AIR FORCE FUEL MAINBURNER/TURBINE EFFECTS PROGRAMS

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In 1979 a multiyear program was initiated within the Air Force entitled "The Aviation Turbine Fuel Technology Program" (ATFTP). The objective of this effort is to provide for the necessary test validation of a jet fuel which will result in adequate fuel availability and lower aircraft system life cycle cost than for the current Air Force standard jet fuel, JP-4. One of the first evaluations to be conducted within this program is the determination of fuel property effects on aircraft gas turbine engine mainburners and turbines. This program is discussed herein.

The objective of the Fuel Mainburner/Turbine Effects Program is to quantify the relationships between select fuel properties and the performance, maintainability, reliability, and durability of mainburner and turbine components of current Air Force aircraft gas turbine engines. This effort differs from preceding combustor/fuel effects programs in two ways. First, the transient performance of these systems is to be evaluated in addition to static performance. Second, fuel effects on turbine materials are extended beyond measurements of the combustor's exhaust gas temperature profile to actual oxidation/erosion studies.

Six engines have been selected as desirable test candidates. These engines are the J79, J85, J57, TF30, TF39, and F100. These engines represent two major combustor configurations (cannular and annular), a wide range of system pressure ratios, several types of mission cycles (fighter, trainer, bomber, and transport), a difference of approximately 25 years from the introduction of the oldest to the newest system, and the design philosophies of the two major suppliers of military aircraft gas turbine engines.

Two awards were made under this program. General Electric (GE) Company was awarded a contract to evaluate fuel effects in the J79, J85, and TF39 systems. The principal investigator at GE is Mr. C. C. Gleason. A contract was established with Pratt and Whitney (PW) Aircraft to evaluate fuel effects in the J57 and F100 engines (the TF30 was dropped from consideration for cost reasons). The principal investigator at PW is Mr. J. R. Herrin. Both efforts are entirely supported by funds under the ATFTP.

Fuel selection for each program has been, in general, the responsibility of the contractors. Two fuels, a petroleum derived JP-4 and an oil shale derived JP-4, are exceptions to this. The petroleum JP-4 is to be used as a baseline in all tests. The shale JP-4 is to be used in nearly all tests (high consumption engine tests are not included) as part of an Air Force Shale Oil Acceptance Program. Up to four other test fuels are to be selected by each contractor for any given test (the fuels can be different from one test to another). Government approval of all test fuels and the specific tests in which they are used is required in both programs.

The GE program is a mix of component rig and full engine tests. The bulk of the data will be obtained in the component tests. Static performance, ignition and stability limitations, carboning and fuel nozzle fouling tendencies, turbine material oxidation and erosion properties, and hardware durability will be assessed through testing of heavily instrumented rigs. The engine tests will then be run to validate some of the rig work and to document fuel effects on the radiant heat load on the turbine stators and fuel effects on the transient operation of each engine (accels and decels). Data generated during engine tests will consist of combustor liner temperatures, turbine stator temperatures, and smoke and gaseous emissions measurements.

The PW program consists of component rig tests, exclusively. The scope of this effort is similar to the GE test rig work except that there is no fuel nozzle fouling test requirement on the PW effort. Transient testing in the PW program will consist of a series of rapid changes in fuel flow while holding constant airflow in the rig. Overshoots and undershoots of the engine fuel-air ratio, experienced when changing power points, will be simulated as will the rate of change of fuel-air ratio.

In both programs fuel properties will be correlated with combustion system performance parameters. In addition life predictions will be made for combustor and turbine hardware. These predictions will be based on a typical mission for each system, measured metal temperatures and temperature gradients, and oxidation/corrosion effects (if any).

Both programs will conclude the test phase of their efforts in the fourth quarter of fiscal year 1980. Contracts will be concluded in the second quarter of fiscal year 1981 with final reports issued shortly thereafter.

AF ENGINE INVENTORY (NEAR FUTURE)

ENGINE	MANUFACTURER	NO. PROJECTED	ACC. % OF PROJECTED TOTAL
J57	P-W	6122	23.8
J79	GE	3218	36.3
J85	GE	2743	47.0
T56	ALLISON	2538	56.9
F100	P-W	2108	65.1
TF33	P-W	2025	73.0
J69	TELEDYNE	1480	78.8
TF34	GE	1466	84.5
F101	GE	960	88.2
TF30	P-W	797	91.3
TF41	ALLISON	293	92.4
TF39	GE	275	93.5

TEST FUELS (GE)

Fuel Blend No. (1)	Component(s)	Estimated Fuel Properties: % H_2	Real Dist., K: IBP	Real Dist., K: FBP	Viscosity mm2/s @ 300K	JFTOT Breakpoint, K
1	Conventional JP-4	14.5	340	525	0.9	535
2	Conventional JP-8	14.0	445	550	1.8	575
8	JP-4/Solvent	12.0	340	545	1.1	535
9	JP-4/Solvent	13.0	340	545	1.0	535
13	Conventional No. 2 Diesel	13.1	445	615	3.2	503
14	No. 2 Diesel/Solvent	12.0	445	615	3.0	503
15	Shale-Derived JP-4	-	-	-	-	-

(1) Blend numbers 1-13 common to previous USAF/GE programs.

