value to owners of elevators, and that they may, by calling attention to certain work that may be done and certain precautions that may be taken, be a means of maintaining the excellent safety record made by vertical transportation during the last two decades.

II. FACTORS AFFECTING THE WEAR OF WIRE ROPE

1. Wire ropes by which elevators and their counterweights are suspended and those used to operate elevator safety devices are replaceable items that are almost unobtainable today, and the maximum possible life consistent with safety must be obtained from each set.

2. The service given by wire rope is generally measured in miles. Mileage, however, is not a safe criterion except for comparison between cars of approximately the same rise, duty, and number of landings. The number of round trips is a better measure. The service which may be obtained from a given set of ropes under a given duty cycle is made up of two different groups of factors:

A. Those over which the owner has little or no control and which in total result in what we may call "normal wear". These factors include the relative hardness of rope and sheave; the ratio of sheave diameter to rope diameter; the shape of the groove, and the type of wrap (single or double), and similar items involved in the basic design of the elevator hoisting machine and the layout of the particular installation.

B. Those factors (not necessarily arranged in order of importance) which may be reduced or eliminated by careful maintenance methods. Among these are:

a. Lack of rope lubrication.
b. Unequal or variable rope tensions.
c. Misalinement of sheaves.
d. Lack of maintenance of sheave grooving.
e. Poor brake setting.
f. Unduly high peaks of acceleration and retardation.
g. Change in top and bottom hoistway clearances.

3. A wire rope is, in effect, a machine with a large number of parts working together in close proximity and moving relative to each other.

1. DISCUSSION OF FACTORS AFFECTING WEAR

(a) NEED FOR ROPE LUBRICATION

4. Elevator ropes are made up of several strands laid about a center of hard fiber. The purpose of the core is twofold: First, to support the steel strands in their proper relative position, and, second, to act as a reservoir of lubrication. This fiber core is treated by the manufacturer with a lubricant which serves to lubricate the wires in the strand and to retard the absorption of moisture.

5. The lubrication supplied by the manufacturer will not last the full life of the rope, so the owner must relubricate the rope periodically if maximum service is to be secured. The frequency of lubrication will depend upon the amount of lubricant retained by the rope, the amount of use of the elevators, the factor of safety of the wire ropes, the temperature of the hoistway in which it is used, and other factors. Continuous lubrication may offer certain advantages over periodic lubrication. As a practical guide to the need for lubrication, a finger wiped in a sheave groove should show a faint smudge and have a slightly oily "feel." If this test leaves the finger dry and clean, lubrication is needed.

6. With a traction drive, the elevator is moved because of the adhesion or friction between the driving sheave and the ropes. With excessive application of lubricants, with lubricants having high viscosity, and particularly with lubricants containing solids, such as graphite, mica, asbestos, soapstone, or similar substances, the coefficient of friction between the rope and sheave may be so reduced that a dangerous slide may result. With traction elevators, the lubricants and the amount used should be limited to those supplied or approved by established elevator or rope manufacturers. After a rope has been relubricated a test should be made before the car is put in service. The empty car should be run in the up direction and stops made at various landings. Any noticeable slide of the ropes during acceleration or retardation is an indication that the lubrication is excessive.

7. If compounds containing graphite or similar solid lubricants have been used on the ropes of traction elevators to such an extent that slipping occurs, the ropes and sheaves should be scrubbed down with a stiff-bristle brush saturated with kerosine or a nonflammable or high-flash-point solvent, wiping the rope and sheave with a clean, dry rag.

8. Where drum machines are used and the hoisting ropes are fixed or anchored to and wind on the drum, heavier lubricants and those containing solids may be employed, but not to the extent that such solids can be built up in sheave and drum grooves.

9. Proper lubrication will prolong rope life by reducing the abrasive action of wire on wire or strand on strand. It will retard core deterioration, thus eliminating excessive distortion of the rope where it runs over sheaves or winds on drums. It will also retard corrosion of the rope by providing a moisture-repellent coating.

10. Before being relubricated, ropes should be thoroughly cleaned. Where continuous lubrication is provided, the rope should be periodically dry-brushed to clear the crevices of accumulated grit.

(b) ROPE TENSIONS

11. Where an elevator is suspended by two or more ropes, the rope tensions should be as nearly uniform as possible and manual adjustment made when necessary.

12. The two principal causes for variation in the tensions between elevator ropes in a set are:

Differences in length of the ropes.
A differential action due to differences in sheave groove diameters and variations in cable diameter.

