

DATE: April 2, 1957  
REPORT NO.: MRD-17N-57  
MR.12M.57

MEMORANDUM

ON

THE TOXICITY OF SYNTHETIC TURBO OILS

Summary

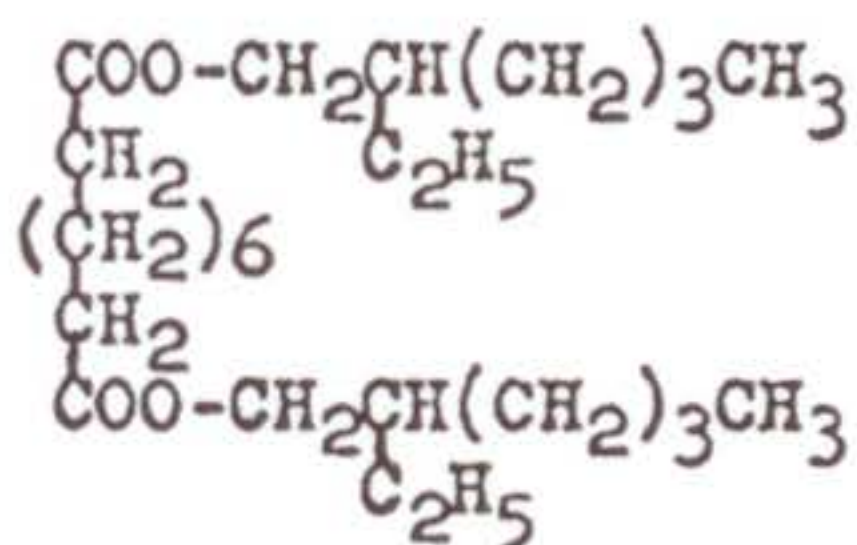
Synthetic turbo oils of the dibasic acid ester type have been shown to have a low order of toxicity for experimental animals by oral ingestion and by skin absorption. The inhalation of their mists is believed to constitute no more of a hazard than that associated with conventional petroleum lubricating oils. Fogs generated at temperatures on the order of 600-700°F were found to be toxic to experimental animals, but when generated at temperatures on the order of 400°F, they were tolerated well. The synthetic oil fogs generated at 700°F were somewhat more toxic than fogs from a paraffinic lubricating oil, but from the practical standpoint, the difference is slight. From these studies, and some confirmatory British data, it is concluded that there is no serious toxic hazard associated with the use of synthetic diester-type lubricating oils in aircraft gas turbine engines. The problem of cabin fogs or smokes seems to resolve itself into the engineering control of a nuisance, which would be present with conventional petroleum lubricants if they could be used. As with conventional petroleum oils, excessive skin contact may cause skin irritation, but the practice of good personal hygiene should prevent the occurrence of any problems of dermatitis.

Introduction

Special lubrication requirements of aircraft gas turbine engines have resulted in the relatively recent development of synthetic lubricants which have outstanding combinations of physical and chemical properties not obtainable with conventional petroleum lubricants<sup>(1)</sup>. Because these are new synthetic materials, the question of their toxicity and potential health hazards has naturally arisen. In addition, the occasional contamination of cabin air with thermally generated oil fogs introduces the further question of toxic effects from thermal decomposition products. Such contamination may occur in planes which utilize compressor bleed air for cabin pressurization and heating; under certain conditions of power development, there may be some leakage of oil from the engine into compressor air, where it can be subjected to temperatures as high as 700°F.

These potential problems have been investigated in laboratory animals and to a limited extent in humans, using representative diester-type synthetic lubricants. These diester-type lubricants contain as the major component, a dibasic acid ester of a branched chain alcohol such as di-2-ethylhexyl sebacate:





Additives are included in small amounts to impart special properties to the lubricant.

Much of the work was done on Esso Turbo Oil 15, which meets the requirements of Military Specification MIL-L-7808, "Lubricating Oil, Gas Turbine, Aircraft." These studies indicate that the diester-type lubricants have introduced no new or unusual health hazards to aircraft crews or to persons handling the oils. Results of published and some unpublished studies are summarized below.

#### Oral and Cutaneous Toxicity(2)

Several milliliters per kilogram of body weight given in a single dose were required to produce fatalities in rats and rabbits by oral ingestion of Esso Turbo Oil 15. This indicates a low order of acute oral toxicity. A used sample of this oil, collected after the engine had run for 63 hours, was likewise of a low order of acute oral toxicity in rats and rabbits.

