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A solid performer

Molybdenum-disulfide lubricant helps stop galling of stainless-steel tube fittings exposed to hostile environments.

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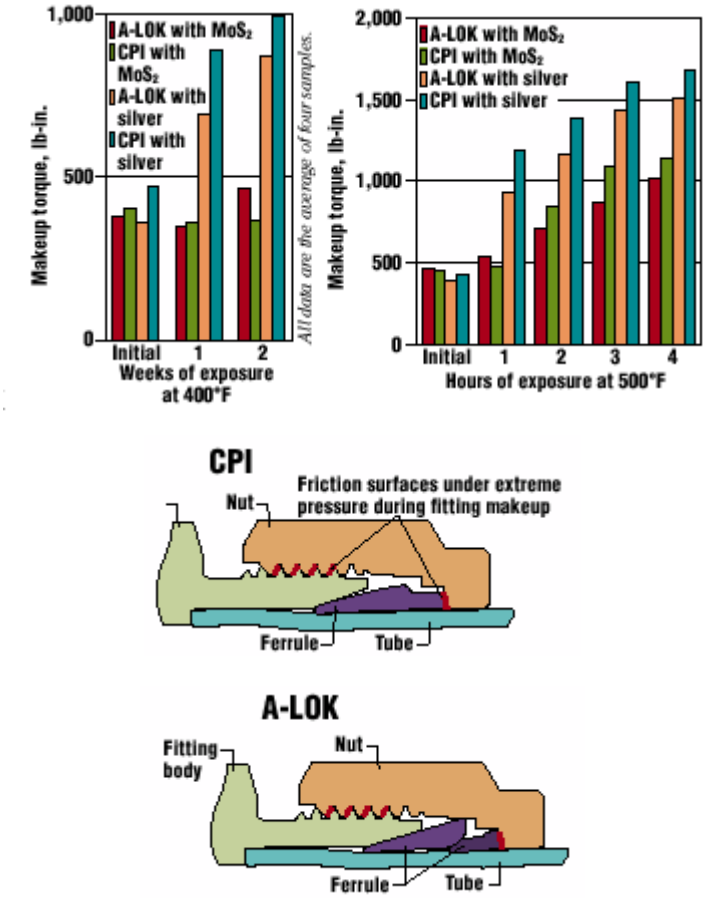

Half-section diagrams of a Parker Hannifin CPI singleferrule and an A-LOK two-ferrule compression tube fitting. Turning the nut drives the ferrule(s) into contact with the body seat and tubing surface.

Molybdenum disulfide (MoS_2) is a solid that has exceptional lubricating properties under conditions of high temperature and pressure, vacuum, and corrosive environments. There are several ways to apply MoS_2 to sliding surfaces, from vacuum sputtering to sprinkling it on as a loose powder. The most common technique mixes the powder with a binder and carrier to form a bonded coating.

The ferrule and tubing do not rotate with the nut, but instead slide axially. This action is critical to forming a leak-free tubing connection during the first makeup and subsequent remakes. Sliding takes place at high pressure between the back of the ferrule and nut flange, and in the threads. These locations need lubricants with exceptional lubrication and anti-galling properties, such as molybdenum disulfide. Electroplated silver with wax lubricant is another option.

Molybdenum disulfide owes its exceptional lubricity to a crystal structure of weakly bonded lamellae. These lamellae shear under low force to provide lubrication with an extremely low (about 0.025) coefficient of friction. The lamellae also strongly resist forces perpendicular to them and therefore don't squeeze out from between mating surfaces under extreme pressure, as do liquid lubricants. This combination of properties builds a boundary layer that effectively prevents pairs of lubricated surfaces from touching. Objects still touch along small contact regions or asperities, however. These contact regions have considerably less area than that of the bulk surface, typically about 0.5 to 0.001% for a machined metal surface. Consequently, the stresses at contact points are significantly higher than those calculated for the bulk surface area and may be sufficient to deform the contact points.

This is especially problematic for stainless steel, which galls and seizes to itself under frictional conditions. That is why effective antigalling and lubricating coatings are critically important for stainless-steel compression tube fittings. During makeup, fitting nuts see high contact stress in the threads and against the ferrule. Without such coatings, these stresses can damage sealing surfaces and compromise sealing integrity. Molybdenum disulfide, in this case, acts as an effective antigall or antiseize compound. Soft metals including tin or silver also work in this capacity, though they do not have the lubricity of molybdenum disulfide.

The lubrication and antigalling performance of molybdenum disulfide varies widely with the environment in which it operates. It retains effective lubrication properties in vacuum to about 700°C (1,292°F). For comparison, graphite, another common solid lubricant, becomes abrasive in vacuum. Pure molybdenum disulfide shows no weight loss in an inert gas or vacuum (nonoxidizing) atmosphere below 930°C (1,706°F), indicating that it is thermally stable to that temperature.

In air, oxidation takes place at temperatures below 400°C (752°F), but accelerates rapidly at higher temperatures. The oxidation products raise friction. Binder deterioration may happen at lower temperatures and obscure the effects of oxidation on the lubrication

itself. Exposure to moisture or humid air also hurts the lubricating properties of MoS_2, though having the proper binder can protect the lubricant and reduce this effect. Strong oxidizing acids and alkalis attack MoS_2, though it withstands most other chemicals.

EFFECT OF CHEMICAL EXPOSURE ON ASSEMBLY TORQUE

Chemical solution	Exposure time, hr	Nuts with bonded molybdenum-disulfide coating	Nuts with electroplated silver and wax
10% NaCL	48	No apparent effect	No apparent effect
10% NaCl + 1% HCl	48	Slight increase	No apparent effect
5% NaOH	48	Slight increase	No apparent effect
2% HNO_3	48	No apparent effect	Significant increase
Ethanol	48	No apparent affect	Significant increase
30% H_2O_2	20	Moderate increase	Extremely high torque; galling, silver removed

Stainless-steel tube fitting nuts with bonded molybdenum-disulfide and electroplated-silver antigall coatings were submerged in various chemical solutions for up to 48 hr. Technicians recorded the torque needed to make up the nuts on compression fittings. Some notable results: Ethanol likely removed the wax-lubricant coating on silverplated nuts and raised makeup torque. Nitric acid eroded both the wax and silver. Hydrogen peroxide completely removed the silver, resulting in high makeup torque and significant galling.

How MoS_2 performs at high temperature

Stainless-steel compression-fitting nuts coated with bonded molybdenum disulfide and silver electroplate (wax lubricant over the silver) on ID surfaces were made up and exposed to 400°F (204°C) for periods of one and two weeks. Technicians measured the torque needed to make the 0.5-in. single-ferrule CPI and two-ferrule A-LOK tubing fittings before exposure, as well as the remake torque after one and two weeks of exposure.

Little effect is seen with the fittings using MoS_2-coated nuts. Results for the fittings with silver-plated nuts likely indicate deterioration of the lubricating wax. The wax coating lowers makeup torque for silver-plated nuts, but it cannot withstand the high temperature.

Exposure of coated stainless-steel fittings to 500°F (260°C) began to degrade the bonded molybdenum disulfide between 1 and 2 hr. This deterioration is probably a limitation of the binder and not of the MoS_2 itself.

Fittings with silver-plated nuts showed significantly higher remake torque after 1 hr, and threads galled after a 3-hr exposure.

Fittings with bonded molybdenum-disulfide coatings could be remade after one day of exposure to 800°F (427°C), but galled severely after two days. Fittings with silverplated nuts galled severely and could not be remade after one day.