

**COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD CONSUMER  
PRODUCTS AND THE ENVIRONMENT (COT)**

**UPDATE DISCUSSION PAPER (DECEMBER 2006) ON THE CABIN AIR  
ENVIRONMENT, ILL-HEALTH IN AIRCRAFT CREWS AND THE POSSIBLE  
RELATIONSHIP TO SMOKE/FUME EVENTS IN AIRCRAFT**

**Thermal decomposition of oils submitted by Honeywell Aerospace  
(available on COT internet site).**

Thermal Decomposition Study of Oils and Fuel Approved for Use in the Honeywell  
LF502/507 Engine

Study Date: December 2001 to January 2002

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**Abstract:**

A joint investigation was performed by Honeywell, BP, Exxon Mobil, and Shell Aviation Lubricants to determine potential thermal decomposition and combustion products of aviation lubricants used in the Honeywell LF502/507 engine. Temperatures chosen for evaluation of decomposition were 400 degrees F (Thermal Decomposition), which simulates a system downstream of the main engine precoolers where hot bleed air from an APU enters the air conditioning system directly without first passing through a heat exchanger. Oil which may have leaked into the system could be exposed to air temperatures up to this level while the APU is providing ground air conditioning. Air entering through the heat exchanger from the engine is typically maintained below this temperature. Actual temperature is dependent upon outside ambient temperature. Low temperature data represent what one would expect in terms of component volatility. A temperature of 700 degrees F (combustion) simulates the highest potential temperature that may be encountered in the bleed air supply upstream of the bleed air precooler during maximum takeoff power on a hot day.

Two of the six oils evaluated in this study were analyzed on two separate occasions (3 December and 11 December 2001). The results provide a measure of reproducibility. In addition, moisture was added to one of the sample analyses in order to determine the impact that humidity may have on the thermal decomposition process.

Results are presented as milligrams (mg) of compound generated per kilogram (kg) of oil decomposed. A kilogram of oil would be roughly equivalent to one liter of oil and is dependent upon density of the oil.

**Procedure, as provided by Performance Analytical to Study Participants:**

Oil samples were submitted to an independent laboratory in Simi Valley, California, which had prior experience in analysis of volatile, semi volatile, and gaseous products in aircraft engine bleed air samples.

The samples were prepared by heating a small aliquot (approximately 50 mg) in a stainless steel furnace under constant air flow of 0.2 L/minute, and either 0% relative humidity (RH) at 45 degrees F, or 100% RH at 45 degrees F, with the sampling media connected to the furnace outlet. Samples for each analysis were generated at two furnace temperatures: 400°F (204° C) and 700°F (371°C). An aliquot of each liquid sample was weighed out onto a small amount of glass wool before loading into the hot furnace. The sampling duration was 25-30 minutes for each type of media.

A 5 liter Tedlar® bag was connected to the furnace outlet using a short length of fused silica-lined stainless steel tubing. The Tedlar® bags were used to perform the following three analyses.

### Methane, Carbon Monoxide, and Total Vapor Phase Organic Carbon Analysis

Each sample and blank bag was analyzed for methane, carbon monoxide and total vapor phase organic carbon according to Modified EPA Method 25C. The analyses included a single sample injection (method modification) analyzed by gas chromatography using flame ionization detection/total combustion analysis.

### Fixed Gases Analysis

Each sample and blank bag was also analyzed for fixed gases (oxygen/argon, nitrogen, and carbon dioxide) according to modified EPA Method 3C (single injection) using a gas chromatograph equipped with a thermal conductivity detector (TCD).

### Volatile Organic Compound Analysis

Each sample and blank bag was also analyzed by combining gas chromatography/mass spectrometry (GC/MS) for selected volatile organic compounds and tentatively identified compounds. The analyses were performed according to the methodology outlined in EPA Method TO-15. The analyses were performed by GC/MS, utilizing a direct cryogenic trapping technique. The analytical system used was comprised of a Hewlett Packard Model 5972 GC/MS/DS interfaced to a Tekmar AutoCan Elite whole air inlet system/cryogenic concentrator. A 100% Dimethylpolysiloxane capillary column (RTx-1, Restec Corporation, Bellefonte, PA) was used to achieve chromatographic separation.

