LATEST ADVANCES IN CORROSION TEST METHODS USED FOR GREASES

Corrosion is one of the most damaging and costly naturally occurring events seen today. The oxidation of metal or metal alloys not only influences the chemical properties but also generates a change in the physical properties and mechanical behaviors of the metal. The deterioration of a material due to its interactions with its surroundings can occur at any point during petroleum and natural gas processing when proper prevention testing techniques are not put in place [1]. The annual worldwide cost of metallic corrosion is estimated to be over $2 trillion, yet experts believe 25-30% could be prevented with proper corrosion protection [2]. Precautionary measures that help mitigate oxidation and rust in many types of key equipment, including reducers, motors, compressors, bearings, and hydraulic power units, consist of several testing methods for measuring the ability of a grease to prevent corrosion. Testing techniques and equipment range from the EMCOR test, Corrosion Preventive Properties Apparatus, Copper Strip Corrosion from Lubricating Grease, and the Digital Penetrometer. Understanding, recognizing, and preventing corrosion is of great importance for industrial facilities, especially when they incorporate many metals in their processes.

There are two primary types of corrosion: electrochemical corrosion and chemical corrosion. Electrochemical corrosion of metals occurs when electrons from atoms at the surface of the metal are transferred to a suitable electron acceptor or depolarizer. Water or any form of moisture must be present to serve as a medium for the transport of ions [3]. The result of this reaction is commonly known as rust. If rusting starts at one place, it will spread, and the whole metal will eventually disintegrate. The badly rusted metals lose their magnetism, hinder electrical conductivity, and can harbor tetanus bacteria [4]. Chemical corrosion involves the attack of aggressive chemical species like acids, bases, and sulfur on a metal surface or metal oxide layer resulting in the formation of ionic metallic or oxidized metallic compounds [5]. It adopts an adsorption mechanism where even a homogenous metal can get corroded. A common example is the degradation of a manufactured material due to chemical reactions between the material and agents in its environment. Corrosion of both types leads to the deterioration of metals resulting in costly and timely repairs within manufacturing processes.

Lubricating greases are the first line of defense against corrosion in equipment in service. Using the right grease through preventative, predictive maintenance can help protect against humidity, water contamination, and high temperatures, which are three leading causes of corrosion [6]. However, the presence of anticorrosive additives alone is not enough to properly protect materials within the system. The lubricating grease must be formulated with the right amount of corrosion inhibitor, not too high or too low of a percentage that could make the inhibitor less effective in mitigating corrosion. The first anticorrosive test that can aid in the protection of materials is the EMCOR Test. This testing method follows ASTM D6138 and tests for corrosion prevention properties of lubricating greases under dynamic wet conditions using an SKF EMCOR test machine [7,8].

The test is conducted to assess the ability of grease to prevent corrosion in rolling bearings operated in the presence of distilled water, synthetic seawater, or sodium chloride solution. The test is set at rating parameters from 0-5 with 0 meaning no corrosion and 5 meaning severe corrosion where more than 10% of the surface area is covered in corrosion. One experiment tested two synthetic polyurea grease blends with different extreme-pressure additives and evaluated their performance [9]. Polyurea greases are non-soap-based greases that offer high melting points along with oxidation resistance. Rust tests were performed using an SKF EMCOR test rig where both prepared polyurea greases passed the rust test with a score of 1 as seen in Table 1 [9].

Another anticorrosion test used to measure corrosion preventative

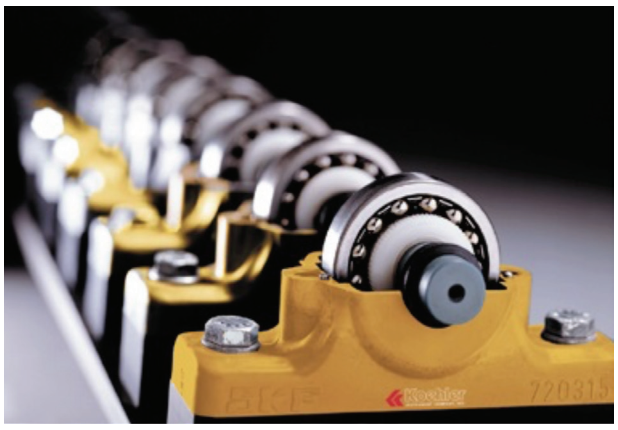

Figure 1: Emcor Testing Apparatus.

