Traction Sheave Hardness

There is a direct relationship between ropes and traction sheaves, yet this relationship is sometimes misunderstood. Many times a problem occurs which appears to be rope related, such as wear or vibration, and the natural assumption of the cause is a manufacturing defect in the wire rope. More often than not, the actual cause of the problem is the sheave. Poor rope performance is the first indication of a sheave problem because <u>a sheave problem is always conveyed to the ropes.</u>

Sheave and Wire Rope Brinell Hardness

Manufactured in a foundry, a traction sheave's Brinell hardness depends on the material composition used when it is cast. For example, a Class #40 traction sheave (a very common grade specifying 40,000 psi tensile strength) typically provides a Brinell hardness of 180/210. However, today most OEM's require a minimum sheave hardness of 220 Brinell, while some OEM's work with a Brinell as high as 260. Therefore, to obtain the specified hardness, foundries utilize two methods.

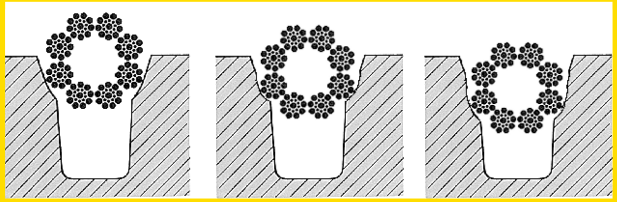
Heat treating, most commonly used due to its lower cost considerations, is a process whereby the casting (sheave) is heated and cooled at controlled temperatures to increase the hardness of the outer shell or skin of the casting. Heat treating, however, has little to no effect on the casting's core hardness. Sheaves which have obtained their hardness through heat treating will gradually become "soft" after multiple rope replacements. Another method is alloying in which the composition of the casting, and thus the hardness, is altered by specifying different alloys in the composition of the steel used in the casting. Alloying provides uniform (homogeneous) hardness throughout the casting. **Figure 1** shows a range of 220 to 260 for current generation traction sheaves.

Figure 1: **Approximate Brinell Hardness of Wire Rope and Sheaves**

ROPE GRADE	BRINELL HARDNESS		
	WIRE	TRACTION SHEAVE	WINDING DRUM
Extra High Strength Traction	450/500		
Traction	365/410	220/260	160/200
Iron	240/365		

Traction grade elevator wire is approximately 165% harder than the sheaves; extra high strength traction wires are approximately 200% harder than the sheaves. <u>Wire rope is harder than the sheave on which it operates.</u> Therefore a sheave will continually wear throughout its life. **Figure 2** shows the progression of sheave wear. As the rope operates, it seats itself into the groove, causing a diameter reduction in the sheave as the sheave is worn to match the diameter of the rope due to the greater hardness of the rope. The resultant worn groove now adversely affects the performance of each new rope.

Figure 2: **Progession of Sheave Wear**



Sheave Wear

The rate of sheave wear is determined by several factors including the specific hardness of the sheaves, the diameter of the sheave (arc of contact), the type of groove (pressure on groove and rope), speed of the car, lubrication (refer to Bethlehem Elevator Rope Technical Bulletin 2, *Lubrication.*)

Sheave Hardness

• <u>Soft Sheaves.</u> A soft sheave condition, seen usually in heated-treated sheaves, can be detected by rope imprinting (sheave corrugation) or metal shavings around the drive sheave. A soft sheave condition is most likely to occur after multiple rope replacements. As the rope seats itself into the groove and wears away the hardened outer shell as discussed previously, the softer steel beneath will eventually be exposed and the groove will have a hardness unacceptable for any elevator rope grade. Under these circumstances regrooving is useless as the required Brinell hardness cannot be achieved.