FUEL MAINBURNER/TURBINE EFFECTS TEST SCOPE (GE)

TEST VEHICLE	Combustor Dome and Liner Temperature	Smoke and Gaseous Emissions	Combustor Exit Temp Distribution	Combustor Stability at Idle	Cold Day Ground Start	Altitude Relight and Stability	Fuel Nozzle Plugging	Carbon Deposition	Transient Response	Turbine Material Erosion	Turbine Stator Heat Load	Fuels to be Tested
J79 Single Combustor High Pressure Rig	X	X						X				3
J85 Full Annular Combustor High/Low Pressure Rig	X	X	X	X	X	X		X				6
TF39 Full Annular Combustor Atomspheric-Pressure Rig			X	X								3
TF39 36° Sector Combustor High Pressure Rig	X	X						X				6
TF39 60° Sector Combustor Low Pressure Rig					X	X						6
J79/J85/TF39 Fuel Nozzle Fouling Rig							X					2
J79/J85/TF39 Turbine Material Erosion Rig										X		1
J79 Engine	X	X							X		X	2
J85 Engine	X	X						X	X		X	6
TF39 Engine	X	X							X		X	2

PW

IGNITION TEST FUELS

Test Fuel No.	JP4	JP4-S	1	2	3	4
Viscosity CS at 60°F	0.8		2.5-3.0	0.8-1.0	1.0-1.5	0.8-1.0
Initial Boiling Pt. °F	140		140	140	340	140
20% Recovery Temperature	230		230	320	370	230
Hydrogen Content	14.		13.8	13.8	13.8	12.5

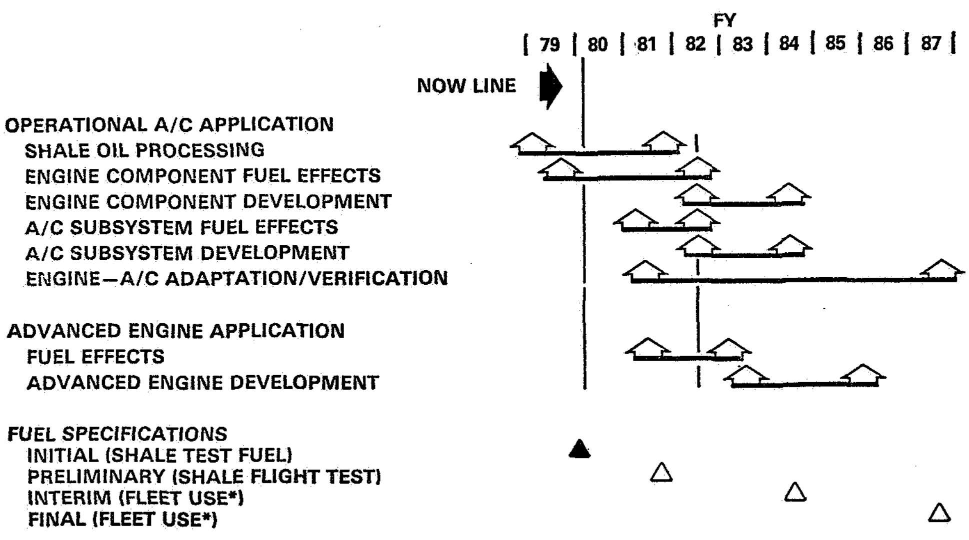
DURABILITY TEST FUELS

Test Fuel No.	JP4	JP4-S	5	6	7	8
Viscosity, CS 60°F	0.8		2.2-2.4	1.6-1.8	2.6-2.8	2.4-2.6
Initial Boiling Pt. °F	140		330	140	360	330
20% Recovery Temperature	230		360	230	400	360
End Point (°F)	474		480	630	630	630
Hydrogen Content	14		13.8	13.0	12.0	12.0
Aromatic Type			Single-Ring		Double-Ring	

FUEL MAINBURNER/TURBINE EFFECTS TEST SCOPE (P&W)

TEST VEHICLE	Combustor Dome and Liner Temperatures	Smoke and Gaseous Emissions	Combustor Exit Temp Distribution	Combustor Stability and Altitude Relight	Standard and Cold Day Ground Start	Carbon Deposition	Transient Response	Turbine Material Erosion
J57 (TF33) Single Can Hi Pressure Rig	6	6	6			3	6	
J57 (TF33) Multiple Can Full Ann/Lo Press Rig				6	6			
F100 90° Sector Rig	6	6	6	6	6	3	6	2
Lo Press Turbine Rig								2

AVIATION TURBINE FUEL TECHNOLOGY



*MULTI SOURCES