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To Charles M Auer

Company US Environmental Protection Agency

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From: Matthew C. Frank

Company: The Boeing Company

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Phone No. 703/465-3243

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Special Instructions:

I thought this might be helpful as background for our meeting on Thursday. Thanks again for the opportunity to discuss this issue. I look forward to seeing you on Thursday at 9:00 AM.

Matt Frank

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October 9, 2000

Charles M. Auer
Director, Chemical Controls Division (7405)
Office of Pollution Prevention and Toxics
USEPA Headquarters
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460



Dear Mr. Auer:

For the past 25 years, The Boeing Company has utilized an erosion-arresting fire resistant hydraulic fluid in its commercial and military transport aircraft. This fluid contains FC-98, a fluorinated compound that is critical in preventing deterioration of the aircraft's hydraulic system components. The FC-98 additive has proven extremely effective in inhibiting erosion of these hydraulic parts due to exposure to the hydraulic fluids. The 3M company, which is currently the only domestic manufacturer of FC-98, is phasing out its production of this critical additive. To date, there is no alternative material for FC-98.

It is Boeing's understanding that EPA intends to propose a Significant New Use Rule (SNUR) that could curtail Boeing's ability to use FC-98 in its hydraulic fluids in the future. Boeing is also concerned that the SNUR could limit the development of a workable substitute material.

Given the critical anti-erosive property of FC-98, Boeing is requesting that any SNUR preserve Boeing's ability to continue to use FC-98 as a hydraulic fluid additive in commercial and military aircraft.

The continued use of the FC-98 additive in our hydraulic fluids is safe. Unlike commercial or household uses of products that contain a similar additive, the hydraulic fluid with the FC-98 additive is used in a closed-loop system on an airplane. There is little opportunity for exposure. Even if there is an external leak or if the hydraulic fluid needs to be replenished (which is not a routine activity), maintenance workers are required to wear proper personal protective equipment, including gloves, safety glasses, and protective gear. As a result, approval of the use of FC-98 in our aircraft hydraulic fluids will pose little threat to our workers or the public at large.

Background

Phosphate ester hydraulic fluids were first introduced in the 1950's as a fire resistant fluid replacement for the highly flammable petroleum-based fluids. These phosphate ester fluids performed satisfactorily with respect to erosion when uncontaminated. Early in the 1970's, however, it was discovered that



severe electro-chemical erosion of certain components of the hydraulic system occurred when these fluids became contaminated with organic chlorine compounds used to clean hydraulic components. Some airplanes in commercial service were found to have hydraulic fluid systems with as much as 3000 ppm chlorine in their fluid samples. In many cases, chlorine increased the erosiveness of the fluid by as much as 5 times. Because there was no suitable and effective cleaning fluid that was not chlorinated, a reformulated hydraulic fluid was developed that effectively eliminated erosion so long as the chlorine content was less than 1000 ppm. This new fluid contained the FC-98 additive. Boeing also set a maximum fluid in-service limit for chlorine of 200 ppm.

There have been no recurring hydraulic fluid erosion-related problems in the Boeing fleet since the introduction of the current hydraulic fluids in 1974.

The critical difference has been the addition of FC-98 to the hydraulic fluid. Because of its anti-erosive qualities, this hydraulic fluid with the FC-98 additive comprises the vast majority of aircraft phosphate ester hydraulic fluid in use today. To date, all Boeing, former McDonnell Douglas, and Airbus approved phosphate ester hydraulic fluids utilize FC-98.

Chlorine contamination remains a significant hurdle. While there may be non-chlorinated cleaning fluids in use today in the United States, chlorinated solvents are still actively in use on aircraft throughout the world. Boeing is still seeing hydraulic fluid samples with 500 – 2000 ppm chlorine.

Electro-chemical Erosion and its Consequences

FC-98 in the hydraulic fluid prevents electro-chemical erosion on the metering edges of control valves and related hydraulic components.

Electro-chemical erosion involves an electrolytic reaction between hydraulic fluid and metal corners or edges within control valves. Control valves are the primary targets of electro-chemical erosion. These valves, which are designed to function for the life of the aircraft, rely on the sharp, accurate edges of their internal parts to control the flow of hydraulic fluid to an actuator. The decay of these edges changes the response characteristics of a valve and the performance of the surface or actuator the valve controls. On an airplane, this could be noticed by slow or partial response from the component controlled by the valve.

Valve erosion also increases the amount of internal leakage within the valve itself. Under normal operating conditions, a small amount of fluid travels through valves and other components to provide beneficial lubrication. This small flow is called internal leakage. Valve erosion increases the amount of fluid that passes through each valve even when the valves are not operating. As a consequence of a significant increase in internal leakage through a number of valves, the pumps in the hydraulic system may not be large enough to power the systems



required for effective response from the hydraulically powered items required for airplane operations. Items typically powered by hydraulics include flight control, brake, landing gear, and steering systems. Some of these systems are critical to aircraft operations. Hydraulic fluid performance is of particular concern because the redundancy provided by multiple hydraulic systems is compromised if there is a common-mode failure that affects all systems simultaneously.

Since excessive internal leakage within a hydraulic system has the potential to render aircraft systems ineffective, the airlines are required to monitor, by periodic testing, the internal leakage in each hydraulic system. This is how erosion can be detected. When the leakage exceeds the manufacturer's limits, the airline replaces the failed valves or components containing valves.

Development, Qualification, and Approval of Substitute

Given the proven performance of FC-98 over the past 25 years, neither Boeing nor its suppliers have engaged in any research and development of an alternative anti-erosive additive. In order to develop, qualify and obtain approval for a substitute material for FC-98, Boeing's suppliers would have to initiate research and development, come up with a candidate replacement fluid, and engage in extensive laboratory testing. Boeing and FAA would then require extensive qualification testing and flight approval. Once we receive flight approval, the fluid must undergo full flight service evaluation (FSE). In order to initiate the FSE, all formal fluid qualification testing must first be completed, reports issued, willing and capable operators identified, and FAA approval received.

The FSE demonstrates the following:

- Compatibility of the candidate with existing fluids in all proportions;
- That the candidate fluid performs as expected in the system;
- That the candidate fluid does not cause any abnormal wear in the hydraulic system;
- Compatibility of the candidate fluid with the hydraulic pumps;
- That there are no abnormal changes to the acidity level, nor any adverse changes to the fluid that could degrade system performance; and
- That the fluid is miscible in all ratios with existing fluids with no harmful effects.

The FSE gives Boeing and operators the reassurance that the fluid will be suitable in the airplane environment.

Based on past experience, research and development, laboratory testing, and flight approval of a candidate substitute are anticipated to take from 5 to 8 years. Full flight service evaluation will take at least 1 year. After FSE, a sampling of

components must be removed from the airplanes and examined for signs of wear and deterioration.

As a result, it is expected to take 7 to 10 years to develop and qualify a substitute additive for FC-98, should Boeing be compelled to do so.

We appreciate your attention to this important issue. I can be reached at (703) 465-3243 should you need to contact me prior to our meeting on October 12, 2000.



Sincerely,

Matthew Frank

Matthew Frank