### Aldehyde Analysis

A pair of midjet impingers was connected in series to the furnace outlet. Each impinger was charged with 10 ml of a 2N HCl/0.05% DNPH solution and 10 ml isooctane.

The samples were analyzed for aldehydes according to modified EPA Method TO-5 using high performance liquid chromatography (HPLC).

### Polynuclear Aromatic Hydrocarbon Analysis ( Semivolatile Compounds)

A low volume PUF/XAD cartridge was connected to the furnace outlet using a short length of fused silica-lined stainless steel tubing.

Each sample and blank was extracted and analyzed for selected polynuclear aromatic hydrocarbons (PAHs) and tentatively identified compounds using combined GC/MS. The extracts were analyzed by GC/MS according to modified EPA Method TO-13A. The samples were also analyzed for tentatively identified compounds using GC/MS according to modified EPA Method 8270C. The analyses were performed using a Hewlett Packard Model 5890 Series II gas chromatograph/Model 5971 mass selective detector equipped with a Model 7673A robot arm autoinjector.

The compiled results are given in tables 1 through 7.

Table 1: Modified EPA Method 25C Analyzed by GC

Modified EPA Method 25 C										Results mg/Kg Oil									
Oil label	Oil A	Oil A	Oil B	Oil B	Oil C	Oil C	Oil C	Oil C	Oil C	Oil C	Oil C	Oil D	Oil D	Oil D	Oil E	Oil E	Oil F	Oil F	Oil F
Temperature	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	700° F
Water content of air	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)
Date	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001
CAS #																			
Carbon Monoxide	140 B	170000 B	140 B	170000 B	190	140 B	180000	210000 B	nd	200000	160	140 B	130000	180000 B	nd on verified on retest	160000 duplicate	nd	160000	nd
Methane Total Vapor Phase Organic Carbon	nd	490	nd	560	nd	810	720	nd	200	nd	nd	600	spilled sample	910-run 1	nd	850	nd	850	nd
	nd	58000	nd	65000	100	nd	70000	82000	97	92000	nd	48000	79000	spilled sample	75000-run 1	nd	70000	nd	70000

Notes:  
 nd= Compound was analyzed for but not detected above the laboratory detection limit  
 M=Matrix interference/results may be biased high.  
 B=Analyte found in method blank  
 E= Estimated; result based on response outside the calibration range  
 J = The Analyte was positively identified below the laboratory method reporting limit  
 \* = Coeluting Compounds

Table 2: Modified EPA Method 3C analyzed by GC

Modified EPA Method 3C										Results reported as % Volume/Volume									
Oil label	Oil A	Oil A	Oil B	Oil B	Oil C	Oil C	Oil C	Oil C	Oil C	Oil C	Oil C	Oil D	Oil D	Oil D	Oil E	Oil E	Oil F	Oil F	Oil F
Temperature	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	700° F
Water content of air	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)
Date Received	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001
CAS #																			
7782-44-7 (coeluting)	22.4 B	22.1 B	22.4 B	22.2 B	22.5 B	22.1 B	22.1 B	22.1 B	20.2 B	19.7 B	22.4 B	22.2 B	22.1 B	22.4 B	22.1 B	22.5 B	22.2 B	22.2 B	22.2 B
7440-37-1 (compounds)	77.6 B	77.7 B	77.6 B	77.6 B	77.5 B	77.7 B	77.7 B	77.7 B	79.8 B	80.0 B	77.6 B	77.6 B	77.7 B	77.6 B	77.7 B	77.5 B	77.6 B	77.6 B	77.6 B
124-38-3 Nitrogen	nd	0.0955 J	nd	0.0703 J	nd	0.0763 J	0.0799 J	nd	nd	0.0959 J	nd	nd	0.0948 J	nd	0.0760 J	nd	0.0748 J	nd	0.0748 J
Carbon Dioxide																			

