SAMSON TECHNICAL BULLETIN

Coefficient of Friction (CoF)

Overview Why is rope CoF relevant? If you want your rope to behave in a predictable way, then rope coefficient of friction (CoF) must be considered. One of Samson's goals is to ensure that the appropriate rope product is used for the job. There are many properties to consider when selecting the right product. One consideration is how the rope interacts with contact surfaces while in use. A quantifiable way to describe these interactions is CoF. Without considering the appropriate CoF for the system, the rope life and performance may be compromised. See Table 1.

What is Rope CoF?

CoF is the ratio of shear force to normal force at the moment of impending slip (static CoF) or during sliding (dynamic CoF). In the case of rope systems, this is manifested as the ratio of the rope tensions on either side of a contact surface. In general, rope with a high CoF should be used to reliably maintain its grip on equipment and function effectively. CoF is expressed in the capstan equation, (Fig. 1). Ropes may come in contact with various surfaces such as a polished sheave, rusty drum, painted bollard, or concrete floor. Depending on the substrate, CoF, as well as rope wear, will be compromised.

There are two types of CoF values: static and sliding (kinetic). For most rope applications, static CoF is the value of interest to ensure appropriate rope selection. Because static CoF is directly related to the force at which slippage occurs, it can be used to determine functional criteria such as minimum safety wraps required, sheave count, etc. On the other hand, sliding friction causes heat generation, and is generally avoided for most applications.

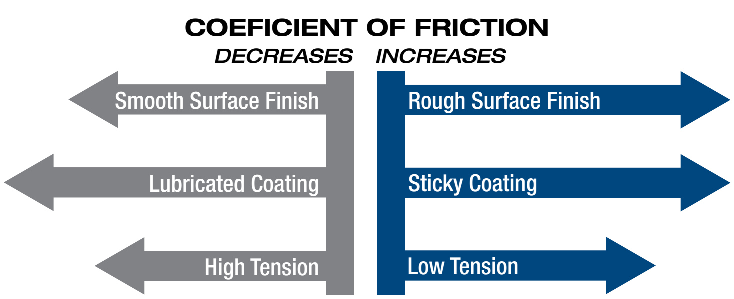


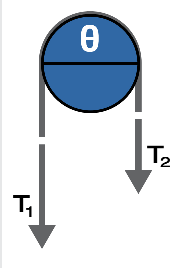
FIGURE 2 Factors affecting CoF

In Fig. 2, the magnitude of each arrow indicates the effect on rope CoF.

The most significant factors affecting the rope CoF are the surface finish of the substrate, material type (not shown), the fiber coating type, and the amount of tension in the system. Material types significantly impact the rope

TABLE 1 CoF requirements for specific applications. Other factors also play important roles in determining the right rope for the application. CoF values are not intended to be the sole property used for rope selection and guidance.

CoF REQUIREMENTS FOR SPECIFIC APPLICATIONS	
High CoF: Prevent slippage and reduce load	**Low CoF:** Minimize friction and heat generation
• Arborist/Climbing: Knotting • Arborist/Climbing: Descending • Mooring: Wraps on Split Drum • Traction Winch Systems • Tug: Bollard Tie-Off	• Rope Rescue: Hoisting • Tug: Contact with Bullnose



The relationship of coefficient of friction with its contact surface can be expressed as:

$$T_1 / T_2 = e^{(\mu\theta)}$$

μ = coefficient of friction

WHERE:

T_1 = tension applied on one side of the surface

T_2 = tension resulting on the opposite side of the surface

e = 2.718

θ = wrap angle, in radians

μ = coefficient of friction

*The rope is wrapped around a capstan and tension is applied to one side of the drum. The tension is increased slowing until the rope begins to slip on the drum. When the rope slips, the tension being applied (T1) and the resulting tension on the opposite side of the drum (T2) are recorded to calculate CoF denoted as **μ**.*

FIGURE 1 CoF measurement and calculation

Coefficient of Friction (CoF)

CoF, on a similar magnitude as the surface finish of the substrate. Slick materials such as HMPE result in a rope with lower CoF, whereas stickier materials such as polyester, LCP, or aramids, result in a rope with higher CoF. See Fig. 1.

