PROPULSION AND VEHICLE
ENGINEERING LABORATORY

MONTHLY PROGRESS REPORT

For Period

March 1, 1967, Through March 31, 1967

FOR INTERNAL USE ONLY

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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PROPULSION AND VEHICLE ENGINEERING LABORATORY

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By

Materials Division
Vehicle Systems Division
Advanced Studies Office
Propulsion Division
Structures Division

GEORGE C. MARSHALL SPACE FLIGHT CENTER

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V. J-2 Engine

A. Investigation of Cracking in a J-2 Engine Turbine Wheel Assembly

The quarter section of the first stage turbine wheel assembly from the oxidizer turbopump assembly of J-2 engine J2027 (S-IVB Program) was received for fracture analysis; however, only limited studies have been made due to scheduling problems. The section contains cracks near the hub-portion of the assembly.

B. J-2 Engine Project Management, Materials

1. After being directed to use Dynatherm, D-4327, to coat the cross-over duct on the J-2 engine, Rocketdyne claimed that they could not get any of this material which is LOX compatible. (It was recommended that the D-4327 be batch tested for acceptability.) One of the batches tested was previously tested by the Space and Information Systems Division of North American Aviation for use on the S-II stage and found acceptable. We have requested samples of the material tested by Rocketdyne to be sent to this Center for LOX impact testing. Apparently, there is some difference in Rocketdyne's testing techniques as compared to ours.

2. Failure of a brazed joint in an ASI instrumentation line (Pc line) on a J-2 engine on the S-II battleship stage recently, resulted in the necessity for inspection of this brazed joint on the same lines on the five engines installed on the S-II-2 stage at Mississippi Test Facility. It was determined by radiographic inspection of the joints, that two of the joints were inadequately brazed. These two lines, and subsequently, the lines on the other three engines were cut, removing the brazed joint, the ends crimped and welded shut. The lines are 347 stainless steel and 347 filler wire was used in welding the crimped ends.

VI. F-1 Engine

A. Study of Effect of Sea Water Immersion on F-1 Engines

The Advanced Systems Office (R-AS) has initiated a program to evaluate the F-1 engine's reusability after immersion in salt water. This program will be similar to a program conducted on an H-1 engine several years ago. This division has requested that we be included in the planning and initiation of this program. Presently, Rocketdyne has been requested to perform a study leading to recommendations as to special preparations and expected performance and reliability in sea water. A report of this study is due April 1, 1967. After a review of this report, further consideration as to the scope of the program will be given.

B. Study of F-1 Engine Primary LOX Seal Mating Ring

Metallographic analysis was continued on three F-1 engine primary LOX seal mating rings. Further evidence was found of cracking in the chrome plating; and by sectioning through various areas of one ring, it

E. Physical and Mechanical Metallurgy

1. Aluminum Company of America, NAS8-5452
2. Battelle Memorial Institute, NAS8-20029

F. Composite Material Development and Testing

1. Douglas Aircraft Company, NAS7-429
2. Mitron, Research and Development Corporation, NAS8-20609

G. Lubricants and Lubricity

Midwest Research Institute, NAS8-1540

H. Corrosion in Aluminum and Steel

1. Aluminum Company of America, NAS8-20396
2. National Bureau of Standards, GO-H2151A
3. Northrop Corporation, NAS8-20333
4. Tyco Laboratories, Inc., NAS8-20297
5. Kaiser Aluminum and Chemical Company, NAS8-20285

I. Explosion Hazards and Sensitivity of Fuels

Stanford Research Institute, NAS8-20220

J. Synergistic Effects of Nuclear Radiation, Vacuum, and Temperature on Materials

1. General Dynamics Corporation, NAS8-18024
2. Hughes Aircraft Company, NAS8-20210

K. Instrument Development

1. Battelle Memorial Institute, NAS8-11891
2. Canadian Commercial Corporation, NAS8-20529

II. General - In-House

A. Development of High Temperature Resistant Polymers

Work is continuing on the development of curing systems for polyaryloxysilanes of the Polymer A type. In an earlier report it was mentioned that a test was being prepared to determine whether free amino groups can survive the condensation process by which Polymer A is formed. The test was designed to allow equal competition between amino and hydroxyl groups in a reaction with an anilinosilane. If the hydroxyl groups react preferentially, the amino group will remain free as shown in the following condensation of model compounds:

promising based on preliminary tests. A much broader test program has been undertaken involving the following alloys stressed in all three grain directions: 2024-T351 - T851, -T4, -T6; 2014-T6; 2017-T4, 2219-T37, -T87, -T62; 7075-T6; 7079-T651.

