PROGRESS REPORT ON THE TRIST-TC1 EXPERIMENT – A. L. Qualls, L. L. Snead, S. J. Zinkle, W. S. Eatherly, R.G. Sitterson, and D.W. Sparks (Oak Ridge National Laboratory), R. Yamada (Japan Atomic Energy Research Institute), and Y. Katoh (Kyoto University, Institute of Advanced Energy)

OBJECTIVE

The objective of this report is to summarize the progress of the TRIST-TC1 Experiment.

SUMMARY

Fabrication of the experiment began during this reporting period. Forty specimens, in addition to eight heat generation measurement standards, were cut to size and brazed into twenty-four specimen pads. The specimen pads were assembled into three temperature zones comprising the experimental region of the capsule.

PROGRESS AND STATUS

Figure 1 shows a typical specimen pad assembly used in the TRIST-TC1 experiment. Specimen pads are made of a vanadium alloy (V4Cr4Ti). The specimens are right circular cylinders. Holes are drilled into the face of the specimens and .023" OD Type N thermocouples are brazed into the holes. One end of each specimen is brazed into a counterbored hole on the two outside surfaces (of the three flat, inner surfaces) of a specimen pad. The specimens are displaced axially so they will not intersect as they extend toward the center of the capsule. The outer radius of the specimen pad fits precisely against the inside diameter of a specimen pad holder, and each pad is secured to the holder with eight stainless steel screws, as shown in Figure 2.

Nuclear interactions produce heat in the specimens, specimen pads and specimen pad holder during reactor operation. The temperature of a holder, and therefore the specimens, is controlled by varying the thermal conductivity of a gas mixture in the annular region between the outer diameter of the holder and the inner diameter of the capsule housing tube, which is cooled to approximately 60°C by the reactor primary coolant.

During operation, the capsule has a constant purge of helium flowing into the central portion of the experimental region. The helium flows into plenums below each specimen holder and then upwards through the temperature control gas gaps and into exhaust plenums at the top of the holders. To control the temperature of an individual holder, neon or argon is mixed into the helium as it enters a lower plenum and forms a gas mixture with a thermal conductivity between that of the gases used (helium and neon or argon). The flow rate of the neon or argon is adjusted to achieve and maintain the desired operating temperature.

Nuclear heating within a specimen will produce a temperature drop as the heat is lost along its length to the specimen pad. The temperature difference from the base to the tip of a specimen is a function of the specimen length, thermal conductivity and the internal volumetric heat generation rate. The heat generation rates within capsule components are relatively constant near the reactor mid-plane, but increase substantially in the upper and lower portions of the experimental region as a reactor cycle progresses. The lengths of specimens are set to produce a 40°C drop across the specimen based on the expected thermal conductivity of the irradiated material and the End-of-Cycle heat generation profile.

