NASA BROADENED-SPECIFICATION FUELS COMBUSTION TECHNOLOGY PROGRAM

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The NASA Broadened-Specification Fuels Combustion Technology program is being conducted (1) to evolve and demonstrate the technology required to enable current and next-generation high-thrust, high-bypass-ratio turbofan engines to use fuels with broadened properties and (2) to verify the evolved technology in full-scale engine tests.

Two contractors are participating in this program. The General Electric Co., using their CF6-80 engine as a baseline design, and the Pratt & Whitney Aircraft Group of the United Technologies Corp., using their JT9D-7 engine. Present planning is that parallel programs will be conducted with the two contractors through the planned three separately contracted phases:

Phase I, combustor concept screening - A series of sector-rig tests to determine the best configurations for further evaluation, based on their ability to use fuels with broadened properties while meeting exhaust emissions and performance goals and having suitable durability characteristics. Phase I is approximately an 18-month effort.

Phase II, combustor optimization testing - A series of sector-rig or full-annular rig tests of the best designs from phase I to establish the required overall combustion system emissions, performance, and durability characteristics and engine adaptability. Emphasis will be placed on interaction of the combustion system with other engine components. This phase is projected to take 16 months.

Phase III, engine verification testing - Steady-state and transient testing of the best combustion system (or systems) of phase II as part of a complete engine. Phase III is projected to take 16 months.

Phase I is scheduled for completion in early 1981, phase II in mid-1982, and phase III in late 1983.

In designing combustion systems for their respective programs, the contractors were required to observe certain constraints:

(1) The program fuels to be used are Jet A and three broadened-properties fuels. One is a reference fuel, called the experimental referee broadened-specification (ERBS) fuel, with a hydrogen content of 12.8 percent by weight. (In comparison Jet A's hydrogen content is 13.5 to 14 percent.) Combustion system designs were to be based on using the reference broadened-properties fuel. The other two fuels are blends of the reference fuel and a blending stock that reduces the 12.8 percent hydrogen content of the reference fuel to 12.3 and

11.8 percent, respectively. These two fuels are being used so that trends in the effects of the progressive lowering of fuel hydrogen content and the corresponding raising of aromatics content can be examined.

(2) Of the three combustion system concepts to be designed by each contractor, one was to involve relatively minor modifications to the production combustion system of the baseline engine. This is to allow modification of in-service engines so that they can use broadened-properties fuels while meeting appropriate emissions requirements and maintaining the performance and durability characteristics of the production combustion system. The other two concepts were to be advanced designs for use in future engines.

Two methods are used to counteract the effects of increased aromatics on liner life:

(1) Reducing the radiation effect by optimizing stoichiometry through staged combustion and variable geometry

(2) Offsetting the radiation effect by improving liner cooling effectiveness and using thermal barrier coatings

Among the problems to be expected in the use of broadened-properties fuels, and which are addressed in this program, are

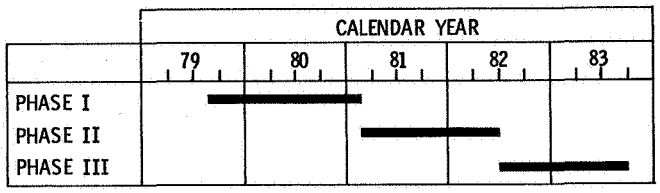
(1) Higher aromatics content, causing
    (a) Increased flame luminosity, which results in increased radiative heat transfer to combustion liners and shorter liner life
    (b) Increased engine visible smoke output
    (c) Increased carbon deposition on fuel nozzles and combustor liners

(2) Lower volatility and higher viscosity, causing
    (a) More difficult cold start and altitude relight
    (b) Greater difficulty in achieving satisfactory emissions levels at low-power conditions

(3) Reduced thermal stability, causing
    (a) Fuel system deposits
    (b) Fuel injector plugging

Final design of the combustion systems has been completed. Phase I is now in the fabrication stage, with testing to begin in approximately 2 months.

ANTICIPATED PROGRAM SCHEDULE



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COMPARISON OF JET A AND BROAD-PROPERTIES TEST FUELS

FUEL PROPERTY	JET A	BROAD-PROPERTIES TEST FUELS		
		TEST FUEL 1 (REFERENCE)	TEST FUEL 2	TEST FUEL 3
HYDROGEN CONTENT, wt %	13.5-14	12.8	12.3	11.8
AROMATICS CONTENT, vol %	~17	35	40	54
INITIAL BOILING POINT, ^{o}C	173	162	163	157
FINAL BOILING POINT, ^{o}C	267	328	333	336

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COMBUSTION SYSTEM CONCEPTS

	TYPE OF DESIGN	APPLICATION
CONCEPT I	MINOR MODIFICATIONS TO PRODUCTION COMBUSTOR	IN-SERVICE ENGINES
CONCEPT II	MORE ADVANCED	FUTURE ENGINES
CONCEPT III	HIGHLY ADVANCED	FUTURE ENGINES

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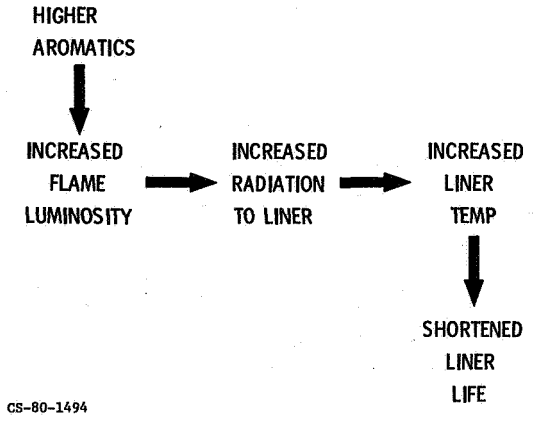
EFFECT OF INCREASED AROMATICS ON LINER LIFE



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