Notes:  
 nd= Compound was analyzed for but not detected above the laboratory detection limit  
 M=Matrix interference/results may be biased high.  
 B=Analyte found in method blank  
 E= Estimated; result based on response outside the calibration range  
 J = The Analyte was positively identified below the laboratory method reporting limit  
 \* = Coeluting Compounds

Table 3: Modified EPA Method TO-15: Volatile Organic Compounds analyzed against known standards- GC/MS analysis

[illegible]

and = Compound was analyzed for but not detected above the laboratory detection limit  
M = Matrix Interference; results may be biased high  
B = Analyte found in method blank  
E = Estimated; result based on response outside the calibration range  
J = The Analyte was positively identified below the laboratory method reporting limit  
\* = Co-elution Compounds



Table 4 Continued: Tentatively Identified Volatile Organic Compounds analyzed by GC/MS

Tentatively Identified Compounds by Modified EPA TO-15 Scanning Ion Mode GC/MS										Results estimated mg/kg Oil									
Page 2	Oil label	Oil A	Oil B	Oil C	Oil D	Oil E	Oil F	Oil G	Oil H	Oil I	Oil J	Oil K	Oil L	Oil M	Oil N	Oil O	Oil P	Oil Q	Oil R
Decontamination Temperature	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F	700° F	400° F
water content of air	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)
Retention Time	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001
23.84 3-Ethyltoluene																			
23.88 C10H22 Branched Alkane																			
23.96 C10H22 Branched Alkane																			
24.05 C10H22 Branched Alkane																			
24.12 C10H22 Branched Alkane																			
24.28 C10H22 Branched Alkane																			
24.51 Octanal																			
24.56 Methylpropylcyclohexane Isomer																			
24.93 n-Decane																			
25 Methyl Heptanoate																			
25.182-Ethyl-1-hexanol																			
25.32 C11H24 Branched Alkane																			
25.32 1,2,3-Trimethylbenzene																			
25.46 C11H24 Branched Alkane																			
25.77 C10H20 Cycloalkane																			
25.78 C10H20 Alkylcyclohexane																			
25.82 C11H24 Branched Alkane																			
25.88 C10H14 Aromatic Compound																			
25.99 C11H24 Branched Alkane																			
26.02 C10H14 Aromatic Compound																			
26.05 C11H24 Branched Alkane																			
26.13 C11H24 Branched Alkane																			
26.17 C11H22 Compound																			
26.17 C12H26 Branched Alkane																			
26.17 C12H26 Branched Alkane + C11																			
26.18 n24 Branched Alkane																			
26.19 C11H24 Branched Alkane																			
26.19 C10H14 Aromatic Compound +																			
26.24 C10H24 Branched Alkane																			
26.26 C11H24 Branched Alkane																			
26.35 Decahydronaphthalene +																			
26.35 Undecylidene Branched Alkane																			
26.37 Decahydronaphthalene Isomer +																			
26.37 C11H24 Branched Alkane																			
26.39 C11H24 Branched Alkane																			
26.39 C11H24 Branched Alkane																			
26.83 C12H26 Branched Alkane																			
27.03 C12H26 Branched Alkane																			
27.03 C11H22 Compound																			
27.08 Methyldecahydronaphthalene Isomer																			
27.08 Methylcyclohexane																			
27.15 C12H26 Branched Alkane																			
27.15 C12H26 Branched Alkane																			
27.37 C10H10 Compound																			
27.37 C10H10 Compound																			
28.64 C11H22O2 Ester																			
28.71 Isobutylcyclohexane																			
28.72 Isobutylcyclohexene																			
29.23 Hexylpentanoate																			
29.31 2,3-Dimethylpentanoate																			
31.13 C15H24 Compound																			
31.50 C15H24 Compound																			

