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RETARDATION ANALYTICAL MODEL TO EXTEND SERVICE LIFE

MONTHLY TECHNICAL PROGRESS NARRATIVE

MONTH OF SEPTEMBER 1984

Prepared for
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA 35812

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FORWARD

The purpose of this program is to develop and test a fatigue crack growth model that incorporates crack growth retardation effects and is applicable to the materials characteristics and service environments of high performance LH_2/LO_2 engine systems.

The work is performed by Rocketdyne Division of Rockwell International under the sponsorship of National Aeronautics and Space Administration, Marshall Space Flight Center, Contract NAS 8-35507. J. R. Wooten of Rocketdyne Division, Materials Technology Programs, is Program Manager; Dan Matejczyk of Rocketdyne Materials Engineering and Technology is Project Engineer; Paul M. Munafo is NASA Program Manager.

I. INTRODUCTION

It is experimentally well documented that during fatigue crack growth, load excursions in the form of single tensile overloads or high-low block loading sequences can result in retardation or arrest of crack growth. The current crack growth analyses for SSME structural components are based on repetitions of a single maximum-operating-stress cycle, but do not include any crack growth retardation effects of variations in load amplitude. The purpose of this program is to develop a crack growth retardation model that is applicable to high-performance LH_2/LO_2 engine components, taking into account the severe service environments and the characteristics of the materials selected for service in these applications. This experimental and analytical work on crack growth retardation will enable a more accurate treatment of the crack growth problem and may result in more accurate predictions of the lives of fracture critical components.

During this 24-month program, crack growth retardation models will be developed for three SSME materials: Inconel 718, Haynes 188, and Ti-5Al-2.5Sn (ELI). Initial models will be based on a survey of existing retardation models, with modifications as necessary to take into account the operational environments of high-performance LO_2/LH_2 system components. Crack growth calculations will be performed using selected variable-amplitude load profiles that are attainable under laboratory conditions at appropriate temperatures in an inert environment. The primary temperatures of interest are 1100F for Inconel 718, 1350^{o}F for Haynes 188, and -320^{o}F for Ti-5Al-2.5Sn (ELI). Crack growth tests will be carried out on the three materials to study the validity of the models. Refinements to the preliminary modeling will be followed by more extensive crack growth testing to obtain further verification of the applicability of the models. Limited high-pressure-hydrogen-environment testing will be performed on Inconel 718 and Haynes 188 for comparison to the inert environment testing.

II. TECHNICAL PROGRESS

An important component of this program is the testing of effects of overloads on subsequent fatigue crack growth for Inconel 718 at 1100°F, for Haynes 188 at 1350°F, and for Ti-5Al-2.5Sn (ELI) at -320°F. During this reporting period, effort under the program has continued to be directed at initiating this testing. Figure 1 depicts the program schedule. Figure 2 depicts the detailed schedule for the crack growth testing portion of the program. The schedule calls for completion of baseline constant-amplitude fatigue crack growth rate tests by December 31, 1984, and completion of all testing by August 30, 1985.

A service agreement has been initiated with the Del Research Division of Professional Services Group, Hellertown, PA to carry out this testing.

During the past month, Inconel 718 and Haynes 188 specimen blanks were shipped to Del Research for specimen fabrication. For Inconel 718 blanks, the source for material was an 0.75" thick plate, procured according to Rocketdyne Specification RB0170-153. Material from this plate also will be used for extensive fracture mechanics testing under other programs. For Haynes 188 blanks, the source of material was a 1" thick plate, procured according to AMS Specification 5608. In all testing of these materials, the crack propagation direction will be in the plate transverse direction.

For Ti-5Al-2.5Sn ELI test material, a 6" x 6" x 6" forged block, conforming to Rocketdyne Specification RB0170-152, and with an equiaxed grain structure, has been ordered from Schlosser Forge Company. To minimize the schedule impact of this Ti-5Al-2.5Sn ELI procurement, we are attempting to obtain early delivery of this material.

III. WORK PLANNED

During the coming month, Del Research will complete the machining of Inconel 718 and Haynes 188 compact tension specimens, and elevated temperature fatigue crack growth rate testing of Inconel 718 and Haynes 188 will begin. At that time, a trip is planned to Del Research to review the Work Plan and testing procedures, and to observe the fatigue crack growth rate testing in progress.

