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PRELIMINARY RESULTS OF EXPERIMENTS 6 THROUGH 10
CONDUCTED AT THE WESTERN NEW YORK NUCLEAR RESEARCH
CENTER REACTOR DURING THE TIME PERIOD
OCTOBER 29 THROUGH NOVEMBER 2, 1962

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1.0 General

The purpose of this memorandum is to present preliminary results of Experiments 6 through 10 conducted at the Western New York Nuclear Research Center. These experiments involved radiation effects tests of the following components and circuits.

- Experiment No. 6 - Coaxial Cables
- Experiment No. 7 - Electronic Tubes
- Experiment No. 8 - Electrical Insulating Coatings
- Experiment No. 9 - DC Impedance Converter (Nuvistor)
- Experiment No. 10 - Tetrode Pulse Preamplifier (Nuvistor)

Details as to the items that were tested and the test procedures used are documented in WANL-TME-169, dated October 19, 1962.

2.0 Experiment Preparation

Each of the coaxial cables tested were prepared in the following manner:

1. The braided shield on the end of the cable to be placed in the reactor was stripped-back about one inch and coated with silicone rubber (Dow Corning Silastic RTV881). The end was then covered with a fiberglass tape (Minnesota Mining and Manufacturing). The cables, together with two copper-constantan thermocouples, were bundled together using fiberglass tape. The thermocouples were attached to the metal sheaths on the Westinghouse vacuum cable and the magnesium oxide cable (RG 81).
2. In order to determine whether "end" effects would be experienced during the tests, an additional sample of the Raychem 32-195 cable was included in the bundle and doubled back about 15 feet so that its end was out of the radiation field.
3. The bundle of cables was placed in an air-filled three-inch diameter standpipe which was located in the core of the WNY reactor during the radiation tests.

The remainder of the tests were placed within the aluminum capsules used in prior experiments and described in detail in WANL-TME-109.

3.0 Radiation Dosimetry

Based upon foils that were located in the interiors of the capsules irradiated during Experiments 2 through 5, the following neutron fluxes are estimated for the present series of tests:

$$\text{Fast neutrons (E > 2.9 Mev)} = 1.2 \times 10^{12} \text{ n/cm}^2 \text{ sec}$$

$$\text{Thermal (cadmium difference) neutrons} = 3.9 \times 10^{12} \text{ n/cm}^2 \text{ sec}$$

Attempts to measure the gamma dose rate with the 4-cc graphite ion chamber were not successful due to the fact that the chamber was found to be damaged internally. It will be returned to General Dynamics/Fort Worth for necessary repairs and it is hoped that it will be available for measurements during the test series planned in December. In the meantime, it is felt that a gamma dose rate of 5×10^7 R/hr is still the best available value.

4.0 Test Results

4.1 Coaxial Cable Tests

- 4.1.1 Induced Current Measurements - Radiation-induced currents were measured at zero applied potential using a linear micro-microammeter for the following coaxial cables:

Westinghouse WX4403 vacuum cable
 Amphenol RG149/U (low-noise polyethylene)
 Amphenol RG-59/U (polyethylene)
 Amphenol 21-541 (low-noise equivalent of RG59/U)
 General cable RG81/U (magnesium oxide)
 Raychem 32-195 (irradiated polyolefin)

Since only free convection of air was available for cooling the cables, the temperatures at 1MW ran as high as 350°F. Although such temperatures far exceed the maximum value specified for polyethylene, useful data were gathered on all of the cables except that during the last fifteen minutes of the test the 21-541 cable shorted out.

In general, the RG149/U cable appeared to be the most immune to radiation induced currents, showing currents ranging from $+7 \times 10^{-9}$ to -4×10^{-9} amperes at the 1MW radiation levels. Oddly enough, the induced current in the RG-149/U cable changed polarity twice during the one hour interval that the reactor was at 1MW. The RG81/U and the vacuum cable showed the largest induced currents ranging approximately ten times higher than the RG149/U.

In order to determine the effect of the high temperature on the induced currents measured, the RG149/U, 21-541, RG59/U and the Raychem 32-195 cables were tested in an oven up to the maximum temperatures reached during the reactor test. No induced currents were observed during any phase of the oven tests.

Upon completion of the oven test, an identical set of cables was vibrated on a shake table over a frequency range of 5 cps to 2000 cps with an acceleration range of 2 g to 7g. Using the same instrumentation set-up as before, no induced currents could be found.

