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January 1967

Westinghouse Astronuclear Laboratory

EXPERIMENTAL INVESTIGATION OF INTERSTITIAL CORROSION

FOR AN ISOTHERMAL MODEL PHASE II
(Title Unclassified)

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EXPERIMENTAL INVESTIGATION OF INTERSTITIAL CORROSION

FOR AN ISOTHERMAL MODEL PHASE II
(Title Unclassified)

by

R. J. Steffen
Thermo-Flow Laboratory

Classification cancelled for changed to
by authority of Doc
by 147.c. TFC, date SEP 10 1973

Approved:

~~E. A. Zubair~~

E. A. Zubair, Manager
Thermo-Flow Laboratory

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ABSTRACT

A test series has been conducted to supply parametric information on graphite-hydrogen corrosion in narrow slots. This program is an extension of work previously presented in References 1 and 2.

The tests described cover a fixed gap of .006 inches in thickness one inch wide and 2 inches long machined in a split specimen fabricated of Graphitite "G". Pressure levels were varied from 50 to 350 psig in 50 psig increments, flow rates were varied from 2.1×10^{-5} lb. H_2 /sec. to 1.7×10^{-4} lb. H_2 /sec. in four steps, by increases of a factor of two from one step to the next. Average material temperatures were maintained at 3500°R for test times of 30 and 15 minutes.

The data presents a raw corrosion reaction rate in $\text{gms/in}^2\text{-sec.}$ (based on geometric area and run time) as a function of specimen inlet pressure, also presented is the corrosion reaction rate as a function of hydrogen mass flow. Pre and post test surface measurements made on the specimen produced surface regression information in the form of a flow slot profile for each set of conditions tested. The variation of this profile with pressure, flow rate, and time is presented in curve form.

Documentation and highlights of an observed mechanical clogging phenomena and steps taken to understand and eliminate this condition are presented. Possible applications of this phenomenon to increase the impedance of the interstitial gaps are discussed.

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The data indicates a general increase in raw reaction rate with increased pressure, an increase from 2.6×10^{-5} gms/in² sec. to 2.2×10^{-4} gms/in² sec. was experienced from the 50 psig to the 350 psig level at the flow rate of 4.2×10^{-5} lb. H₂/sec. A general increase in raw reaction rate was also experienced with flow increase. The reaction rate went from 8.25×10^{-5} gms/in² sec. to 4.0×10^{-4} gms/in² sec. when the flow was increased from 2.1×10^{-5} lb/sec. to 1.7×10^{-4} lb. H₂/sec. at the 250 psig pressure level.

-
- (1) Steffen, R. J., Test Series HHT-6, Preliminary Interelement Corrosion Study, WANL-TNE-1138, March 1965. CRD.
  - (2) Steffen, R. J., Test Series HHT-6, Experimental Investigation of Interstitial Corrosion For An Isothermal Model Phase I, WANL-TNE-1430, May 1966. CRD.

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INTRODUCTION

The corrosion tests reported in Reference 2 introduced data obtained from a refined test program which evolved from preliminary corrosion work reported in Reference 1. Through each phase of the programs development, major design changes and innovations have been added which further refined and molded the hardware into a useful and versatile tool capable of providing large quantities of corrosion data gathered under closely controlled parametric conditions.

Several significant statements can be made regarding this data, they are as follows:

1. There is no extraneous hydrocarbon generation upstream of the test section.
2. The only unexposed graphite in the system is that of the test section, all other hardware is fabricated of Molybdenum.
3. The test section is essentially isothermal.
4. The initial size and shape of the test specimen is such that dimensions can be easily controlled and classic solutions can be applied without the aid of an excessive number of assumptions common to large complicated test fixtures.
5. The test system is capable of fine control of test parameters and can duplicate previously established conditions with the same accuracy.

The data presented in this report is the first in a general parametric

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study of the graphite-hydrogen corrosion in narrow slots. The data shows variance of corrosion reaction rate with pressure and mass flow keeping conditions of material, gas composition, inlet gas temperatures, material temperature, and flow slot size constant.

Also presented are variations in surface regression in the form of slot profiles, with respect to pressure, mass flow, and time. The intended use of this information is to gain a better understanding of the corrosion reaction in narrow slots characteristic of the NERVA Reactor. The test fixture can also be used as a tool to check and increase confidence levels in computer solutions used to predict reactor core life.