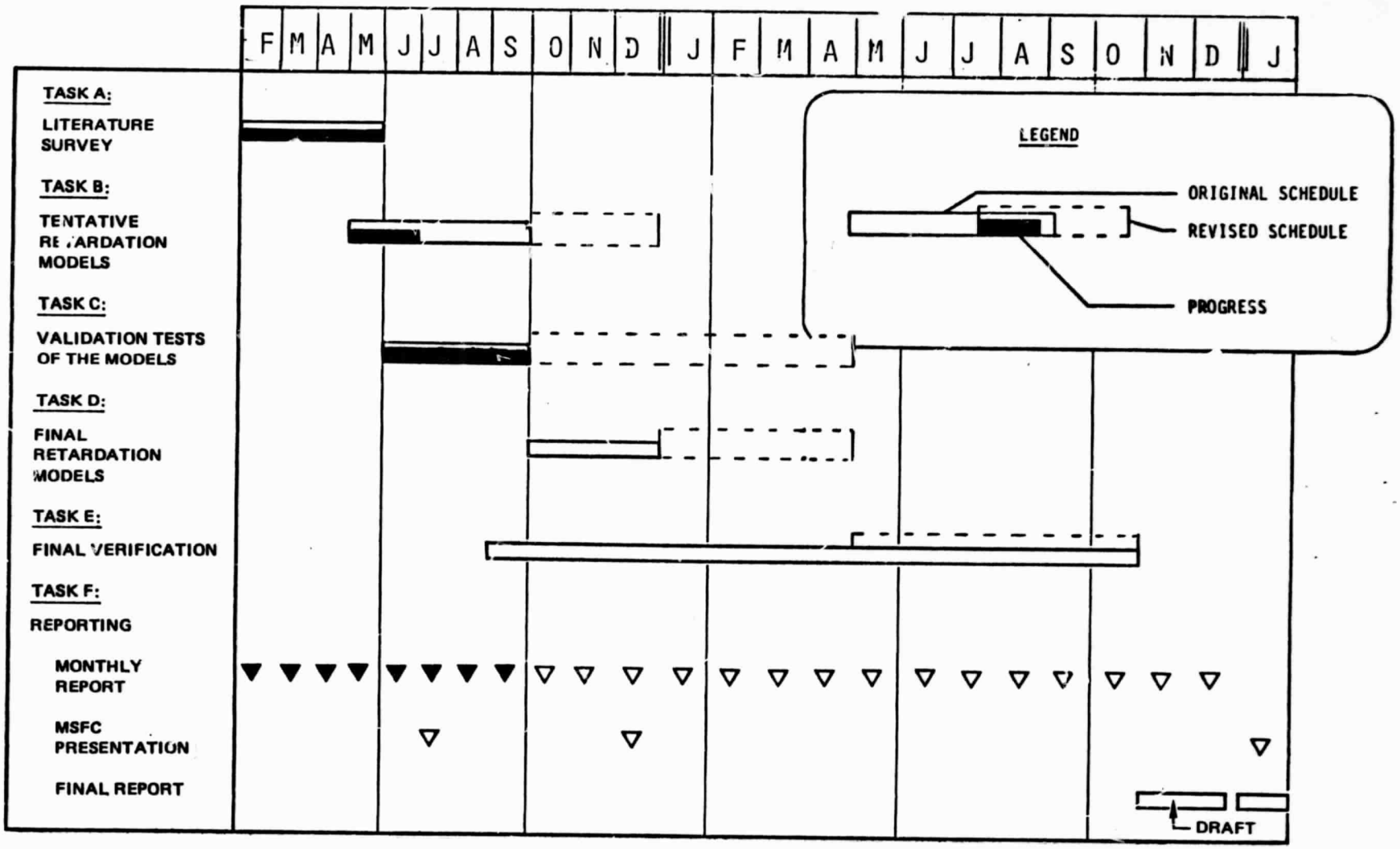

FIGURE 1. PROGRAM SCHEDULE

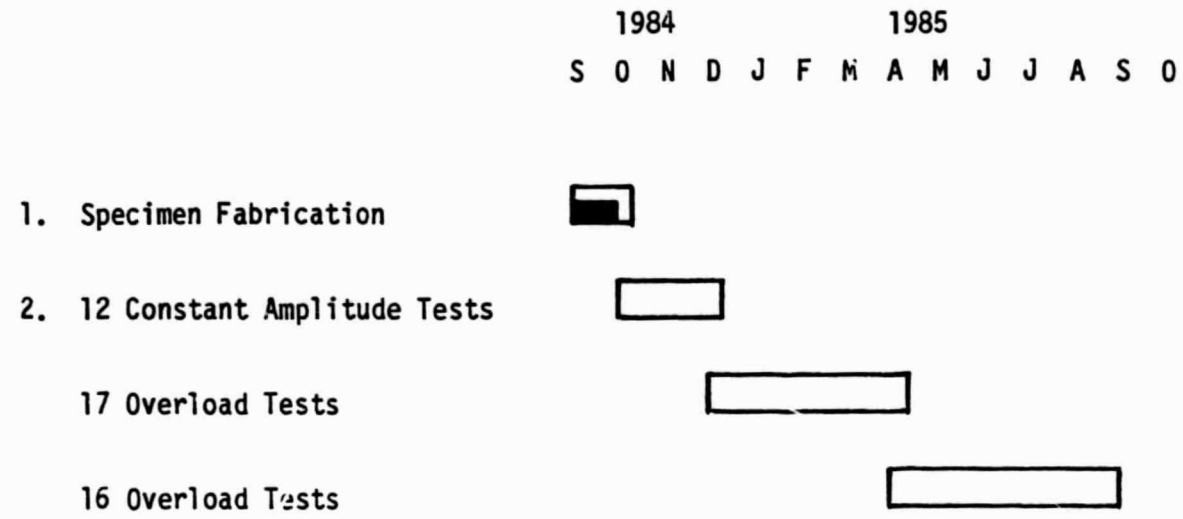

FIGURE 2. CRACK GROWTH TESTING SCHEDULE

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TO EXTEND SERVICE LIFE

CONTRACT NAS8-35507
G.O. 95356
MONTHLY FINANCIAL REPORT

(1) Cumulative hours and costs incurred through the month of Sept. 84 : $ 25,516

(2) Contractor final cost estimate: $175,657

(3) Estimated percentage of physical completion: 15%

(4) Cumulative cost to physical completion percentage variance explanation (if any): None

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