Notes:  
 Net Compound was analyzed for but not detected above the laboratory detection limit  
 M=Matrix Interference results may be biased high.  
 B=Analyte found in method blank.  
 E= Ester, result based on response outside the calibration range  
 J= The Analyte was positively identified below the laboratory method reporting limit  
 \* = Coupling Compounds



Table 5: Modified EPA Method TO-5: Aldehydes analyzed against known standards by HPLC

Modified EPA Method TO-5										Results mg/Kg Oil															
Oil Label	Oil A 400° F 0%RH (73° F)	Oil B 400° F 0%RH (73° F)	Oil B 700° F 0%RH (73° F)	Oil C 400° F 0%RH (73° F)	Oil C 700° F 0%RH (73° F)	Oil D 400° F 0%RH (73° F)	Oil D 700° F 0%RH (73° F)	Oil E 400° F 0%RH (73° F)	Oil E 700° F 0%RH (73° F)	Oil F 400° F 0%RH (73° F)	Oil F 700° F 0%RH (73° F)	Oil G 400° F 0%RH (73° F)	Oil G 700° F 0%RH (73° F)	Oil H 400° F 0%RH (73° F)	Oil H 700° F 0%RH (73° F)	Oil I 400° F 0%RH (73° F)	Oil I 700° F 0%RH (73° F)	Oil J 400° F 0%RH (73° F)	Oil J 700° F 0%RH (73° F)						
Temperature																									
Water content of air																									
Date Received	11/29/2001	11/29/2001	11/29/2001	12/3/2001	12/3/2001	12/11/2001	12/3/2001	12/11/2001	12/3/2001	12/11/2001	12/3/2001	12/11/2001	12/3/2001	12/11/2001	12/3/2001	12/11/2001	12/3/2001	12/11/2001	12/3/2001						
CAS #																									
50-00-0	Formaldehyde	13 B	11000 B	8.3	7400 B	26 B	3.7	9000 B	1700, 2000 B	12000, 15000 B	5.4 B	3800 B	15 B	3.7	9200 B	4800 B	17 B	6100 B	28 B						
75-07-0	Acetaldehyde	37 B	17000 B	23	15000 B	50 B	16	17000 B	12000, 15000 B	7.7	13000 B	51 B	12000 B	16000 B	51 B	17000 B	51 B	17000 B	31 B						
123-38-6	Propionaldehyde	4	5400 B	6.9	5800 B	nd	nd	5700 B	3400, 4500	4.2	4900	4.9	6.5	5000 B	5700	4800 B	nd	4800 B	16000 B						
123-73-9	Crotonaldehyde	3.9 B	2000 B	nd	1800	8.0 B	nd	2300 B	820, 770	4.1	1700	7.5 B	nd	2000 B	1600	8.4 B	1900 B	4.3 B	900 B						
123-72-8	Butyraldehyde	14 B	4000 B	22 B	3800 B	21 B	18 B	4100 B	2000, 2500 B	13 B	3000 B	17 B	15 B	3600 B	3400 B	16 B	3400 B	11 B	3300 B						
100-52-7	Benzaldehyde	nd	nd	34 B	nd	nd	34 B	nd	nd	nd	63	nd	55 B	nd	nd	nd	nd	nd	nd						
590-86-3	Isovaleraldehyde	11 B	nd	20 B	nd	28 B	20 B	2100 B	nd, 670 B	6.6 B	930 B	17 B	16 B	nd	1300 B	15 B	nd	9.6 B	nd						
110-62-3	Valeraldehyde	4.5	1100 B	8.9	1500 B	5.5	4	1900 B	nd, 590 B	26 B	960	5.8	6.3	750 B	1300 B	5.3	1500 B	5	1400 B						
529-20-4	o-Tolualdehyde	nd	nd	14 B	nd	nd	12 B	nd	nd	nd	nd	nd	nd	5.8 B	490	nd	nd	nd	nd						
620-23-5	m-Tolualdehyde + p-Tolualdehyde*	nd	nd	25 B	nd	nd	19 B	nd	nd	nd	nd	nd	9.0 B	nd	nd	nd	nd	nd	nd						
104-87-0	Tolualdehyde	nd	370 B	nd	380	4.2	nd	440	nd	13	100	nd	nd	nd	nd	nd	360	nd	470						
66-25-1	Hexaldehyde	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd						
215-103-1	2,5-Dimethyl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd						
5779-94-2	Benzaldehyde	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd						