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EXPERIMENTAL EQUIPMENT

The design, development, and operation of the test equipment is covered in detail in References 1 and 2. The above mentioned phases, plus the techniques of data gathering, have not changed since the publishing of Reference 2.

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RESULTS

The first area of investigation was that of pressure effects on the hydrogen corrosion reaction. The tests were conducted at pressure levels of 50, 100, 150, 200, 250, 300, and 350 psig, while flow rate, material, material temperature, inlet gas temperature, inlet gas composition, and flow slot size were maintained constant. A flow rate of 4.2×10^{-5} lb. H_2 /sec. was established as a reasonable mean slot flow and considered a normal condition which other parameter changes could be compared to. Material temperatures were maintained at the $3500^\circ R$ level during this series. The composition of the inlet gas is considered to be pure hydrogen. The flow slot specimen is consistently fabricated from Graphitite "G" which is the accepted filler strip material in the reactor. Its size is maintained at 1 inch in width, 2 inches in length, and .006 inches in thickness. All outer surfaces of the cylindrical graphite test specimen have been coated with NbC to further reduce the possibility of extraneous hydrocarbon generation.

Figure 1 presents the data obtained from the test program and shows reaction rate versus pressure for various mass flow rates. The data shows the magnitude of reaction rate increase with increase in inlet pressure. Plotted as shown in Figure 1, the slope of the data indicates the chemical kinetic order of reaction. The data points above and below the established norm are generated by changes in mass flow, each set of points represents an increase by a factor of 2 in the flow of the points beneath. The span encompassed by the top and

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bottom curves represents a flow rate increase by a factor of 8. As can be seen from the curves, flow changes appear to shift the data for a given mass flow up or down without significantly changing the slope.

Figure 2 is a cross plot of Figure 1 showing reaction rate as a function of mass flow along lines of constant pressure. This curve again shows the increase in reaction rate with increase in mass flow with little or no slope change from isobar to isobar.

Pre and post test surface measurements provided surface regression information in the form of flow slot profiles which varied with pressure. Figure 3 shows the axial mid plane profile of the corrosion depth recorded from the samples listed, the most corrosion taking place at the highest pressure. These specimens were all tested at the normal mass flow of 4.2×10^{-5} lb. H_2 /sec. Notice that in every case the major surface regression extends no further than halfway along the slot, and the bell mouth shape prevails from test to test. The test time for the data as shown on Figure 3 was 30 minutes.

Figure 4 is a plot of the axial mid plane corrosion depth for a mass flow of 4.2×10^{-5} lb. H_2 /sec. showing specimens that were tested for 15 minutes. The trend of increased corrosion depth with increased pressure is still evident, also apparent is the fact that the most severe corrosion takes place in the upstream half of the flow slot. The corrosion effects seen in Figures 3 and 4 appear to be direct functions of pressure level.

Figure 5 shows the axial mid plane corrosion profile for two pressure

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levels and various flow rates. The specimens were tested for 15 minutes at 350 psig or 250 psig with flow rates of 2.1×10^{-5} lb/sec., 4.2×10^{-5} lb/sec., or 8.5×10^{-5} lb/sec. In these tests, the only effect to be seen is the effect of corrosion rate due to mass flow change for each pressure level. These curves show that where the mass flow rate is high, severe corrosion exists at the inlet and rapidly tapers off.

On this same plot are 2 sets of data obtained at the 250 psig level, one at 2.1×10^{-5} lb/sec., the other at 8.5×10^{-5} lb/sec. When a comparison of the high flow rate tests at the two pressure levels (350 and 250) are made, the profiles show a similar unusual characteristic, for the length of the flow slot. This characteristic is shown as an expansion then contraction, another expansion then contraction in the recession for the first half of the flow slot. Expansion indicates large cross-sectional area; contraction, small cross-sectional area. For the last half of the flow slot there is one area of very distinct contraction. The 250 psig data tends to lag the 350 psig data but conforms to the same general trend, displaying one less contraction in the first half of the slot. It is apparent that as the mass flow rate increases, the cross-section of the flow slot undergoes a profile change.