Factors Affecting CoF

Rope CoF is dependent on usage conditions, such as contaminants, lubricants, line tension, substrate geometry, substrate surface finish (material and polish), wet vs. dry applications, temperature, etc. Rope characteristics such as fiber, coating, and rope construction heavily influence CoF which inherently affects rope wear, slippage, and wrap requirements. If a specific CoF value is required, it is important to work with Samson to achieve optimum rope performance. See Fig. 3.

CoF in Operation

The CoF between the rope and its substrate has a direct effect on how the rope will interact in a system. Fig. 4 makes a comparison between how the load is transferred throughout a series of capstan wraps for ropes with varying CoF values. Load transfer is an important phenomenon in the following applications where the rope is used to apply specific tension(s) throughout the system:

- **SPOOLING PERFORMANCE:** CoF dictates the tendency for rope to slip against itself and against the drum.
- **TYING OFF ON A BIT OR BOLLARD:** CoF determines the number of necessary dead wraps on bits and bollards to prevent slippage.
- **HEAT GENERATION DUE TO CONTACT:** Heat generation against chocks or bullnoses as the rope moves relative to the hardware increases with higher CoF values.
- **TRACTION WINCHES:** CoF is used in traction winch design to determine the required back tension in the system and the rope routing through the traction sheaves.
- **SAFETY WRAPS:** The required number of safety wraps on rope drum to ensure safe load transfer to the storage drum or inboard termination is calculated using the CoF.
- **SPLICING:** CoF influences the minimum splice length required, routing method, and tapering pattern for a particular splice.
- **FRICTION MANAGEMENT DEVICES:** CoF influences the required back tension and number of wraps to safely lower loads when rope is routed through hardware in arborist, climbing or rope rescue applications.

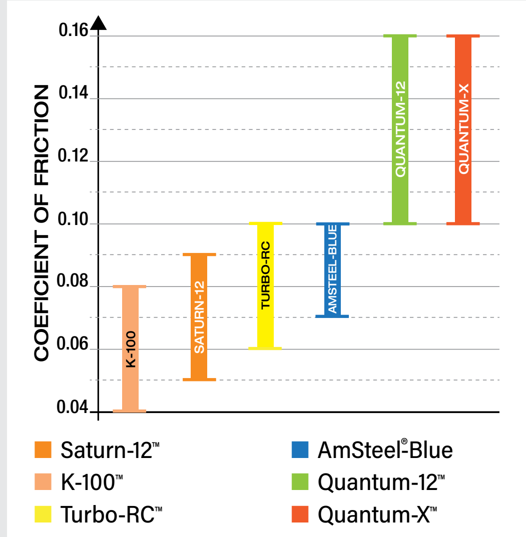


FIGURE 3 Samson product CoF values relative to one other based on contact with a steel drum with a surface roughness of approximately 100 to 300 RMS. CoF values are expressed as a range instead of a single distinct value due to the vast array of possible rope operating conditions. This graph is only to be used as a general guideline and presents a small sample of Samson rope products.

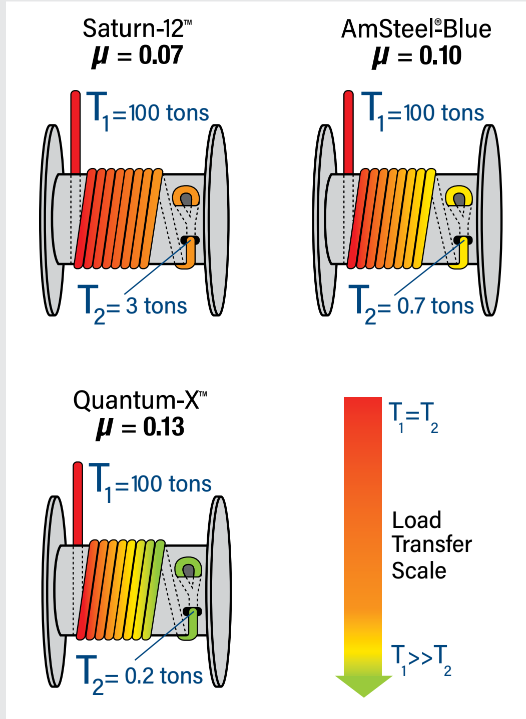


FIGURE 4 Rope with higher CoF will see greater load reduction over identical wrap counts. On the 8th wrap, Quantum-X (bottom left) reduces incoming load T_1 by 15x more than Saturn-12 (top left).

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SamsonRope.com | EMAIL CustServ@SamsonRope.com | TEL +1.360.384.4669