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TRITIUM MONITORING SYSTEM FOR THE GB-10 GCFR FUEL IRRADIATION EXPERIMENT

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A tritium monitoring system was designed, tested, installed, and operated on the sweep gas from the GB-10 capsule. The objective was to quantatively determine tritium production, release, cladding permeation, and the molecular species released (HT or HTO). This information is necessary in predicting tritium transport pathways in a reactor.

Capsule irradiation began on August 29, 1972. Tritium monitoring experiments began June 17, 1975 at which time the capsule had achieved a burnup of approximately 70,000 MWd/metric ton. FIRST SLIDE. The GB-10 capsule contains a shortened prototype of a GCFR vented-and-pressure equalized fuel rod. It consists of a 9-in long $(U,Pu)O_2$ fuel column, a 2-in long upper blanket region of depleted UO_2 pellets and a 1-in long charcoal trap above the blanket. Two UO_2 half pellets at each end of the mixed-oxide column were included to supress power peaking at the end of the test fuel.

NEXT SLIDE (2) The system was designed to operate with a maximum inlet pressure of 1000 psig and a 250 psig maximum differential across the fuel column. The system flow was designed for 150 to 1300 cm^3/min STP. The original burnup goal was 75,000 MWd/metric ton. This was later extended to 100,000 MWd/metric ton. Five sweep gas lines were built into the capsule. The left sweep line introduces gas at the bottom of the fuel. The next line terminates at the bottom of the blanket. The third terminates at the bottom of the charcoal trap. The other two lines terminate above the charcoal trap. Flow through these lines provide capsule venting and are the standby mode of operation. Therefore, heavy fission product plateout would be expected on this line. ~~The line.~~

A simplified schematic of the tritium monitoring system is whown in the NEXT SLIDE (3). The tritium monitoring system was designed to retain fission products and induced activities while continuously monitoring tritium for many hours. GB-10 sweep gas and/or other gases are introduced to the tritium system at this point. The HTO converter consists of granular Mg at 500° C. When gas is passed through the hot Mg, HTO is converted to HT and a response obtained for HT + HTO. If the HTO converter is bypassed, only HT is measured. When the HTO converter was laboratory tested, greater than 95% recoveries were obtained. However, H_2 was used as a carrier. The charcoal traps were designed to retain fission products and induced activities for long time periods while allowing the tritium (HT) to break through in a matter of minutes. The traps were loaded and valved to permit the use of 1 g, 3 g, or 8 g, of charcoal. Expermental parameters determined the trap configuration. However, typical breakthrough times varied between 12 and 30 minutes. A laboratory test to determine the holdup time for ^{39}Ar on 1 g of charcoal was terminated after 29 hours with no indication of breakthrough.

After breaking through the charcoal traps, tritium then passes through a 1 liter ionization chamber. The signal is picked up by a vibrating reed electrometer and transferred to a strip chart recorder. The sensitivity of the ionization chamber is approximately 1 mv or 1×10^{-6} uc/cc STP. When tritium in high purity He was passed directly to the ion chamber a response was obtained as shown in the NEXT SLIDE (4). Notice the peaking effect. This effect was observed on all laboratory tests. The NEXT SLIDE (5) shows a typical response when tritium in pure He was passed through the charcoal traps. As a safety measure, the charcoal traps were regulated at $-188 \pm 1^{\circ}$ C to prevent concentration of ozone in a radiation field. The sine wave resulted from and closely

followed the 2°C temperature cycle. The cycle time is about 10 min. The average value for the sine wave curve was in good agreement with direct flow and molecular seive calibrations.

An additional tritium determination technique was included in the system. NEXT SLIDE (6). The tritium (HT) is passed over CuO at 500° C. which converts HT to HTO. The HTO then passes through heated lines to tandem 4A molecular seive traps. After a specific collection period, the traps are removed from the system and taken to the laboratory. There the tritium is desorbed with water and subsquently determined by beta liquid scintillation counting. The sensitivity of this technique is one or two orders of magnitude better than the ionization chamber. H_2 carrier has always been used in this portion of the tritium system. We felt that carrier was necessary to quantatively transfer the HTO from the HT converter to the molecular seive traps. This work was responsible for the use of H_2 in evaluating the HTO converter.

After the system was installed in the ORR two problems were encountered. The first was the retention of tritium by the HTO converter. This problem was eliminated by the addition of 2000 ppm H_2 upstream of the HTO converter. However an interesting side effect was observed. NEXT SLIDE (7). Here tritium in high purity He was passed directly to the ion chamber. At this point the gas stream was diluted about 10% with H_2 in He. The peaking effect was never observed when H_2 was present in the carrier gas.