• <u>Hard Sheaves.</u> Sheaves with a Brinell hardness of 220+ will last longer than sheaves in the 210 range. However, harder sheaves will in time also wear smaller in diameter due to the hardness of the ropes. Eventually the groove will become tight and pinch the rope, resulting in abrasion and a flattening of the outer wire crowns. A hard, tight sheave may deteriorate the wire rope in as little as two years. Prior to regrooving, check ASME A17.2-2004, Paragraph 2.25.1.1(c). It should be noted, however, that some sheaves cannot

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be regrooved due to the manufacturer's specifications or previous regroovings. Please consult with the sheave OEM.

In the field, the only way to determine hardness is through the use of portable testers. However, the test is conducted on the outside of the sheave and not within the groove. In heat-treated sheaves, the exterior may show an acceptable Brinell hardness (Figure 3), while the groove itself has actually worn below the hardened surface into the relatively soft core material.

Figure 3: **Acceptable Sheave Brinell Hardness**

ROPE GRADE	TRACTION SHEAVE BRINELL HARDNESS		
	UNDER 210	210	OVER 220
Traction	not acceptable	acceptable	acceptable
Extra High Strength Traction	not acceptable	not acceptable	acceptable

Sheave Diameter/Arc of Contact

Wire rope is subject to radial pressure by its contact with the sheave. This pressure sets up shearing stresses in the wires, tends to distort the rope structure and affects the rate of wear of the sheave grooves. In recent years, the industry has moved towards smaller diameter sheaves. Older equipment utilized sheaves more than twice the size of today's sheaves, thereby reducing the radial bearing pressure. Today's smaller sheaves, though harder, lack the bearing surface area and run at increased speeds (more revolutions per cycle), increasing the load (pressure) exerted upon the sheaves by the wire rope. Radial pressure increases as the sheave diameter decreases.

Groove Type/Groove Pressure

To compensate for smaller diameter sheaves and resultant loss of surface contact (traction), the industry developed undercut U- and V-grooves. These groove types also add to the increased pressures placed upon the sheave and ropes. As shown in **Figure 4**, the rope's contact points are evenly spread throughout the U-groove. Today's modern groove profiles reduce the groove surface with which the rope comes into contact, therefore sheave and rope wear are increased exponentially. The V-groove illustrates the points at which wear will begin.

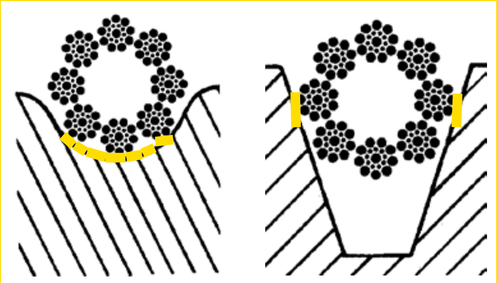
Speed

Today's cars not only travel faster, but accelerate and decelerate in shorter periods of time. Combined with the effects of slippage/creepage, higher groove pressures and smaller sheave diameters, sheaves now wear faster.

Tensioning

Further wear to the sheave results from higher groove pressures and the "sawing effect" characteristic of improperly tensioned ropes.

Figure 4: **Contact Points**



Conclusion

<u>If any rope shows signs of abrasion it is an indication that the sheave groove is wearing as well.</u> An indication of sheave damage is premature rope diameter reduction. It is important to remember that as the rope seats itself into the groove, the groove profile will be "molded" to the rope diameter. Therefore, if a 1/2" diameter rope reduces to 0.469" or 15/32" (ASME A17.1-2004 Table 8.11.2.1.3(cc)(3) retirement criteria), the groove has also reduced in diameter. It is also important to recognize that foreign wire rope manufacturers do not manufacture to the same specifications (rope diameter and wire tensile strengths) as the U.S. manufacturers.

Many OEM field handbooks state that sheaves are to be checked, regrooved or replaced prior to installing a replacement set of ropes, yet many times this practice is overlooked. Installing a new set of ropes on a worn sheave is very detrimental to both rope life and sheave performance. Without proper sheave maintenance, sheave-related rope problems will continue.

Sheave groove gauges are available from many sources. Contact your wire rope, elevator or sheave OEM for a list of qualified vendors.

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