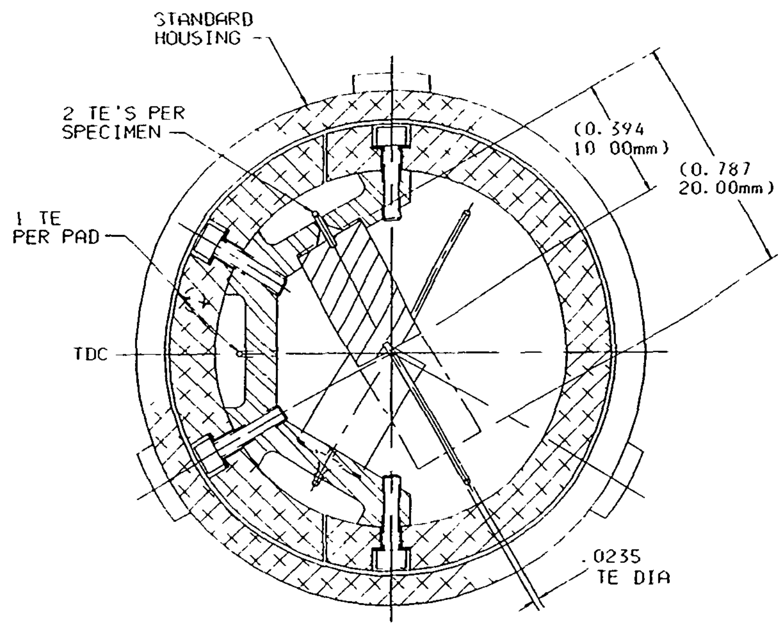

Figure 1. Specimen pad assembly for the TRIST-TC 1 experiment.

The experimental matrix for the TRIST-TC1 capsule is summarized in Table 1. A total of 17 different types of ceramic specimens are contained in 3 different temperature zones. The specimen matrix includes both monolithic ceramics and current state-of-the-art ceramic composites (C/C and SiC/SiC).

The experiment contains eight steel measurement standards displaced over the length of the experimental region. The standards are in positions 1, 6, 16, 21, 27, 33, 40, and 46, numbered from the top specimen location. The thermal conductivity of the steel will not change due to irradiation damage, and the temperature drop across the standards will provide a direct measurement of the heat generation at different axial locations within an unshielded RB* position of HFIR. The interpolated (and for two specimens, extrapolated) data will allow those temperature changes resulting from changes in specimen thermal conductivity to be distinguished from those that are a result of a changing heat generation profile.

Average specimen temperatures are to be 400°C in Zone A, 700°C in Zone B, and 200°C in Zone C. Temperature control and thermal isolation of the three zones is based on concepts tested in the Varying Temperature Experiment (RB-13J) [1]. Temperature zones with temperature differences of 150°C are separated by approximately 1.9 cm in that experiment, and a temperature increase of 150°C in a zone results in only a 5°C increase in the temperature of adjacent temperature zones. To accommodate larger temperature differences between zones in the TRIST-TC1 experiment, the spacing between zones has been increased to 2.5 cm. Figure 3 shows the assembled experimental region of the irradiation capsule.

Table 1. Experimental matrix for TRIST-TC1 capsule. Position #1 is located at the top of the irradiation capsule and #48 is located at the bottom of the capsule. Samples 1-20 are in the 400°C irradiation zone (Zone A), Samples 21-40 are in the 700°C irradiation zone (Zone B), and Samples 41-48 are in the 200°C irradiation zone (Zone C).

Material	Position	Temperature (°C)			Vendor and Grade
		200	400	700	
F82H F/M steel (standard)	2,5,12,15,28,34,39,45	1	3	4	NKK (IEA heat)
CVD SiC (Hi TC)	11,20,21,42	1	2	1	Morton CVD (K_{th}^{rt}~400 W/m-K)
CVD SiC (Lo TC)	17,30,41	1	1	1	CVD SiC (K_{th}^{rt}~110 W/m-K)
Single X SiC	19		1		Cree Systems 6H-Alpha
3D SiC Composite	6,33		1	1	Kawasaki PIP 3-D, Hi-Nicalon fiber
Felt SiC Composite	8,31		1	1	Mitsui CVI/PIP, Hi-Nicalon-S fiber
2-D SiC/SiC, in-plane	7,9*,29		2	1	ORNL FCVI, Satin Weave Hi-Nicalon-S
2-D SiC/SiC, cross plane	10,27		1	1	ORNL FCVI, Satin Weave Hi-Nicalon-S
2-D SiC Composite	16,25		1	1	MER CVR, T-300 PAN Fiber
SiC Doped CFC	13,32		1	1	Tonen, (K_{th}^{rt}~410 W/m-K)
1D CFC	12		1		Mitsubishi MKC-1PH (K_{th}^{rt}~560 W/m-K)
1D CFC	18,26		1	1	Tonen, (K_{th}^{rt}~495 W/m-K)
2D-CFC	1,23		1	1	FMI-222 (K_{th}^{rt}~200 W/m-K)
Graphite	14,24		1	1	Segri-Great Lakes H451
Sapphire	4,37,48	1	1	1	Crystal Systems Hemlux Ultra (VUV)
Silicon Nitride	38,46	1		1	Kyocera SN235P
Beryllium Oxide	3,36,44	1	1	1	Brush Wellman 995
Aluminum Nitride	35,43	1		1	Tokoyama SH15
Spinel	40,47	1		1	Commercial Crystal Systems

*Sample oxidized for 24 hr. at 600°C.

