

Early Failures of Conveyor Wire Ropes: The Root Cause NOT covered by AS 1755-2000.

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A common failure mode for belt conveyors with trolley gravity take-ups is the failure of the wire rope. These failures can result in a significant damage to equipment, as well as costly production downtime and safety risk to personnel. Whilst AS 1755-2000 Clause 2.2.5 focuses on wire rope tension strength in its selection, it unfortunately ignores fatigue: a failure mode fairly common in the industry. This paper addresses this issue in conveyor wire rope design, and provides guidance for the prediction of fatigue induced wire rope failures.

In my engineering experience I have encountered several incidents of wire rope breaks. Fortunately there were no injuries, but these failures caused significant equipment damage and production downtime. Early assumptions of the root causes was tensional failure, indicating either faulty product (wire rope) or bad design for strength. Interestingly however, my investigations revealed the designs met AS 1755, and the root cause of the early failures was in fact fatigue – not covered by the Australian Standard. The sole cause of all wire rope breaks I investigated was fatigue - not monotonic/static, but dynamic, cyclic and sometime unsteady bending fatigue.

The good news is the fatigue life of wire ropes can be calculated, to enable appropriate design or prediction of failure. The first step is to determine the magnitude and frequency of gravity take-up movements.

All belt conveyors during operation are subjected to normal incidents of starting, stopping, loading, accelerating, coasting, load variations etc. All of them create belt tension deviations, and those in turn create gravity take-up movements. The magnitude and frequency of these movements depend on factors such as:

- length of the conveyor
- type and size of the belt
- load and its variations
- location of take-up in relation to the drive pulley
- location of take-up in relation to the loading chute
- mass of the take-up
- speed of belt
- acceleration of belt
- presence of a tripper or a shuttle
- local atmospheric conditions
- type of a driving system; VVVF, DOL
- presence of special couplings, clutches etc.

Each movement of take-up (no matter how small) results in the wire rope rolling in and out of the sheaves, each time bending it. Regardless of what causes take-up movements, there is a substantial number of them. I estimated that in average conditions, wire ropes are subjected to between 35,000 and 67,000 bends a year for the conveyors that I have analysed in the mining industry. The magnitude and frequency of these movements can however be estimated.

Fatigue life of wire ropes is a function of:

- rope diameter and MBF
- sheave diameter
- pull force
- rope grade
- rope construction

The “number of bends to failure” can now be obtained from rope manufacturers. The design of the take-up should therefore be based on the projected life of a rope, clearly predicting wire rope discard time. Running rope selection should be based on service life. The service life can be assessed and calculated to provide reasonably accurate replacement time.

AS 1755 bases wire rope selection on safety factors and sheave-to-rope diameter ratios. These still need to be used as a minimum requirement in the design, but must not be the sole consideration. Bending fatigue could be the root cause behind the wire rope life being as little as 1 year. Preventative maintenance (wire-rope replacement) should therefore be based on the fatigue life calculation to minimise downtime and the risk to personnel. It is important that operators, reliability/maintenance engineers and design engineers are aware of this issue.

Current state of standards relevant to wire ropes for take-ups is as follows:

1. AS 1755–2000: Conveyors – Safety requirements. In clause 2.2.5 Take-ups and counterweights – only minimum safety factor is mentioned. Nothing about sheaves, fatigue life or winches.
2. AS 1418.1–2004: Cranes, hoists and winches. Section 7 Crane Mechanisms. This standard would be perfect for take-ups and winches. However as it stands now, load spectrum factor K_m will always be over 0.5 (due to constant static load) and that would lead to State of loading L4 – Heavy. That in turn makes rope and winches too big and too heavy, unnecessarily so, prohibiting the use of that Standard for practical and economical reasons.
3. Other standards like: AS 2759 (Steel wire rope – Use, operation and maintenance), AS 1735.2 (Lifts, escalators and moving walks) are too general or too specific to be applied to take-ups.

In summary, AS 1755-2000 does not fully cover wire ropes, fatigue life and winches. It is a complex problem and requires additional engineering calculations and assessment.

Don't risk it, have your take-up properly analysed and designed.

I will be happy to provide knowledge and experience in working with you on this important issue.

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