The second problem was encountered when capsule gas was passed through the tritium system. An immediate high level response was observed on the ion chamber. This response leveled out with chamber fill time.

NEXT SLIDE (8). By closing these valves, the ion chamber was isolated and the decay followed by the electrometer. NEXT SLIDE (9). This shows the result of the decay strudy. The bottom portion of the curve is due to ^{24}Na formed before the chamber was isolated. The triangles represent the ingrowth of ^{24}Na during the decay study. The solid circles represent the corrected decay data which ~~is~~ are in good agreement with the published half-life of ^{24}Na. After obtaining the dacay data, the ion chamber was valved in line and the run continued. Molecular seive samples were collected to determine the tritium concentration.

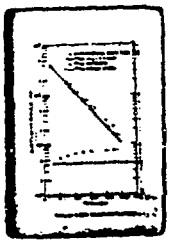
During this experiment, the electrometer response increased slowly with time. After the experiment and routine system cleanup the electrometer continued to indicate 125 millivolts. Again the ion chamber was isolated and a decay study initiated. NEXT SLIDE (10). We determined the half-life of ^{24}Na. This is conclusive evidence that ^{24}Ne was passing through the charcoal traps and the daughter product ^{24}Na was depositing in the ion chamber. The specific reactions are not known, however, ^{24}Ne appears to be formed by activation in the fuel region. The presence of ^{24}Ne did not alter our experimental schedule but did require the use of molecular seive samples.

Eleven experimental campaigns have been completed with the tritium monitoring system. We feel that our HT/HTO ratios are questionable due to the possibility of tritium interchange in the H_2, HT, HTO system. Therefore, all data pertain only to tritium as HT. NEXT SLIDE (11). These experiments can be summarized as follows. When high purity He was introduced at the top of the trap and exited at the top of the trap, less than 0.1% of the predicted tritium production was detected. Introducing He at the bottom of the fuel and exiting at the top of the fuel rod trap, less than 1% of the predicted tritium production

was detected. Introducing He at the bottom of the fuel and exiting at the top of the blanket (bypassing the fuel rod trap) gave a tritium release of approximately 5%.

When a standard gas mixture of tritium (HT) in high purity He was passed through the sweep system, but bypassed the capsule, 100% recovery was obtained. Less than 10% recovery was obtained when the standard gas was passed through lines to and from the top of the fuel rod trap. Less than 1% was recovered using the same return line but injecting at the bottom of the trap. These data indicate that tritium in high purity He is retained in areas exposed to heavy fission product plate out. This experiment was conducted on Oct. 1, 1975 and depleted the funds then available for tritium monitoring.

Valuable information has been obtained on tritium monitoring and transport in a high purity He system. A significant experimental program will be required to meet all the original objectives. Funds have been made available for one or two additional runs involving H_2 and/or H_2 and tritium injections. At best, these experiments will be limited in scope due to capsule flow restrictions. These experiments are scheduled about July 1. At that time, GB-10 will be approching the revised burnup goal of 100,000 MWd/metric ton. However, sufficient data have been obtained to provide comprehensive tritium monitoring on capsule GB-11.



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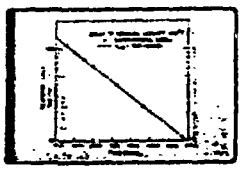

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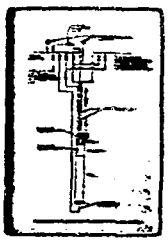

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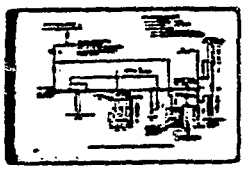

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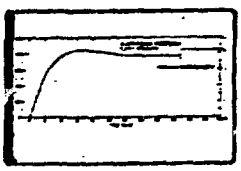

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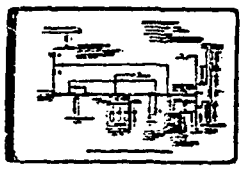

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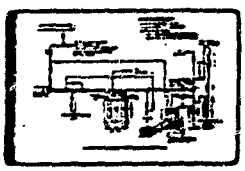

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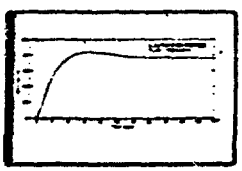

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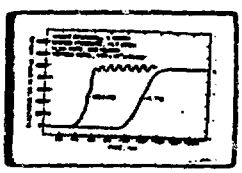

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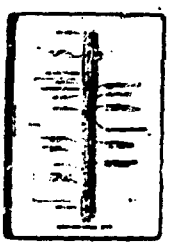

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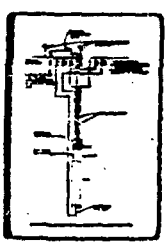

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