13. In a group of ropes cut from the same reel to the same length and carefully adjusted to the same tension, each rope will stretch a different amount and after a few weeks or months some of the ropes may be quite loose, whereas a few may be carrying an excessive load. It is necessary to equalize tensions if maximum rope life is to be obtained.

14. Most of this stretch takes place early in the life of ropes, and if the tensions are adjusted once or twice during this period of rapid and uneven stretch, the ropes will maintain their tensions fairly well for considerable periods during their remaining life.

15. The best place to test the tension is from a landing near the center of the hoistway, with the car at the bottom. When the ropes are pulled toward the landing, the greater the deflection for a given pull, the less is the tension in the rope. A spring balance will enable the mechanic to exert the same pull on all ropes. The deflection may be measured with a rule.

16. The tensions should be equalized by turning the nuts on the shackle rods, then running the car up and down the hoistway to distribute the tensions on both sides of the drive sheave and retesting the tensions. This process should be repeated until the tensions in the ropes are substantially equal. Tension adjustments must not be made by twisting or untwisting the rope. After the adjustment is completed, be sure that lock nuts are tight and cotter pins are inserted.

17. A more accurate method of equalization of tensions is to place the car at the bottom of the hoistway, deflecting each rope in turn, not more than 1 percent of its length, releasing it and counting the vibrations for a fixed number of seconds, say, 10. This may be done from a landing near the center of the shaft. Where the ropes have been so adjusted that the number of vibrations are the same within the accuracy of an ordinary watch, the tensions are practically equal. For comparatively short ropes the vibration test should be made with the car empty to increase the time of each vibration, whereas for long ropes the car should be loaded, both to decrease the time of vibrations and to cut down secondary vibrations.

18. When used, rope equalizers must be lubricated frequently, examined, and adjusted to center the available travel, or they may present a hazard in themselves.

19. Ropes of a given nominal size vary in diameter [1] from rope to rope and there are small variations in diameter of a single length of rope. Further, there are frequently slight differences in the width and depth of sheave grooves so that ropes do not seat to exactly the same depth in the sheave giving unequal pitch diameters so that differential action is set up resulting in wear of the ropes. It is important to check the seating of ropes and, where the difference is considerable, the sheaves should be regrooved by competent mechanics.

(c) ALINEMENT OF SHEAVES

20. The alinement of all sheaves, the lubrication, and the condition of bearings should be checked periodically, as wear, settlement of building foundations, and similar causes may result in sufficient misalinement to affect rope life seriously.

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[1] The diameter of a rope is the diameter of a circumscribing circle and is measured across an opposite pair of strands, or preferably, is the average of the readings over 3 or (in the case of 8-strand rope) 4 pairs of strands.

(d) LUBRICATION OF SHEAVE BEARINGS

21. A traveling ("vibrating") sheave for a drum machine should slide as well as rotate on its shaft. Misalinement of sheaves, wear, or lack of lubrication may prevent proper lateral movement of the sheave as it rotates.

22. A rope used for long periods decreases materially in diameter. When ropes are to be replaced the condition of the grooves should be checked. This may be done by making a plaster of paris or wax impression of the grooves. On this mould the width of the rope seat may be measured with calipers or a micrometer. If this is appreciably less than the diameter of the new rope, the sheave should be regrooved, otherwise the new ropes will not seat in the old grooves but ride on a pair of ridges in each groove, those ridges tending to cut into the new ropes. The diameter of the new rope should also be measured.[2] When it becomes necessary to regroove, it may be well to consult the company manufacturing the equipment, as most manufacturers have special tools for regrooving sheaves. For long rope life, be sure sheave grooves are of proper contour and width before reroping.

(e) BRAKE ACTION

23. Harsh stops are detrimental to long rope life. Harsh brake action due to heavy spring pressure, brake shoe wear, excessive dynamic braking, etc. tends to shorten rope life.

(f) MACHINE ACCELERATION

24. An excessive acceleration shortens rope life. To get maximum service from wire ropes, keep the machine acceleration as low as practical. In many cases, service will not be noticeably affected if the acceleration is reduced. Such adjustment should be made only by a competent elevator mechanic.

(g) INCHING

25. Rope life is affected by the number of starts and stops, and "inching" for a landing is frequently an aggravated start and stop. Poor operation will materially shorten rope life. It is important that operators be trained to handle the equipment properly.