- 4.1.2 Noise Measurements - The testing of cables with high voltage applied ($\pm 900V$) for radiation induced noise did not disclose any alarming effects. The worst case observed was on the RG81 cable which indicated a generated noise level of approximately 85 micro-volts. The other cables indicated a peak noise level in the order of 50 to 65 micro-volts at the 1MW reactor power level. These measurements were made with a peak noise of 40 micro-volts in the measuring system. Noise measurements were made with a 100 KC high pass filter. Measurements with 500 KC and 1 MC filters indicated negligible changes in noise level indicating noise to be predominately higher frequencies.

The noise levels were essentially the same at all lower power levels and indicated about a 50 micro-volt peak noise level.

4.2 Electronic Tube Test

In general, there were no complete failures due to irradiation of the tubes. An important factor here may have been the ambient gas and tube temperatures which were kept to a minimum. The highest temperature recorded ($168^{\circ}F$) was on a nuvistor tube at 1 megawatt. The subminiature glass triode tubes exhibited the greatest changes with permanent increases in plate current, grid current and transconductance. The largest change was in one section of a 6112 where the post-irradiation values differed from the pre-irradiation values by the following amounts: 75% increase in transconductance, 100% increase in plate current, and a 200% increase in grid current (largest grid current was 2.15 μa). The other subminiature glass triodes exhibited similar increases in plate current, grid current and transconductance but were smaller in magnitude than the example given above.

The nuvistors exhibited smaller changes in their characteristics, with approximately 30% increase in plate current and transconductance, and about 10% increase in grid current for the worst cases. One nuvistor did, however, exceed the average changes exhibited by the other nuvistors. This tube indicated a slight gassy effect in tests performed at 1 megawatt. This effect was not evident in the post-irradiation test. However, the transconductance reading at this point was drifting.

The subminiature glass electrometer tubes had grid currents in the order of 5×10^{-9} amperes at 1 megawatt while the plate currents exhibited a slight decrease.

Nearly all of the tubes exhibited a small increase in filament current. However, there was only 3.3% increase in the worst case.

4.3 Electrical Insulating Coatings Test

The insulating coatings test proved the value of circuit coating; however, the results were not up to expectations. The best insulation recorded at the end of 4 hours was 95 megohms to ground on an insulator coated with mica-filled silicone resin. Another insulator coated with the same material indicated a resistance to ground of 11.4 megohms at the same time. This was only a factor of 10 better than the uncoated insulators. The glyptal, un-filled silicone resin and the filled epoxy resin insulations were about 5 to 15 megohms at the end of the test with the filled epoxy appearing the best of the three.

The insulation of the samples generally decreased during the full power run from 25 to 50 per cent. All exhibited excellent recovery after irradiation.

It was noted during the full power run that reversing the applied potential from a positive to a negative voltage reduced the leakage currents considerably. A factor of 100 improvement in the apparent insulation resistance was observed.

4.4 DC Impedance Converter Test

Two DC impedance converter circuits were irradiated, one coated with a mica-filled silicone resin, the other uncoated. In general, both circuits were disturbed by the radiation to the extent that both low-current distortion and response shift took place. These two effects are similar to those observed in the pre-amplifier irradiated in the August test, although not as severe. From a standpoint of linearity, the uncoated circuit is linear to about 5×10^{-6} amperes. The coated circuit exhibits linearity down to 5×10^{-7} amperes. This disparity would seem to indicate that at least part of the low current disturbance is due to leakage currents external to the electrometer.

4.5 Tetrode Pulse Preamplifier Test

The tetrode preamplifier and cable driver were irradiated as a unit. There was no detectable change in gain or pulse response characteristics noted during the test. Under radiation, output noise increased from its pre-irradiation value of 1.5 MV to about 3 MV. Noise dropped back to 1.5 MV on post-irradiation. Slight increases in plate and screen supply currents were observed and are attributed to the high temperatures reached by the tubes due to gamma heating. Since there was no thermal sinking of the tubes in this particular model, gamma-

induced temperatures ran quite high, one reaching 340°F. Aside from the slight variation in supply currents, the high temperatures appeared to have no effect on circuit performance.

5.0 Conclusions

Conclusions regarding the suitability of the components and circuits tested during this set of experiments for use in NERVA environments will be prepared after a more detailed analysis of the data has been completed. This detailed information including plots of component and circuit performance, dosimetry, etc. will be published as a technical memorandum within one to two months.