Figure 6 compares two tests at the 200 psig pressure level, one test conducted at the normal flow of 4.2×10^{-5} lb/sec., the other conducted at the highest flow of 1.7×10^{-4} lb/sec. It should be noted that the test time varied for each test. The normal flow exhibits the typical bell mouth entrance with

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the most severe corrosion taking place in the first half of the slot. The high flow profile shows less severe corrosion on the inlet with an increase to a relatively stable level at the 3/4 inch station. However, at high flow rates the downstream material temperature is greater than the upstream temperature. Figure 7 shows the axial mid plane corrosion profile of a specimen tested at the highest flow rate and 300 psig, this specimen was tested for only 9.0 minutes. The high flow rate of 1.7×10^{-4} lb/sec. is considered the maximum flow that can be used without the aid of a gas pre heater to level the temperature distribution. Typical, as measured temperature differences for the various mass flow rates at the 250 psig pressure level are 6°R for the 2.1×10^{-5} lb/sec. flow, 19°R for the 4.2×10^{-5} lb/sec. flow, 162°R for the 8.5×10^{-5} lb/sec. flow, and 319°R for the 1.7×10^{-4} lb/sec. flow. In all cases the exit material temperature was the hottest. The mean material temperature desired was 3500°R . The mean temperatures of the above mentioned tests were 3501°R , 3480°R , 3435°R , and 3501°R , respectively, the maximum derivation being 66° . Temperature distribution is considered to be a factor in specimen profile change as mass flow is increased. In this case the competing effects of hydrocarbon concentration and temperature profile will result in different specimen profile changes.

Figures 8 and 9 show the fixture ΔP decay recorded for the tests conducted at a flow of 4.2×10^{-5} lb. H_2 /sec. The initial magnitude of the ΔP is established by the inlet pressure of the test. The slope represents the effect of flow area change due to corrosion. With a constant flow rate, the magnitude of the pressure differential would increase with decreasing pressure levels. In

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all cases this trend is not followed, and the causes contributing to this effect which occurs mainly far into the run are not understood.

Examination of the curves describing the tests above a 200 psig inlet pressure show a slight increase in pressure differential toward the end of the test period. This is the beginning of the mechanical clogging phenomena which will be covered in detail below.

Preliminary data obtained during the pressure effect series indicated that above the 200 psig inlet pressure level a phenomena existed which produced a corrosion rate lower than the rates obtained at the lower inlet pressures. The observed increase in specimen pressure differential towards the end of the tests conducted at pressure levels above 250 psig provided a clue as to what was taking place in the gap. It was observed that graphite particles were collecting in the last 1/2 inch of flow gap and clogging it. Microscopic examination of the slot surfaces indicated that it is purely a mechanical process and not chemical deposition of carbon. The reduced flow area created by the accumulation of graphite particles at constant flow rate caused an increase in pressure drop across the specimen. The accumulation can also provide more surface area for hydrocarbon generation, which would inhibit corrosion in the last half inch of the flow slot. To eliminate this effect, the test time was reduced to 15 minutes. This time was picked because the ΔP anomaly indicating this effect was not observed at that time in the 30 minute test. Figure 10 shows the increase in pressure differential created by this condition in its early stages. The increase is so rapid that pressure differentials in the area of 100 psid were ob-

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served before the switch-over to helium could be accomplished.

Figure 11 shows magnified pictures of the particles taken from a clogged gap. The 50X photo shows particles whose largest dimension is in excess of .006 inches. The third picture shows the location of the deposit at the exit of the flow slot.

Photos of each fixture are taken after the test in order to have a permanent record of the flow slot surfaces before it is marked by the measuring instrument. At the perpendicular inlet face of the flow slot the NbC coating remains after corrosion removes the graphite behind it. This can be used as a visual guide as to how much graphite has been removed. The most informative photo is taken from the exit end of the disassembled fixture angled to show the flow slot surfaces and the remaining NbC coating on the inlet edge. The following sequence of photos, Figures 12, 13, 14, 15, 16, 17, and 18 shows the fixtures tested to establish the normal or 4.2×10^{-5} lb/sec. curve presented in order of increasing inlet pressure. Differences in the length of which corrosion extends through the slot can be seen up to the 150 psig level. The remaining photos show increased surface regression in order of appearance. In all cases, the most severe corrosion took place in the first half of the flow slot. The next series of photos, Figures 19, 20, 21, 22, and 23 show the test fixtures tested to generate the low flow, 2.1×10^{-5} lb/sec., data presented in order of increasing inlet pressure. In all the specimens corrosion never appears to extend to the outlet of the slot, however, corrosion does increase in length and depth in order

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of presentation. The grid visible on these specimens was placed there with a graphite pencil and is used to position the probe of the measuring instrument used to obtain pre test surface data.

