

Eliminating VOC's, Lead and Antimony from Solid Film Lubricants used in Aircraft Engines

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PROBLEM STATEMENT

It is necessary to further reduce VOC's and eliminate lead and antimony from solid film lubricant (SFL) formulations in order to comply with environmental regulations and protect the health of personnel. SFL's are used to prevent galling, fretting and seizing in aircraft engines. These lubricants are expected to provide continuous motion lubrication for compressor and turbine disks and blade roots. NAVAIR's Technology Needs Database lists an unfulfilled need (NA807-99) for a low VOC replacement for room temperature curing solid film lubricant, MIL-L-23398. It identifies MEK, toluene, xylene and lead as EPA-17 chemicals and targeted for reduction by NAVAIR. It also predicts that NESHAP regulations are likely to require lower VOC levels or costly control measures.

MIL-L-23398 SFL is used in a variety of applications and is referenced in over 200 technical manuals in the NAVAIR database. Affected Navy engine programs include F110, F404, F414, J52, LM1600, LM2500, LM6000, TF30 and TF40. MIL-L-23398 SFL is also required to lubricate AMRAAM control surfaces, propulsion section, and warhead, as well as the AMRAAM launcher. Six other missile systems, two gun systems, and one target system also require the use of MIL-L-23398 on 25 different systems components. SFL's are used on flap braces, hinges, turnbuckles, cargo

latches and other areas where conventional lubricants are difficult to apply or where they may entrap dust, dirt, or moisture.

WHO CAN BENEFIT?

Within the military, there are many more engines that are affected by the environmental regulations for SFL's. The affected programs in the Air Force include the F100, F101, F103, F107, F108, F110, F112, F117, F118, F119, F404, T56, T64, T406, TF30, TF33, TF34 and TF39 engines. Programs in the Army include the T53, T55, T700 and T800 engines. Within the private sector potential applications include lubrication for commercial aircraft engines, turbines, guns and other heavy equipment.

BASELINE TECHNOLOGY

The current MIL-L-23398 specification does not have restrictions on lead, antimony or VOC content as there have been.

Current SFL's that meet MIL-L-23398 specification contain lead and/or antimony as well as greater than 250g/L VOC's. Graphite has also been used with other solid lubricants and is known to instigate galvanic corrosion of many metals. Pricing for traditional SFL's range from \$9.55 to \$13.25 per 16 oz can.

SFL manufacturers are developing new low VOC, lead and antimony-free products in response to this need. The Propulsion Environmental Working Group (PEWG) has been working to identify and test alternative lead-free SFL's. Nine candidate alternative SFL's were originally selected for testing by PEWG, and six of these have been eliminated to date. E/M 1380B and Everlube 10030 have identical compositions, thus E/M 1380B was eliminated from further testing. Aseal 333 and Tiolube 29 were eliminated because of their performance in dry tape adhesion and solvent rub tests. Aseal 360, Surf-Kote LOB-1800G Class A, and X-204 Solid Film Lubricant were eliminated from testing because of their performances in fluid resistance and thermal shock stability tests. Sliding wear testing of Everlube 812, and Everlube 10030/853 has been completed and the data is being analyzed. Humidity testing will be performed to address concerns with potential rehydration. PEWG has qualified Tiolube 614-T9B as a viable alternative for antiseize applications. While these formulations eliminate lead, none are low VOC. Everlube 812 is not a low VOC formulation. Everlube 853 is a water based formula but wear life was only rated for 30 minutes when tested against ASTM D2625A. All of these products are heat cured thus not meeting the need for an air cured formulation.

Sandstrom's has a low VOC SFL, Poxylube #429, is listed as meeting MIL-PRF-46147C but no mention of MIL-L-23398. Slickote M2 has been submitted as a low VOC SFL for QPL listing to MIL-L-23398. The curing time for Slickote M2 is critical and may require up to 72 hours to meet optimal endurance. In addition, Slickote M2 still contain some VOC's. It is anticipated that new formulations will be

required that completely eliminate VOC's. Pricing is not available at this time for the new formulations.

TECHNOLOGY DESCRIPTION

TRI/Austin, Inc. has developed a lead-free, antimony-free, VOC-free, water-based, solid film lubricant that is cured at room temperature. This SFL can withstand high pressure, has a long wear life, and provides protection against corrosion. It meets most of the military specifications that pertain to solid film lubricants. Because of its nontoxicity, it is environmentally friendly and may potentially offer a cost advantage in packaging and transportation, especially in states with regulatory restrictions on toxic solvents. Testing has been completed and the formulation has been submitted for QPL listing MIL-L-23398. The following table compares TRI's formulation with Slickote M2.

Parameters¹	TRI Product	Slickote M2
VOC Level	Zero g/l	<135 g/l
Lead Free	Yes	Yes
Antimony Free	Yes	Yes
Graphite Free	Yes	Yes
Endurance Life (ASTM D2625A)	60+ minutes	65 minutes
Average Load (ASTM D2625B)	2,750 lbs.	2,417 lbs.
Cure time	24 hours	18-72 hours. Curing time affects endurance life
MIL-L-23398D	Submitted to QPL	Submitted to QPL

CURRENT STATE OF DEVELOPMENT

Much of the steps required for this project have already been completed including NAVAIR testing of the lubricant, a preliminary market assessment and patent application. The NAVAIR TPOC, Todd Standish, is evaluating the test data and it is anticipated that the product can be on the QPL for MIL-L-23398 before the end of the year. NAVAIR is also budgeting work to create a type change specification which would call for a VOC free formulation within MIL-L-23398. No further testing is scheduled.

¹ Source for parameters and Slickote data is TARDEC Technical Report No. 13800, "Investigation to Remove Lead and Antimony from Solid Film Lubricants", July 2001

TECHNOLOGY AVAILABILITY

The product will be ready for transition in early 2005. TRI/Austin is also in talks to arrange a licensing agreement with a SFL manufacturer and anticipate signing an agreement at the beginning of the year. Once a licensing agreement has been established, next steps will include providing technical assistance for the scale up of manufacturing and support. Within the Navy, NATIP will modify the numerous technical manuals that are affected on an ongoing basis.

REFERENCES

The references listed below can provide performance validation of TRI/Austin's SFL formulation. Lynn Cahoon at NADEPCP is involved in product qualification and technical aspects for the pertinent military specifications. The NAVAIR Technology Need Champion is Cindy Webber and a Technology Needs Survey Document is in place. Third party test results completed by the Navy are available from Todd Standish, whose contact information is listed below.

Name	Location	Telephone
Lynn Cahoon	Naval Air Depot , Cherry Point, NC Material Engineering Laboratory	252-464-8141
Cindy Webber	Naval Air Warfare Center, China Lake	760-939-2060
Todd Standish	Naval Air Systems Command Research and Engineering Group	301-342-8110

ABOUT THE COMPANY

Founded in 1975 by Dr. J. Scott Thornton, TRI is a small business specializing in engineering material solutions for defense and government applications. Over 70 scientists, researchers, and support personnel perform applied research, product development, and testing in a wide variety of physical and organic sciences. TRI/Austin's areas of recognized technical expertise include: materials science, composite materials and products, environmentally compliant alternative material development, adhesives, polymer science, coatings, nondestructive testing, accelerated life testing, reliability engineering, and specialized instrument development. TRI/Austin performs contract research and development, and product development for DOD, other government and private industry, as well as operating certification testing laboratories for compressed air, geosynthetics and protective clothing. We have developed a variety of innovations that are now commercially available, including nonskid coatings for aircraft carriers, protective coatings for electrical connectors, an environmentally friendly lead substitute, and a new aircraft adhesive.