When given repeatedly to rats and rabbits at daily oral dosages of 0.4-0.9 ml/kg over a 10-week period, neither unused nor used Esso Turbo Oil 15 induced any significant toxic effects. The oil, therefore, probably has little tendency to exert a cumulative toxic action.

Studies on rabbits indicate that both the unused and used oils are practically non-toxic when large quantities are maintained in contact with the skin over a 24-hour period. Dosages of 9.4 ml/kg were used, but fatalities could not be produced by this method of administration.

On repeated applications of the unused and used oils to the intact skin of rabbits at daily dosages of 2-5 ml for a period of 10 weeks, there was no evidence of systemic toxicity, but some irritation was induced by the prolonged contact. Excessive skin contact with Esso Turbo Oil 15 should therefore be avoided, and when contact does occur the lubricant should be removed from the skin by washing with generous quantities of soap and water. The practice of good personal hygiene throughout the working day should prevent the occurrence of any problems of dermatitis.

#### Inhalation Toxicity

##### Oil Mists Generated at Room Temperature(3)

Oil mists were generated by the aspiration of exposure chamber air through the sample at room temperature. Cats, guinea pigs, rabbits and rats tolerated without serious effect, exposures to concentrations of 1.14 mg/l of Esso Turbo Oil 15 and to 0.40 mg/l of its principal constituent, di-2-ethylhexyl sebacate, 7 hours daily, for a 10 day period. Average particle



size of the droplets was estimated to be on the order of 1-2 microns. While the data are limited, it is believed that the inhalation of synthetic oil mists would constitute no more of a practical problem than the inhalation of conventional petroleum lubricant mists. Both should of course be avoided.

### Fogs Generated at Elevated Temperatures(3)

The effects of thermal breakdown products were studied by dropping the sample into an Inconel furnace at varying rates and temperatures, then sweeping the fogs produced into the exposure chambers. Air flow through the furnace was 31.8 liters per minute in all cases.

Tests on the diester alone indicated that both the temperature of decomposition and the rate of delivery of sample into the furnace influence the response of animals. When toxic effects were produced in these tests, they consisted of mucous membrane irritation, pneumonitis and degenerative changes in the brain, lungs and kidneys.

As indicated in Table 1, animals tolerated well, the fog formed by decomposition of the diester at 400° and 550°F for 7 hours. But at 600°F there were fatalities following 7 hours of exposure, and at 700° and 900°F there were fatalities after only 2 hours of exposure.

Various tests conducted at 700°F indicated that guinea pigs will survive two-hour exposures to the fog when the oil is delivered at a rate of 56 mg/min into the furnace (equivalent to 1.76 mg of sample per liter of air going into the chamber) but when the rate was increased to 85 mg/min (2.67 mg/l) there were some deaths. When delivered at the rate of 37 mg/min (1.17 mg/l) guinea pigs survived 7 hours of exposure, but again when the rate was increased to 61 mg/min (1.92 mg/l) deaths occurred.

The fog generated at 900°F seemed to be somewhat more toxic than that generated at 700°F, but not to the extent of difference seen between 400° and 700°F. Rats and rabbits were somewhat more susceptible to the fogs than guinea pigs, but again, they tolerated well, the fogs generated at 400° and 550°F.

Tests on Esso Turbo Oil 15, confirmed the higher toxicity of the fog generated at 700°F over that at 400°F (Table 1).

In another series of parallel experiments at 700°F, only minor variations were obtained in mortality among guinea pigs, rabbits and rats exposed to fogs of the diester and of Esso Turbo Oil 15, as indicated in Table 2. It appears that the increased toxicity of the fog generated at 700°F arises from decomposition products of the diester rather than to any other component of the oil. Aldehydes, carbonyls, carbon monoxide and undecomposed diester were found in the exposure chamber, but none in concentrations high enough to induce the observed effects. It is not known if the toxic effects were produced by the combined action of demonstrated decomposition products or by the action of some unidentified toxic product of decomposition.

### Hydrocarbon Oil Fogs Generated at Elevated Temperatures(3)

When an ordinary paraffinic lubricant was decomposed thermally at



800°F, the fog was found to be about one-half as toxic for guinea pigs as that generated from the diester at 700°F. The difference was not so great for rabbits. Rats, on the other hand, were able to survive the diester fog longer than the hydrocarbon oil fog when exposures were mild; but for severe exposures, they were able to survive the hydrocarbon oil fog longer than the diester fog. Thus, considering the response of all species to the various conditions of exposure, the difference in toxicity between the diester fog and the hydrocarbon oil fog is probably not great for all practical purposes.