properties in greases is the Corrosion Preventive Properties Apparatus [10]. This testing equipment distributes a lubricating grease sample in a roller bearing by running the bearing under light thrust load which is stored under wet conditions. Corrosion preventative capability is determined on a pass/fail basis by the presence of rust spots 1mm or larger on the bearing race after

Table 1: Test results for greases A, B, and C [9].

Test	Grease A	Grease B	Grease C	Method
NLGI grade	2	2	2	NLGI
Rust test	Fail	1	1	ASTM D1743
EMCOR rust test	Fail	0.0	0.0	IP 220

a 60 second run-in period followed by prolonged exposure to water at a constant temperature. The Copper Strip Corrosion from Lubricating Grease system measures the tendency of lubricating grease to corrode under static conditions [11]. This is performed by immersing a polished copper strip in a sample of grease at elevated temperatures for a specified period. The strip is then examined for corrosion using classification numbers from 1-4 which are assigned based on a comparison with the ASTM Copper Strip Corrosion Standards.

Figure 2: Copper Strip Corrosion for Lubricating Greases

Measuring a lubricant's shear stability is also essential in efforts to test for anticorrosive properties. Shear stability describes the property of an oil to resist the action of shear forces and the related mechanical destruction by breaking and tearing [12]. It is important to ensure that lower viscosity oils offer protection to engines as they may be susceptible to changes in viscosity. A Digital Penetrometer determines the consistency and shear stability of petroleum products for design, quality control, and identification purposes [13]. One experiment focusing on environmentally friendly lubricants and greases tested the effects of Polysoap on the physical and tribological properties of soybean oil-based grease using the cone penetration procedure (ASTM D217) [14]. Penetration tests were conducted using the microprocessor-based digital penetrometer from Koehler Instrument Co. to investigate the properties of soybean oil-based grease containing polysoaps synthesized from polymeric epoxidized soybean oil (PESO). The grease sample was mounted onto the instrument in a small cup with a stainless-steal-tip brass cone touching the grease surface. The cone was then allowed to drop and penetrate freely through the grease medium for 5 seconds where the resulting penetration value was recorded as seen in Table 2. The test was repeated at least three times to show the effect of grease composition on hardness. Hardness measures the ability of the grease to resist deformation, which can include corrosion, under applied load. Overall, penetration data showed that grease formulated in the presence of polysoap was harder than that without polysoap, which was expected from the cross-linking in the polysoap structure to provide higher resistance to deformation [14].

Figure 3: Digital Penetrometer [13].

Many lubricants are formulated with additives that form chemical bonds with surfaces or that exclude moisture, to prevent corrosion and rust. Different testing techniques and equipment are used to identify these properties and their success in preventing the corrosion of materials. Corrosion harms many aspects that can affect industry and life, forming pits and decreasing mechanical properties of in-water rotating propellers, leaks in pipelines transporting fluids like water or petroleum, corrosive effects of acid rains on metallic and/or non-metallic surfaces, etc. Corrosion causes plant shutdowns, waste of valuable resources, a reduction in efficiency, and can lead to costly maintenance and expensive overdesign processes that can be all avoided with precautionary measures. Implementing the testing of different lubricants and their ability to prevent rust and corrosion can stop any ingression early on and improve the process quality of the overall system, saving time and unnecessary cost.

Table 2: Cone penetration (ASTM D217) and the NLGI grade for polysoap greases [14].

Grease formulation	[Polysoap] (% w/w)	Cone penetration 10^{-4} m	NLGI[a] grade number
Grease I	0	113	6
Grease II	3.8	90	6
Grease III	7.3	94	6

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https://www.petro-online. com/news/fuel-for-thought/13/koehlerinstrument-company/dr-raj-shah-director-at-koehler-instrumentcompany-conferred-with-multifarious-accolades/53404

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