H. Developmental Welding

Tensile specimens of electron beam weldments of aluminum alloys 2014-T6, 2219-T87, and X7106-T6 have been fabricated and will be tested during the next report period. Electron beam weldments of these alloys also have been submitted for metallographic examination. The metallurgical structure of the weldments will be correlated to the mechanical properties in an effort to determine meaningful relationships between metallurgical structure and mechanical properties.

The investigation of the weldability of X7007 and X2021 aluminum alloys has been temporarily delayed because of a material shortage. Material in 1/2-inch and 1/8-inch thicknesses of both alloys has been ordered to provide for continuation of this study.

The program to compare the weld crack susceptibility of various aluminum alloys has been temporarily discontinued, awaiting procurement of required materials. No welding or weld evaluation was accomplished during this report period.

I. Investigation of Dielectric Properties of Materials

Determination of the conductivity of RJ-1 as a function of temperature and additive (ASA-3) concentration is continuing. Tests have been completed on samples at temperatures from 5 to 60°C with additive concentrations from 0 to 80 ppm.

The variation of conductivity with temperature appears to indicate that the ASA-3 is increasing conductivity by charge carrier addition. Conductivity of pure RJ-1 varied by a factor of 10 over the temperature range from 5 to 60°C (increasing with temperature) while the samples with additives varied from a factor of 3 to 5 over the same temperature span.

J. Development of Nondestructive Techniques for Evaluating Materials and Components

A project has been initiated to develop a suitable laboratory apparatus for measurement of the rate of crack propagation in metals subjected to stress corrosion environment. The apparatus is needed for experimental study of the influence of stress, reactive environments, temperature, etc. on the rate of crack propagation. Its eventual use is for the study of the mechanism of crack propagation in aluminum at the grain boundary level. The apparatus for this project has been designed, assembled and checked out for soundness of principle. Deficiencies have been discovered which would cause the apparatus to be unreliable for the extended operation required. A modification to the

B. Vehicle Design Handbook

Recently received abstracts of design programs from MSC are being reviewed and evaluated for inclusion in the handbook. The final selection of necessary design programs to be used in the handbook is approximately 80 per cent complete. Initial checkout and conversion of several on-hand programs is being accomplished in conjunction with the Computation Laboratory.

C. Liquid Strap-on Pods, "660 K Launch Vehicle"

Documentation of Phase I of the 156-inch-diameter pod design (formerly 154-inch-diameter pod design) study is continuing. Phase II of this study is also continuing with emphasis on further refinements and innovations of the launch vehicle configuration chosen in the Phase I study.

II. Earth Orbital

A. Advanced S-IVB Workshop

The initial contract orientation meeting was held with the Douglas Aircraft Company on March 8, 1967, to discuss the details of the contractor study plan. Key guidelines on the configurations, subsystems, and experiments were presented and discussed.

A configuration matrix of the major variables of a Saturn V launched Early Orbital Space Station was completed and drawings were prepared for each configuration.

An orbital heat computer program and a three-dimensional transient heat transfer program have been developed for preliminary thermal analyses in support of the Advanced S-IVB Workshop efforts. Insulation requirements and wall temperatures for various configurations are being investigated. Also, an analytical procedure and computer program is being developed to investigate the location and area of radiators, heat exchangers, cold plates, pumps, and piping for active thermal control system concepts.

B. Five-year Space Station

Several concepts for a long-term space station have been developed. One of the more promising concepts, a multi-purpose module, has been chosen for some preliminary analyses. The analyses have been limited thus far to two principal areas: (1) mission responsiveness and flexibility; and (2) structural.

Note: Reference to the Document Monthly Progress Report (March 1st 1967 through March 31st 1967) following are the missing pages.
Page Nos – 32, 44, & 56.