T1D15NA -- 2222

Copy 2
7 June 1971

8p

METALLURGY SECTION
ADVANCED TECHNOLOGY
AEROJET SOLID PROPULSION COMPANY

MAY

MONTHLY PROGRESS REPORT - MAY 1971

DESIGN OF STRESS CORROSION SPECIMEN FOR DETERMINATION OF
 K_{Isc} IN PRESSURIZED GASEOUS HYDROGEN EXPOSED TO IRRADIATION

I. INTRODUCTION

MASTER

Department 4830 has been requested to determine the feasibility of determining the threshold stress intensity factor (K_{Isc}) for Inconel 718, A-286 and SAE 9310 when subjected to the combined effects of 1500 psi gaseous hydrogen and a nuclear environment. The reactor environment will include a fast neutron fluence of about 10^{20} and a specimen temperature in the range between 155 and 200°F.

The specimen development and calibration will be conducted in three phases where phase 1 will be to design and evaluate a test specimen for phases 2 and 3, phase 2 will be the initial specimen testing in the PLUMBROOK REACTOR without gaseous hydrogen (CH_2) and will be performed to verify instrumentation concepts and confirm the specimen design through testing in the reactor environment, and phase 3 will be in reactor testing to determine the combined effects of 1500 psi CH_2 and the nuclear environment.

II. CURRENT STATUS SUMMARY

The preliminary program plan outlining objectives and procedures has been submitted.

A. SPECIMEN CONFIGURATION

1. Stress Corrosion Specimen

Sketches for modified WOL specimen, 1-1/2 and 2.0 in. thick compact tension (CT) specimen, and encapsulated specimen design have been submitted. Minor dimensional changes to existing 1.0 in. thick CT specimen were also made.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

7 June 1971

METALLURGY SECTION
ADVANCED TECHNOLOGY
AEROJET SOLID PROPULSION COMPANY

MONTHLY PROGRESS REPORT - MAY 1971

DESIGN OF STRESS CORROSION SPECIMEN FOR DETERMINATION OF
 K_{Isc} IN PRESSURIZED GASEOUS HYDROGEN EXPOSED TO IRRADIATION

I. INTRODUCTION

Department 4830 has been requested to determine the feasibility of determining the threshold stress intensity factor (K_{Isc}) for Inconel 718, A-286 and SAE 9310 when subjected to the combined effects of 1500 psi gaseous hydrogen and a nuclear environment. The reactor environment will include a fast neutron fluence of about 10^{20} and a specimen temperature in the range between 155 and 200°F.

The specimen development and calibration will be conducted in three phases where phase 1 will be to design and evaluate a test specimen for phases 2 and 3, phase 2 will be the initial specimen testing in the PLUMBROOK REACTOR without gaseous hydrogen (GH_2) and will be performed to verify instrumentation concepts and confirm the specimen design through testing in the reactor environment, and phase 3 will be in reactor testing to determine the combined effects of 1500 psi GH_2 and the nuclear environment.

II. CURRENT STATUS SUMMARY

The preliminary program plan outlining objectives and procedures has been submitted.

A. SPECIMEN CONFIGURATION

1. Stress Corrosion Specimen

Sketches for modified WOL specimen, 1-1/2 and 2.0 in. thick compact tension (CT) specimen, and encapsulated specimen design have been submitted. Minor dimensional changes to existing 1.0 in. thick CT specimen were also made.

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

2. Encapsulated Specimen

Sketches for the encapsulated specimen have been submitted to a possible vendor to determine their ability and tentative cost for providing the encapsulation device.

B. INSTRUMENTATION

Fabrication of COD gages to be used for gaseous hydrogen tests has been initiated.

1. Stress Wave Analysis Technique (SWAT)

a. Sensors

Preliminary information concerning stress wave emission sensors that could be used in the reactor has been obtained. Comparison test data between a possible sensor (Endevco P15) for use in the reactor tests and the sensor presently being used for data collection by ASPC has been obtained. Both sensors (P15 and 2213E) were connected to voltage amplifiers and the P15 results compared very favorably to that of the 2213E sensor.

b. Cables

Two cable types have been suggested, an oxide packed and insulated co-axial cable and a tri-axial cable. Additional data is being obtained to evaluate their applicability in this program.

2. Other Slow Crack Growth Detection Equipment

Strain gages may also be used in conjunction with SWAT to detect slow crack growth. Tests are planned to compare the data obtained by each technique.

III. ACTIVITIES DURING THE REPORTING PERIOD

PHASE I - Design and Evaluation of Test Specimen

Sketches for a modified WOL specimen, 1-1/2 and 2-in. thick compact tension (CT) specimens, and the tentative design for the encapsulated specimen have been prepared and submitted for final drawing preparations. Minor changes to existing 1.0-in. thick CT specimen design were also made; this specimen will be used to determine the apparent K_{Ic} value for each alloy at 160°F.