The next series of photos, Figures 24, 25, 26, 27, and 28 show the fixtures tested to gather the high flow, 8.5×10^{-5} lb/sec., data. In all cases, the corrosion extends completely through the slot and increases in depth in order of presentation. The next series of photos, Figures 29, 30, and 31 show the fixtures tested to gather the extra high flow, 1.7×10^{-4} lb/sec., data. In this case again the corrosion extends completely through the slot with the most severe corrosion taking place toward the outlet end. The wall of NbC coating was left on the inlet and outlet end of these specimens, the outlet end generally showing the severest attack. Figures 6 and 7 show plots of the surface regression profiles obtained from the 200 and 300 psig pressure level specimens confirming the profiles described before.

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CONCLUSIONS AND RECOMMENDATIONS

A test fixture has been designed and proven capable of generating parametric data on the graphite-hydrogen corrosion reaction in narrow slots.

The data has proven useful in providing comparison information to support results obtained in large complicated test systems. It can be used to increase confidence levels in computer models used to predict core lifetime by using the model to predict surface regression of the specimen, which can be tested at closely controlled specified conditions.

The parametric information obtained can be used to gain a better basic understanding of how the variables effect the kinetics of the reaction, and to formulate equations by which this effect can be more accurately calculated.

Based on the experience gained in conducting and reducing the test data, the following recommendations are made:

1. Design and fabricate a heat exchanger to obtain an isothermal specimen temperature at flow rates higher than previously obtained.
2. Study the effect of specimen geometry on the results obtained. Current inlet and outlet configurations do perturbate the stream lines once corrosion starts to occur. Experiments should be conducted on specimens with NbC coated, gradual sloping inlets and outlets to determine what the effect of the existing stream-line disturbance is.

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3. Corrosion rates reported are based on a geometric surface area of 4 square inches. Work should be done to determine if the specific area of the sample can be accurately determined and how the results would be changed. If so, a relationship between corrosion rate based on these two values should be developed.
4. Conduct more tests where the phenomena of gap clogging takes place to determine if this characteristic can be applied to the problem of reducing interstitial flow in the core.

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Test Conditions

Hydrogen Inlet Pressure - As Shown
Average Material Temperature - 3500°R

Flow Rate -

- 2.1×10^{-5} lb/sec
- 4.2×10^{-5} lb/sec
- ◇ 8.5×10^{-5} lb/sec
- △ 1.7×10^{-4} lb/sec

Material - Graphitite "G"

Gap Size

1 Inch Wide
2 Inches Long
.006 Inch Thick

Figure 1

Variation Of Reaction Rate With Pressure For Constant Mass Flows

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Test Conditions

Hydrogen Flow Rate - As Shown
Average Material Temperature - 3500°R
Material - Graphite "G"

Gap Size

1 Inch Wide
2 Inches Long
006 Inch Thick

Figure 2

Variation of Reaction Rate With Mass Flow For Constant Pressure

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Figure 3

Variation of Axial Mid Plane Corrosion Depth With Pressure

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Serial No.	Test Inlet Pressure	Average Material Temperature - 3500°R
□ 16	150 psig	Flow Rate - 4.2×10^{-5} lb/sec-H ₂
○ 14	300 psig	Material - Graphitite "G"
◇ 15	350 psig	Test Time - 15 Minutes.

Figure 4

Variation of Axial Mid Plane Corrosion Depth With Pressure

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Serial No.	Flow Rate	Test Pressure	Average Material Temperature - 3500°R
□ 1	2.1×10^{-5} lb/sec-H ₂	250 psig	Material - Graphitite "G"
○ 25	8.5×10^{-5} lb/sec-H ₂	250 psig	Test Time - 15 Minutes
◇ 19	2.1×10^{-5} lb/sec-H ₂	350 psig	
△ 15	4.2×10^{-5} lb/sec-H ₂	350 psig	
X 20	8.5×10^{-5} lb/sec-H ₂	350 psig	

Figure 5

Variation of Axial Mid Plane Corrosion Depth With Mass Flow

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Figure 6

Variation of Axial Mid Plane Corrosion Depth With Mass Flow and Time

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Figure 7

Axial Mid Plane Profile at Highest Mass Flow and Pressure Point

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	Serial No.	Test Pressure
○	5	52 psig
□	12	100 psig
◇	11	200 psig
△	7	250 psig

Average Material Temperature - 3500°R
Flow Rate - 4.2×10^{-5} lb/sec-H₂
Material - Graphitite "G"

Figure 8

Variation of Test Specimen Pressure Differential
With Time and Inlet Pressure

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Serial No.	Test Pressure
○ 16	150 psig
□ 14	300 psig
◇ 15	350 psig