Notes:  
nd= Compound was analyzed for but not detected above the laboratory detection limit  
N=Matrix Interference results may be biased high  
B=Analyte found in method blank  
E= Estimated; result based on response outside the calibration range  
J = The Analyte was positively identified below the laboratory method reporting limit  
\* = Coeluting Compounds

Notes:  
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E= Estimated; result based on response outside the calibration range  
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\* = Coeluting Compounds

Table 6: Modified EPA TO-13 A Semivolatile compounds analyzed against known standards by GC/MS

Modified EPA TO-13A Total Ion Mode GC/MS		Results mg/kg Oil															
Oil label	Oil A	Oil B	Oil C	Oil D	Oil E	Oil F	Oil G	Oil H	Oil I	Oil J	Oil K	Oil L	Oil M	Oil N	Oil O	Oil P	Oil Q
Temperature	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)	700° F 0%RH (73° F)	400° F 0%RH (73° F)
Water content of air	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)
Date Received	11/29/2001	11/29/2001	11/29/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001	12/3/2001
CAS	Number	Compound	Oil A	Oil B	Oil C	Oil D	Oil E	Oil F	Oil G	Oil H	Oil I	Oil J	Oil K	Oil L	Oil M	Oil N	Oil O
91-20-3	nd	Naphthalene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
208-96-8	nd	Acenaphthalene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
83-32-9	nd	Acenaphthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
86-73-7	nd	Fluorene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
85-01-8	nd	Phenanthrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
120-12-7	nd	Anthracene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
133-99-2	nd	1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)-cyclic phosphate (TMP-P)	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
206-44-0	nd	Fluoranthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
129-00-0	nd	Pyrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
56-55-3	nd	Benzo(a)anthracene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
218-01-9	nd	Chrysene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
205-99-2	nd	Benzo(b)fluoranthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
207-08-9	nd	Benzo(k)fluoranthene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
50-32-8	nd	Benzo(a)pyrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
193-39-5	nd	Indeno(1,2,3-cd)pyrene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
53-70-3	nd	Dibenz(a,h)anthracene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
191-24-2	nd	Benzo(g,h,i)perylene	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
78-30-8	nd	Tri-o-cresyl Phosphate	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
1330-78-5	nd	Other Triresyl Phosphate isomers	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Notes:	4500	3500	3400	5300	3600	2000	9800	7400	2500	6700	3000	4300	7700	6600	9000	16000	2100
Oil F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F
Oil F	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH	0%RH
Oil F	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)	(73° F)

Notes:  
nd= Compound was analyzed for but not detected above the laboratory detection limit  
M=Matrix interference results may be biased high.  
B=Analyte found in method blank  
E= Estimated; result based on response outside the calibration range  
J = The Analyte was positively identified below the laboratory method reporting limit  
\* = Coeluting Compounds

Table 7: Modified EPA Method 8270C Semivolatile analysis of tentatively identified compounds