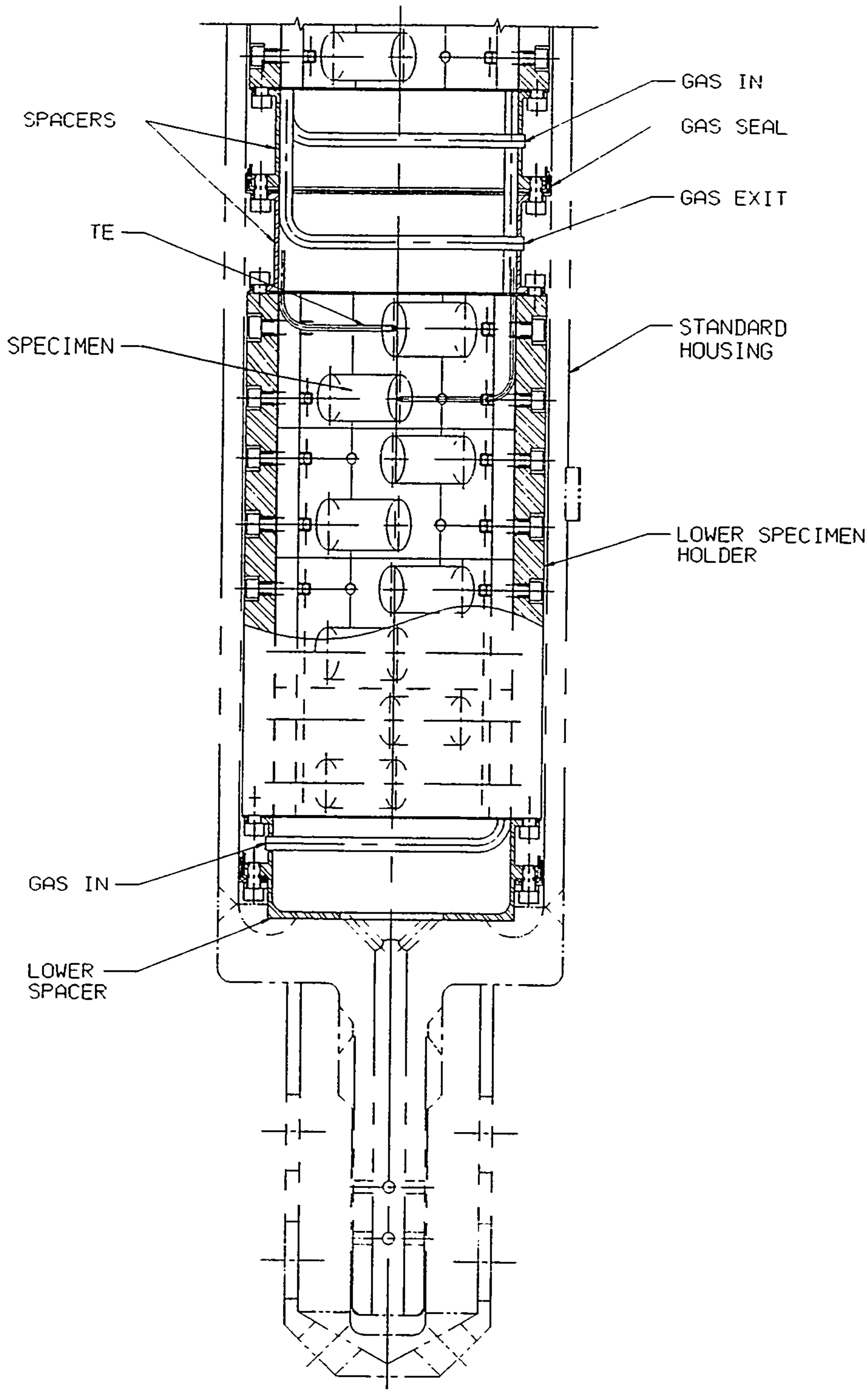

Figure 2. Cross sectional view of the 200°C temperature zone of the TRIST-TC1 experiment.

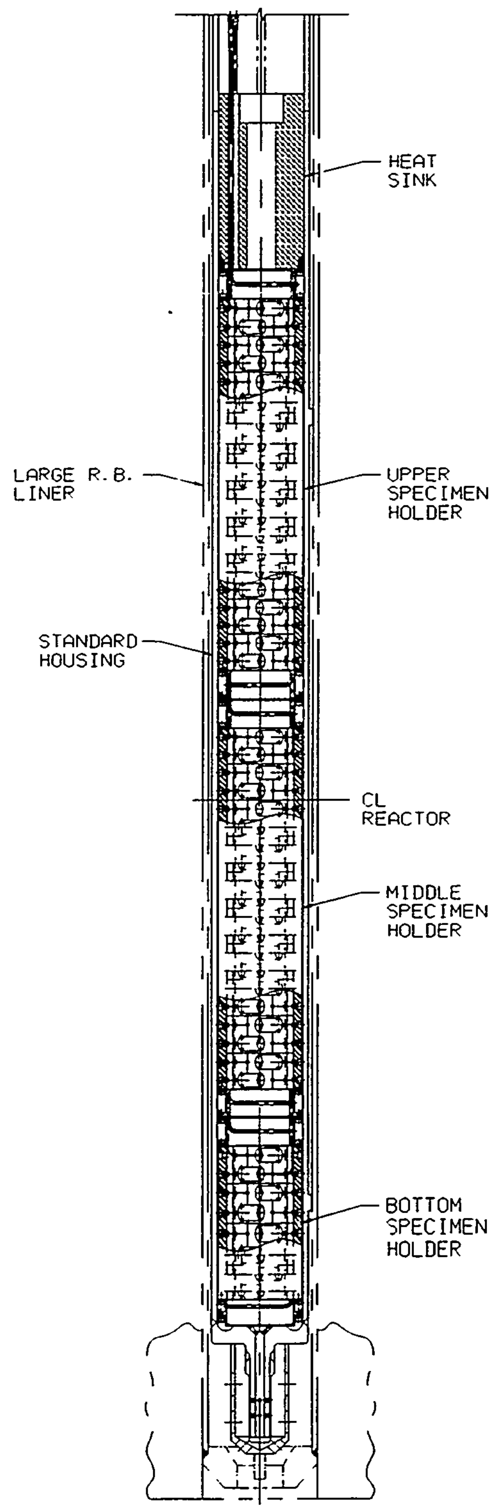

Figure 3. View of the experimental region of the TRIST-TC1 experiment.

Typically, experiments are rotated 180° after each cycle to ensure that specimens receive a balanced dose during irradiation. However, since this rotation would change the nuclear heating rate of individual specimens (and thereby produce difficulties in interpreting the data), it is currently planned to maintain the same capsule orientation for all three irradiation cycles. Dosimetry packets are positioned such that the accumulated dose of all specimens can be determined.

The three-cycle irradiation is projected to begin near the first of March and end in June 1999.

REFERENCES:

A. L. Qualls and T. Muroga, "Progress on the Design of a Varying Temperature Irradiation Experiment for Operation in HFIR, "Fusion Materials Semiannual Progress Report for Period Ending December 31, 1996, p. 255.