Average Material Temperature - 3500°R
Flow Rate - 4.2×10^{-5} lb/sec-H₂
Material - Graphitite "G"

Figure 9

Variation of Test Specimen Pressure Differential
With Time and Inlet Pressure

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TEST SPECIMEN ΔP - PSID
Figure 10

Variation of Test Specimen Pressure Differential With Time
Showing the Initial Stages of the Gap Clogging Phenomenon

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12X PHOTO OF MIXED LARGE AND SMALL PARTICLES

50X PHOTO OF LARGE PARTICLES

1.5X VIEW OF FLOW SLOT SHOWING PARTICLE DEPOSITS

Figure 11

Photos Showing Location and Size of Gap Clogging Particles

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Figure 12

Test No. TFL-5.b-001 Specimen Tested at 3500°R for
30 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

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Figure 13

Test No. TFL-5.b-008 Specimen Tested at 3500°R For
30 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

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Figure 14

Test No. TFL-5.b-012 Tested at 3500°R for
30 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

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Figure 15

Test No. TFL-5.b-007 Tested at 3500°R for
30 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

Figure 16

Test No. TFL-5.b-003 Tested at 3500°R for
30 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

Figure 17

Test No. TFL-5.b-010 Tested at 3500°R for
15 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

Figure 18

Test No. TFL-5.b-011 Tested at 3500°R for
15 Minutes With a 4.2×10^{-5} lb/sec Hydrogen Flow

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Figure 19

Test No. TFL-5.b-020 Tested at 3500°R for
15 Minutes With a 2.1×10^{-5} lb/sec Hydrogen Flow

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Figure 20

Test No. TFL-5.b-022 Tested at 3500°R for
15 Minutes With a 2.1×10^{-5} lb/sec Hydrogen Flow

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Figure 21

Test No. TFL-5.b-016 Tested at 3500°R for
15 Minutes with a 2.1×10^{-5} lb/sec Hydrogen Flow

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Figure 22

Test No. TFL-5.b-013 Tested at 3500°R for
15 Minutes With a 2.1×10^{-5} lb/sec Hydrogen Flow

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Figure 23

Test No. TFL-5.b-018 Tested at 3500°R for
15 Minutes With a 2.1×10^{-5} lb/sec Hydrogen Flow

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Figure 24

Test No. TFL-5.b-021 Tested at 3500°R for
15 Minutes With a 8.5×10^{-5} lb/sec Hydrogen Flow

Figure 25

Test No. TFL-5.b-017 Tested at 3500°R for
15 Minutes With a 8.5×10^{-5} lb/sec Hydrogen Flow

Figure 26

Test No. TFL-5.b-024 Tested at 3500°R for
15 Minutes With a 8.5×10^{-5} lb/sec Hydrogen Flow

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Figure 27

Test No. TFL-5.b-023 Tested at 3500°R for
15 Minutes With a 8.5×10^{-4} lb/sec Hydrogen Flow

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Figure 28

Test No. TFL-5.b-019 Tested at 3500°R for
15 Minutes With a 8.5×10^{-5} lb/sec Hydrogen Flow Rate

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Figure 29

Test No. TFL-5.b-027 Tested at 3500°R for
15 Minutes With a 1.7×10^{-4} lb/sec Hydrogen Flow Rate

Figure 30

Test No. TFL-5.b-028 Tested at 3500°R for
6.75 Minutes With a 1.7×10^{-4} lb/sec Hydrogen Flow Rate

Figure 31

Test No. TFL-5.b-026 Tested at 3500°R for
9 Minutes With a 1.7×10^{-4} lb/sec Hydrogen Flow

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APPENDIX A

Appendix A contains a tabulated listing of the conditions at which all the specimens included in this report were tested, also tabulated are results in the form of weight losses and reaction rates. Temperatures and flow rates are average values calculated from raw data taken at 2.5 minute intervals throughout the test period. Weight loss information is the total weight loss for the time the test was conducted.