Modified EPA 8270C Tentatively Identified Compounds using scanning mode GC/MS										Results estimated mg/kg Oil									
Oil label	Oil A	Oil B	Oil C	Oil D	Oil E	Oil F	Oil G	Oil H	Oil I	Oil J	Oil K	Oil L	Oil M	Oil N	Oil O	Oil P	Oil Q	Oil R	Oil S
Decomposition Temperature	400° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F	700° F
Retention Time	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)	0%RH (73° F)
water content of air	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001
Date Received	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001	11/29/2001
4.11 Ketone Compound	100	100	200	200	300	300	200	200	200	200	200	200	200	200	200	200	200	200	200
4.33 Hexanal	100	100	200	200	300	300	200	200	200	200	200	200	200	200	200	200	200	200	200
5.2 Butanol																			
5.52 Ketone Compound																			
6.18 Heptanone																			
6.7 Ketone Compound																			
7.31 Dihydronaphthalene																			
7.41 Pentanoic Acid	7000																		
7.64 Ketone Compound																			
8.03 Phenol																			
8.6 Decane																			
9.29 Hexanoic Acid																			
9.48 Ethylhydrotartrate	1000																		
10.41 4-Methylphenol	200																		
10.43 Carboxylic Acid Compound																			
10.74 Undecane																			
11.18 Heptanoic Acid																			
11.87 Dihydropropylurethane	800																		
11.97 Carboxylic Acid Compound																			
12.79 Dodecane																			
13 Octanoic Acid																			
14.49 Nonanoic Acid	2000																		
16.24 Decanoic Acid	900																		
18.3 Saturated Hydrocarbon Compound																			
18.9 Saturated Hydrocarbon Compound																			
19.91 Tetramethylbutylphenol																			
20.62 Saturated Hydrocarbon Compound																			
21.27 C7 Saturated Hydrocarbon	300																		
21.3 Saturated Hydrocarbon Compound																			
27.38 Phenylphenylamine	3000																		
27.62 Ester Compound	700																		
28.52 Acid Compound																			
29.89 Butyl Octadecanoate (Butyl Stearate)																			
31.06 Saturated Hydrocarbon Compound																			
31.06 bis(2-ethylhexyl)phthalate																			
32.09 Saturated Hydrocarbon Compound																			
Tricresylphosphate - Unidentified																			
32.68 Compound																			
33.06 Saturated Hydrocarbon Compound																			
20-41 Heavy Hydrocarbon Matrix																			

Notes:  
 nd= Compound was analyzed for but not detected above the laboratory detection limit  
 M=Matrix interference; results may be biased high.  
 B=Analyte found in method blank  
 E= Estimated; result based on the calibration range  
 J = The Analyte was positively identified below the laboratory method reporting limit  
 \* = Coeluting Compounds

#### Results:

Oil types are listed as Oil A through Oil F in order to protect the confidentiality of the test participants in this project.

It should be noted that in the total ion mode of GC/MS analysis that compounds were analyzed for against known standards of those compounds. In the scanning ion mode of GC/MS, a total scan of the spectra was made against surrogate standards. Amounts listed for compounds detected are therefore only estimates, based on the surrogate standard responses.

In the analytical results for EPA Method 8270 C, a range of time is given for "Hydrocarbon matrix". This range represents a broad matrix of very heavy tar like co-eluting compounds which eluted over a twenty minute time interval.

It should be noted that neither TMPP nor TOCP were detected in any of the thermal decomposition samples. Other TCP isomers were detected.

#### Conclusion:

The thermal decomposition data indicate that in the range of normal operation, which is below 400° F, very little thermal decomposition of oil occurs. The low temperature data at 400°F represent what one would expect in terms of component volatility. There was little pyrolysis or oxidation taking place and flow remove volatile formulation components. The high temperature regime at 700°F was combustion, not pyrolysis. Jet oil oxidative decomposition products resembled hydrocarbon combustion products, i.e. carbon dioxide and carbon monoxide. The time that an engine would provide bleed air at this temperature would be only a matter of minutes during the initial takeoff climb on a hot day.

Humidity in the air during thermal decomposition did not appear to have a significant effect on thermal decomposition or oxidation products or amounts produced.