Sketches of the anticipated design for the encapsulated specimen have been submitted to a vendor to determine his capabilities and tentative cost for providing the encapsulation device. The following methods are being considered to bond the encapsulation device to the specimen:

- (1) Welding - electron beam welding appears to be the best approach because of the size of the weld and heat affected zone. The major drawback to welding will be the cost.
- (2) Brazing - this approach may cause problems in that heat treatment may be required after brazing. This is particularly true with the 9310 alloy where it is necessary to get an adequate quench in the region of the notch which will be covered by the bellows at the time of heat treatment. Also, the effect of heat treatment on the plastic zone/precrack region (precracking should be performed prior to bellows attachment) is not known.
- (3) Bonding Agent - Epoxy 6203 has been used in a radiation environment. Information concerning the effect of fluence and gamma heating on the epoxy has been requested and will be received during the next reporting period. The advantage of a bonding agent, such as epoxy, is evident in that considerable cost saving will be incurred and the bond could be made at our convenience. The disadvantage of the epoxy will depend upon how much degradation is observed due to the reactor environment and if the epoxy would contaminate the reactor cooling water.

PHASE II - Initial Specimen Testing in Plumbrook Reactor

This test series may be rescheduled for General Dynamics, Fort Worth, and will be conducted without gaseous hydrogen to verify instrumentation concepts and the specimen design through testing in a reactor environment.

Two tentative SWAT system designs (Figure 1) are being considered for testing in the reactor. The major disadvantages of the charge system is the high noise level which results in a low signal to noise ratio and signal

amplification (about 500X). The advantage of the charge system is that the initial cable length is unlimited.

The voltage system has the advantage of low noise which gives a high signal to noise ratio coupled with high amplification ($\sim 5000X$). The disadvantage to the voltage system is that the initial cable length is limited by the capacitance and the effect of radiation on capacitance of the cable. The cable limitation can be offset somewhat by using a preamplifier which, however, may require lead shielding.

Several sources have been contacted for information concerning sensors that could be used in the reactor. The results of these contacts are indicated below.

(1) Argonne National Laboratory (Ted Anderson)

A single crystal of lithium-niobate, which is capable of withstanding 650°C has been successfully used at Argonne. Available information concerning the effect of a fast neutron fluence, up to 3×10^{18} , on the lithium-niobate will be obtained and reviewed.

(2) Gulton Industries (Ted Swanson)

Little information concerning the effect of radiation on sensors was available.

(3) Endevco (Dr. Bouche)

Tests have just been performed at General Dynamics-Fort Worth for NERVA which indicated no degradation of performance for P-14 and P-15 piezoelectric crystals up to a fluence of 3×10^{18} .

(4) Endevco (Robert Bell)

Mr. Bell spent the week of 1-4 June 1971 at ASPC making comparisons of data obtained using various acoustic emission sensors and that (2213E) used by ASPC. One of the sensors evaluated was a P-15 and it compared very favorably with the 2213 presently used, indicating the P-15 would be an excellent choice for a sensor. Endevco could supply one or two sensors (approx. cost is \$1000 each) needed for the reactor tests and could make the sensor compatible with the cable limitations so the voltage system could be used.

(5) NERVA (S. Jang)

Strain gages were suggested as an alternative to accelerometers and strain gages are available for comparative tests to determine the ability of each technique to detect crack growth. Strain gages offer an advantage in that radiation has a negligible effect on the gages but one obstacle is evident in that the gage leads must come out of the encapsulation device.

Additional work was also performed to determine the acceptability of acoustic emission system components in the reactor environment.

Several sources were also contacted for information on acoustic emission system cables that could be used in the reactor. The results of these contacts are indicated below.

(1) Argonne National Laboratory (Ted Anderson)

Argonne uses a high temperature inorganic cable which is supplied by several vendors but to a strict Argonne National Laboratory Q.C. requirement. Additional information concerning these Q.C. requirements will be requested from another contact (A. Knox) at Argonne.

(2) Electronic Specialty Co. (Robert McMahon)

An oxide packed and insulated co-axial cable is being considered as an alternate to the inorganic cable. However, this type of cable would require from 1 to 1-1/2 months for delivery. Also, compatibility with the SWAT system must be determined.

(3) Endevco (Dr. Bouche)

Endevco will have a hard line tri-axial cable which will soon be available and may be useful for the planned tests. The advantage is that the tri-axial cable will have less electrical noise than the bi-axial cable. Additional information concerning the characteristics of this cable will be requested.

PHASE III - Testing the Combined Effect of 1500 psi CH₂ and the
Nuclear Environment

Dependent on results obtained in Phase I and II.

IV. ANTICIPATED ACTIVITIES DURING THE NEXT REPORTING PERIOD

Test compact tension specimens and initiate testing of modified WOL specimens in accordance with the program plan previously submitted. Both acoustic emission and COD gage will be employed to determine the SWAT system sensitivity necessary to detect crack growth.

Obtain information from the vendor regarding the encapsulation device design and associated cost. Review methods of bonding the encapsulation device to the specimen and recommend a suitable technique.

Continue evaluation of alternate acoustic emission system designs. Determine when the test will be conducted in reactor so sensors and cables may be ordered.

Prepared by:

Walter G. Reuter

Walter G. Reuter

Approved by:

P. P. Crimmins

P. P. Crimmins
Metallurgy Section

ANTICIP D SYSTEM

1. Voltage Amplifier

2. Charge Amplifier