Also, included in this appendix are pre and post test surface measurements taken on each specimen included in the report. The profiles presented in the text of the report are axial mid plane surface regression profiles. The data is provided so the reader can calculate average axial and transverse profiles. The data sheets used are identical to those used to gather the raw data. Keep in mind that the specimen surfaces as shown on the data sheet are not the same as the surfaces when the specimen is assembled, in that one surface is turned over when the model is assembled. Axial profile measurements taken to the left of center on one specimen half coincide with axial profile measurements taken to the right of center on the other specimen half. Also provided are flow slot width measurements before and after test taken at .25 inch intervals for the entire length of the slot. The data is presented in order of increasing pressure for the 4.2×10^{-5} lb/sec., 2.1×10^{-5} lb/sec., 8.5×10^{-5} lb/sec. and 1.7×10^{-4} lb/sec. curves respectively.

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APPENDIX A

TABULATION OF TEST CONDITIONS AND RESULTS

TFL-5.b. Test No.	Run Time	Inlet Pressure	Inlet Gas Temp	Outlet Gas Temp	Inlet Mtl. Temp	Outlet Mtl. Temp	Flow Rate	Weight Loss	Reaction Rate	Ave. Mtl. Temp
Specimen Ser. No.	Min.	psig	°R	°R	°R	°R	lb/sec H ₂	gms	gms/in ² sec.	°R
001 5	30	52	525	2101	3458	3495	4.2×10^{-5}	.187	2.6×10^{-5}	3477
008 12	30	100	549	2244	3498	3495	4.3×10^{-5}	.430	5.97×10^{-5}	3497
012 16	15	150	551	2086	NG	3485	4.3×10^{-5}	.296	8.23×10^{-5}	-
007 11	30	200	552	2111	3497	NG	4.2×10^{-5}	.830	1.15×10^{-4}	-
003 7	30	250	532	1991	3470	3489	4.2×10^{-5}	1.116	1.55×10^{-4}	3480
010 14	15	300	542	2108	3485	3497	4.3×10^{-5}	.680	1.89×10^{-4}	3491
011 15	15	350	531	2241	3467	3502	4.3×10^{-5}	.860	2.38×10^{-4}	3485
019 21	15	50	526	1974	3484	3465	2.2×10^{-5}	.089	2.47×10^{-5}	3475
022 23	15	100	505	1677	3486	3496	2.1×10^{-5}	.124	3.9×10^{-5}	3491

APPENDIX A

TABULATION OF TEST CONDITIONS AND RESULTS

TFL-5.b. Test No.	Run Time	Inlet Pressure	Inlet Gas Temp	Outlet Gas Temp	Inlet Mtl. Temp	Outlet Mtl. Temp	Flow Rate	Weight Loss	Reaction Rate	Ave. Mtl. Temp
Specimen Ser. No.	Min.	psig	°R	°R	°R	°R	lb/sec H ₂	gms	gms/in ² sec	°R
<u>016</u> 17	15	150	526	1719	3476	3506	2.1×10^{-5}	.221	6.13×10^{-5}	3491
<u>013</u> 1	15	250	552	1726	3498	3504	2.2×10^{-5}	.290	8.06×10^{-5}	3501
<u>018</u> 19	15	350	520	1769	3503	3488	2.1×10^{-5}	.503	1.39×10^{-4}	3496
<u>021</u> 22	15	100	518	2213	3414	3437	8.5×10^{-5}	.369	1.025×10^{-4}	3425
<u>017</u> 18	15	150	517	2301	3376	3509	8.5×10^{-5}	.450	1.25×10^{-4}	3442
<u>024</u> 25	15	250	517	2383	3354	3516	8.5×10^{-5}	.929	2.58×10^{-4}	3435
<u>023</u> 24	15	300	522	2269	3394	3530	8.5×10^{-5}	1.113	3.09×10^{-4}	3462
<u>019</u> 20	15	350	513	NG	3366	3497	8.5×10^{-5}	1.355	3.76×10^{-4}	3421
<u>027</u> 28	15	200	518	2460	3404	3683	1.7×10^{-4}	1.114	3.1×10^{-4}	3544

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APPENDIX A

TABULATION OF TEST CONDITIONS AND RESULTS

TFL-5.b. Test No.	Run Time	Inlet Pressure	Inlet Gas Temp	Outlet Gas Temp	Inlet Mtl. Temp	Outlet Mtl. Temp	Flow Rate	Weight Loss	Reaction Rate	Ave. Mtl. Temp
Specimen Ser. No.	Min.	psig	°R	°R	°R	°R	lb/sec H ₂	gms	gms/in ² sec.	°R
028 43	6.75	250	523	2460	3342	3661	1.7×10^{-4}	.625	3.86×10^{-4}	3501
026 27	9	300	512	2199	3443	3639	1.7×10^{-5}	1.180	5.46×10^{-4}	3541

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