Not all cables are for communication
Wire ropes are yet another challenge for tribologists.

STEEL CABLES, MORE PROPERLY CALLED WIRE ROPES, comprise a number of steel wires that are wound or twisted into multiwire strands, which in turn are twisted about each other to form a wire rope (see Figure 1). Wire ropes are used in a variety of applications including drag lines (mining), elevators (both lift and balance cables), bridges, hoists and marine tow ropes, to name a few.

Wire ropes are often stressed and relaxed, when loaded and unloaded, and undergo additional frictional stress as they are wound on a drum or transverse a sheave. Interestingly and somewhat counterintuitively, the helical nature of construction provides many parallel load paths leading to radial load components. In turn, it can generate surface shears such that broken wires rapidly recover their share of the applied load at some distance from the break. As a result a single broken wire does not weaken the rope. In fact, at least theoretically, over a sufficient length of rope and assuming an even distribution of breaks, each individual wire could be broken, yet not weaken the rope.

In unlubricated wire ropes, the individual wires move in relation to each other, causing wear damage to the rope. The trick is to lubricate these ropes to promote unrestricted movement of the wires and to minimize fatigue, frictional wear, rust and corrosion. Once again, we see that a commonplace item like a wire rope, largely taken for granted in our society, is in fact another challenge for the practicing tribologist.

Let’s take a look at the wire-rope market. First it is a most significant application area. Wire-rope sales are on the order of $2 billion worldwide. The market segments generally are about 33 percent construction cranes, hoists (see Figure 2), winches and port cranes; 2 percent marine (ship mooring, tow ropes and ship handling); 5 percent logging; 12 percent oilfield (drilling rigs, pipeline rope, cranes and hoists); 3 percent fishing (trawling lines, etc.); 34 percent mining (drag lines, vertical shaft hoists, counterbalance lines and shaft sinking); 8 percent elevators (hoist and counterbalance ropes) and 3 percent miscellaneous (see Figure 3).

Each of these application areas usually requires one or more specific rope designs (see Figure 4). This has to do with the number and diameter of wires in a strand, the number of strands in a rope and often the number of ropes twisted into an even larger rope. Additionally, the tightness and direction (clockwise or counterclockwise) of the twist also is important. Some wire ropes have solid cores (either plastic or hemp) and others are encased in a plastic sheath. Likewise, each of these application areas has very specific lubrication requirements to minimize fatigue, frictional wear, oxidation, rust and corrosion.

Wire ropes are, in fact, quite difficult to lubricate. Lubrication is a classic boundary problem. When the rope is stressed, the lubricant is usually squeezed out. Further, it is difficult to get the lubricant to penetrate into and around each strand while having enough boundary lubrication properties to be effective.
Most wire ropes are lubricated by heavy asphaltic lubricants with corrosion inhibitors and other additives. The most effective application of the lubricant is during manufacture where the individual wires are passed through the heated lubricant to aid flow around each wire. For wire ropes with a core, lubricants are impregnated into the plastic or hemp cores so that some lubrication occurs from within as the wire rope is stressed. In the field, the first major problem in redressing wire rope is to first clean the rope to remove old lubricant contaminated with dirt and water. If this is not properly done the wire rope will deteriorate more rapidly. It is especially important to clean the valleys between the strands to minimize contamination to the interior of the rope.

It is common to lubricate wire ropes by applying heavy coats of grease in the hopes that the oil in the grease will penetrate and the grease structure will protect from contamination. Other wire ropes are passed through oil baths that may be heated to facilitate penetration or diluted with solvents for the same purpose. Additionally wire ropes are lubricated by dripping oil on the rope.

However the best approach is a lubricating system that redresses the wire rope by cleaning and applying the lubricant with pressure to ensure that the lubricant reaches the inner core of the wire rope (see Figure 5). All of these techniques are to one degree or another less effective than lubricating during manufacture, some are quite messy and all add maintenance cost. But the alternative is premature failure.

Most of us don’t get much of a chance to look closely at a wire rope in action, but the next time you are in a fancy high-rise hotel with glass-enclosed elevators in the lobby, check them out. From the top of the elevator car you will see one or more of the lift ropes (see Figure 6). These run from the car to the top of the elevator and run over large sheaves to a windup drum either at the top or bottom of the shaft. Attached underneath the car is a counterbalance wire rope. This rope is sized to offset the weight of the car and however much lift rope is extended. Thus when the car is on the first floor, most of the weight of the system consists of the car, and its lift rope is fully extended.

When the car is at the top, the lift rope is mostly retracted, and the weight of the system is the car and the counterbalance rope. In high-rise applications, the weight of the car and ropes can often greatly outweigh the load in the car (people). Thus loaded or unloaded, the lift motor must pretty much do the same work whether the elevator is loaded or not. The counterbalance rope itself is very specialized because it needs to be constructed in such a way that, as the car speeds up and down, the rope pays out or in without any twists or torsions causing any lateral movement that would cause car instability.

Another very visible application for the skiers among us is the wire rope used on ski lifts (see Figure 7). Clearly exposed to the elements, this wire rope must carry the skiers safely to the top of the mountain throughout the ski season. Ski ropes pass over a number of rubberized sheaves on the support poles going up the mountain and then pass along large—as much as 20 feet in diameter—horizontal drive and idler sheaves at the top and bottom, to ensure enough friction to pull the rope up the mountain.