III. INSTALLATION OF NEW ROPES

1. MAINTENANCE OF OVERHEAD AND PIT CLEARANCES

26. Allowance must be made in cutting the ropes to compensate for at least part of the anticipated stretch. The counterweight buffer must not bottom when the car is at the top landing, but a new rope must be long enough to provide the minimum top clearances required for car and counterweight. *See that counterweights do not compress their buffers if you want maximum rope life*, but for safety sake do not install ropes that are too short.

27. When reroping is necessary, all ropes in a set on a traction machine and both ropes of the same pair on a drum machine should be replaced. The ropes in the set should all be of the same material, grade, construction, and diameter and preferably be cut from the same reel.

[2] See footnote 1.

2. GOVERNOR ROPE REPLACEMENT

28. When replacing governor rope, if it is not possible to get a rope of the same material or construction, a full-load safety test (which is required by the American Standard Elevator Safety Code under these circumstances) should be made to see that the new rope will cause the safety device to function properly.

IV. ROPE INSPECTION

1. ITEMS TO BE CONSIDERED

29. All ropes should be subject to competent periodic inspection. The factors that must be considered in judging a rope include surface wear, number of broken wires in a unit length (generally one rope lay—a full turn of the strand helix), distribution of broken wires among strands,[3] loss of rope lay, condition of the core, and corrosion or pitting. The proper evaluation of these items takes years of training—good inspectors cannot be made overnight. If in doubt as to the remaining strength of a rope, the manufacturer might well be consulted.

2. FATIGUE FAILURE

30. Internal fatigue is difficult to detect and is consequently a greater hazard than surface wear. The surface of a rope may show little or no wear, but if the rope is bent over a short radius, the individual wires will snap, and in extreme cases a rope may be broken by hand. Such failures are more likely to occur in ropes of relatively low tensile strength, such as iron or the milder grades of steel, and are more frequent in governor or compensating rope usage, where ropes are lightly loaded. It is possible to locate such fatigue where there are actually broken wires by lifting, or attempting to lift, the individual wires. The breaks are generally under the strand or in the valley between strands. Ropes, particularly governor ropes, which have given abnormally long service, should be regarded with suspicion. If there are no or only a few broken wires, the rope should be bent to a short radius without kinking it; if fatigued, wires will part.

3. EXTENT OF WEAR AND ITS RELATION TO THE FACTOR OF SAFETY

31. In condemning worn wire ropes most inspectors do not differentiate between two sets of ropes which show equal wear even though one set may be on a drum machine where the factor of safety of the suspension members is 6, although the other is on a traction machine, where the factor may be 12 or more, yet obviously this factor of safety should be taken into consideration. Ropes with low factors of safety should receive most careful and frequent inspection, particularly all ropes on drum machines.

[3] Some of these items were covered in a method which appeared in Wire Rope Engineering for July 1932. The results of analysis of approximately 100 ropes by this method are reported in National Bureau of Standards Research Paper RP920, vol. 17, (Sept. 1938), which may be consulted in many reference libraries.

V. SPECIAL ROPE MAINTENANCE ITEMS FOR DRUM MACHINES

1. RESOCKETING OF ROPES

32. The car and counterweight ends of ropes on drum machines are particularly subject to fatigue. This condition is more severe on overhead machines. The ropes on overhead drum machines should be resocketed every year, and on basement machines every 2 years. All socketing, whether on new rope or old, should be carefully inspected before the elevator is returned to service.

2. JUMPING OF ROPES

33. The most common cause of rapid deterioration of wire rope on drum machines probably is jumping the grooves with consequent overwinding. This may be due to a brake action which is too harsh, high retardation, or poor equalization, but probably will be found to be due, in part at least, to an excessively heavy car counterweight. In such cases a competent elevator company (preferably the company making the original installation) should be consulted as to the proper procedure.

VI. SAVING ROPE BY REDUCTION OF SERVICE

34. Marked savings in wire rope may be effected by reducing the speed or by shutting down some of the elevators. Either of these steps will reduce the total number of miles run during any 1 day. A careful study of elevator traffic in a given building may result in revised schedules with fewer cars operating in "off peak" hours but with no serious curtailment of service. Skip stops or the elimination of down stops at second and third floors will give fewer stops and longer rope life. When curtailing service, care should be taken to avoid overloading the cars which are in operation, as excessive stresses will shorten the life of wire rope. In any event, the possibilities of saving wire rope offered by these methods are great and should be investigated most carefully.

WASHINGTON, November 4, 1942.

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