Falex Litigation Technical Investigations

Small Arms Case Study

Falex Litigation Technical Investigations conducts small arms investigations for insurers, litigators, and intellectual property attorneys, which involve testing of materials and lubricants to determine the cause of failures, or conformance to patent claims.

Small arms contain a variety of actions that involve unidirectional and oscillatory sliding motion and impact with sliding motion with a range of loads. Some of the actions are driven by the expansion of gas and have an excess of energy, and some of the actions are driven by springs and have far less energy. Materials span a wide range of properties, and service temperatures vary widely. The performance of small arms is also impacted by abrasive wear, adhesive wear, fatigue wear, corrosion and tribo-oxidation, and adhesion of soot to surfaces. The mechanism of failure that is observed depends to a large degree upon the operating conditions. Alteration of surface roughness and formation of deposits and wear particles is extremely problematic in small arms because they do not have a great deal of reaction energy and this energy has to be sufficient to extract the previous round from the chamber and expel it, then extract the next round from the magazine and feed it to and load it into the chamber.

Abrasive wear is caused by hard particles or asperities exceeding the hardness of the surfaces, which cutes scratches or grooves depending on the severity. Polishing of the surfaces can occur in less severe cases of abrasive wear. Abrasive wear can be extremely detrimental to small weapons because it can rapidly cause substantial roughening of surfaces, significant loss of dimensional tolerance, and the formation of debris that jams the motion of the surfaces. An abrasive environment is not necessary for abrasive wear to be observed. We have found, for example, that a commonly used lubricant, CLP, can form abrasive carbonaceous char, due to thermally-driven decomposition. This abrasive char causes wear and jamming of the weapon. Abrasive wear is observed on slides, firing pins, hammers, and gas tube components, but it is especially detrimental when it occurs in the receiver.

Adhesive wear can also occur because materials can exhibit substantial affinity for each other, which is especially true when the mating surfaces are of similar materials. This affinity results in cold welding, scuffing, scoring, pits, and built-up deposits and seizing can also occur.

Fatigue wear is another possibility. Surfaces contain asperities (i.e. peaks) that contact each other in the absence of hydrodynamic lubrication. Fatigue occurs when the surfaces form micro-cracks due to the repeated mechanical deformation from contact of the asperities. The cracks grow and coalesce over time.

Corrosion is also a significant concern in weapons. Corrosion can be due to ambient conditions, but it can also be driven by sliding contact that causes the build-up of

electrical charge (tribo-corrosion) that drives the oxidation reaction to occur at a much faster rate than would normally occur under the ambient conditions. Corrosion can increase surface roughness and pitting, form adhesive particles, and cause fretting.

All forms of wear increase the coefficient of friction. The coefficient of friction is critically important in small arms because friction uses energy that is needed to drive the actions of the weapon. In the case of small arms, the dynamic coefficient of friction of conventionally coated surfaces is about 0.13, and CLP lubricant lowers this further. Our testing shows that higher coefficients of friction cause jamming of the weapon. The service temperature limit of a material is also an important parameter for small arms applications. Our test results suggest that the required service temperature limit is probably above 300°C.

More detail on the technical methods and tests we use can be found in:

- *Small Arms Bench-Scale Testing Protocol*
- *Small Arms Full-Scale Weapons Testing*
- *Electrochemical Corrosion Test Methods*