#### British Work on Synthetic Oil Fogs<sup>(4)</sup>

The absence of highly toxic decomposition products in thermally generated oil fogs has been more recently confirmed in an unpublished British Air Ministry Report of tests on three synthetic lubricants and one standard mineral oil lubricant. One of the lubricants was Esso Turbo Oil 35, which like Esso Turbo Oil 15, is an ester-type synthetic lubricant. In these tests, one monkey, rabbits, rats, guinea pigs and pigeons were exposed for 6 hours in a 10 cu.m. chamber to the fogs generated by heating 20 ml. of the oil sample in a porcelain dish for periods up to three hours at 300°C (572°F) (approximately 1.4-1.7 mg of oil dispersed per liter of air). The fogs from all three synthetic oils produced varying degrees of mucous membrane irritation, with some respiratory difficulty in guinea pigs and to a lesser extent in rabbits. The mineral oil produced only irritation in guinea pigs and pigeons. All animals were normal after 24 hours and were healthy at the end of 14 days.

Human volunteers were also exposed for two hours to similarly generated oil vapors in a 100 cu.m. chamber (approximately 0.14-0.17 mg oil dispersed per liter of air). The majority complained of transient dryness of the throat and slight irritation of the nose, with occasional slight eye irritation, sniffing and slight headache, all of which passed before the end of exposure. There were no complaints of nausea and all were able to carry out normal functions.

#### Discussion

In view of these test results and the intermittent nature of exposures during flight, it is believed that no serious hazard is associated with the seepage of oil fogs into the cabin of planes using compressor bleed air for cabin pressurization and heating.

The eye irritation, which apparently consistently accompanies the appearance of fogs in the cabin, may be due to some unknown irritant present in very low concentrations, or to the less likely possibility of free organic acid, used as a starting material in the preparation of the diester, and present in the undecomposed fine particles of diester. Whatever the cause, the eye irritation is not a desirable condition during flight. It appears to be principally a nuisance but should be eliminated by whatever means, engineering or otherwise, seem best suited for the individual circumstances involved.

June 7, 1956

Retyped April 2, 1957

R. E. Eckardt, M. D.

Lois C. McTurk

Medical Research Division, Esso Research and Engineering Company



## REFERENCES

- (1) A. B. Crampton, et al. Performance of Turbo Engine Synthetic Oils. Paper, S.A.E. National Fuels & Lubricants Meet., Tulsa (11/6-7/52); Esso Aviation World 5:92-5 (Jan.-Feb. 1953).
- (2) J. F. Treon, et al. Immediate and Cumulative Toxicity Studies on a Synthetic Lubricating Oil. Unpublished report from the Kettering Laboratory, Dept. of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati (4/29/54).
- (3) J. F. Treon, et al. The Toxicity of Products Formed by the Thermal Decomposition of Certain Organic Substances. American Industrial Hygiene Association Quarterly 16:3 (1955).
- (4) S. Callaway. Report on the Toxicity of Synthetic Lubricating Oils and Some of Their Components. Unpublished report (5/23/55). Referred to by permission of the British Ministry of Supply and the Controller, HBM Stationary Office, England.



TABLE 1\*

THE TOXICITY OF FOGS FORMED BY THE THERMAL DECOMPOSITION  
OF DI-2-ETHYLHEXYL SEBACATE AT VARIOUS ELEVATED TEMPERATURES

<u>Furnace Temperature (°F)</u>	<u>Sample Delivery Rate (mg/min)</u>	<u>Exposure Time (Hours)</u>	<u>Number of Fatalities/Number Exposed</u>		
			<u>Guinea Pigs</u>	<u>Rabbits</u>	<u>Rats</u>
900	82	2	1/2	3/4	2/4
700	85	2	1/2	3/4	0/4
700	61	7	1/2	3/4	4/4
600	58	7	0/2	4/4	3/4
700	37	7	0/2	2/4	4/4
550	42	7	0/2	0/4	0/4
400	36	7	0/2	0/4	0/4
<u>Esso Turbo Oil 15</u>					
700	20-87	7	1/12	10/17	17/22
400		7	0/10	1/13	1/20

\*From Table II presented by J. F. Treon, et al. (3)