Y-DD-113

EXPERIMENTS TO DETERMINE SENSITIVITY
OF NMC GAMMA MONITORS TO
DISTANT FISSION BURSTS

E. C. Crume

December 1974

MASTER

**UNION
CARBIDE**

**OAK RIDGE Y-12 PLANT
OAK RIDGE, TENNESSEE**

*prepared for the U.S. ATOMIC ENERGY COMMISSION
under U.S. GOVERNMENT Contract W-7405 eng 26*

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Date of Issue: December 12, 1974

Report Number: Y-DD-113

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Oak Ridge Y-12 Plant

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EXPERIMENTS TO DETERMINE SENSITIVITY OF NMC GAMMA MONITORS TO DISTANT FISSION BURSTS

In February and March 1967, experiments were run both at the Oak Ridge National Laboratory^(a) and the Oak Ridge Critical Experiments Facility (ORCEF) at the Oak Ridge Y-12 Plant.^(a) In these experiments, from one to four calibrated Nuclear Measurements Corporation (NMC) gamma detectors with built-in trip points were located from 1000 to 1100 feet from prompt burst reactors. The NMCs were calibrated in the calibration facility at Y-12. They were operated from either gasoline generators or truck-mounted 110-volt generators for both the tests and calibrations. Because the NMCs used did not have latching-trip relays, a latching-trip box containing four such relays was built and used in these tests. Bursts having fission yields ranging from 7.13×10^{14} to 1.3×10^{17} were observed in these experiments. The full width at half maximum of the bursts ranged from a few hundred microseconds to approximately 3 milliseconds. Results of the experiments are given in Table 1.

The main results and inferences from the experiments are summarized as follows:

1. A burst of 7.13×10^{14} fissions caused a trip at a setting of 50 mr/hr on an NMC located ~ 1000 feet from the burst (2/16/67 HPRR burst). Only incidental shielding from trees and air was between the HPRR and NMC.
2. For burst magnitudes increasing from 2×10^{16} to 1.3×10^{17} fissions, only about a 10% increase in NMC readings was observed, and most of this increase occurred between 2.0×10^{16} and 2.9×10^{16} fissions. This difference is a consequence of the decreased width of the major part of the pulse; ie, as the fission yield rises, most of the fissions occur during a shorter time.
3. Based on steady-state measurements at the location of the NMC for the HPRR tests^(b) (see Figure 1 and Table 2), the gamma dose rate per kW of reactor power is 4 mrem/hr. Assuming that the 7.13×10^{14} fission burst occurred in 1 msec, and using a conversion of 3×10^{10} fissions/kW msec, an equivalent steady power of 2.38×10^4 kW was obtained. Thus, the dose rate at the NMC during the burst was 9.51×10^4 mrem/hr. Assuming that the NMC would not have read higher than its trip point of 50 mrem/hr, the NMC was only $50/9.51 \times 10^4 \simeq 1/1900$ as sensitive as ideal detection. Alternatively, the 9.66×10^{15} HPRR burst which tripped a meter at a 750 mr/hr setting was considered. The equivalent steady power here would be 3.22×10^5 kW, yielding a dose rate of 1.29×10^6 mrem/hr. Assuming that the NMC would not have read higher than its trip point of 750 mrem/hr, the NMC was only $750/1.29 \times 10^6 \simeq 1/1700$ as sensitive as

(a) Facilities operated by the Union Carbide Corporation's Nuclear Division for the US Atomic Energy Commission.

(b) Intra-Laboratory Correspondence - ORNL; September 16, 1965.

Table 1
TABULATION FOR NMC RESPONSE TESTS
(February - March 1967)

Date	Location (1)	Burst Size (fissions)	Full Width or Half Maximum (ms)	Tripped at Trip Settings of:	Comments
2/16/67	HPRR Site	7.13×10^{14}		50, but not 500	
2/21/67	1000 ft from HPRR	9.66×10^{15}	1.0	50, 300, 500, 750	
2/23/67	ORCEF Site, > 1100 ft from APR; ~ 1 ft Concrete Cell Shielding	8.7×10^{15}		5, 10, 15, 100	
2/23/67	Same as 2/23/67 Test	2.0×10^{16}		50, but not 500	
2/24/67	Same as 2/23/67 Test	2.0×10^{16}		50, but not 300, Although an Observed 400 Pegged but did not Latch	550 mr/hr, read on 5000 scale of one instrument. Between 10 - 26 mr/hr at various buildings on other side of hill in Y-12 main area.
2/24/67	Same as 2/23/67 Test	2.9×10^{16}	0.6	50, but not 1000	600 mr/hr, read on 5000 scale on one instrument and 550 - 600 mr/hr on scale of another. Same range on instruments in Y-12 main area as for previous shot.
2/25/67	Same as 2/23/67 Test	3.6×10^{16}		50, but not 650	600 mr/hr, read on 5000 scale of one instrument and 550 mr/hr on 1000 scale of another. Approximately same range of readings in Y-12 area as before.
2/28/67	Same as 2/23/67 Test	4.2×10^{16} to 1.3×10^{17}			Little if any increase in NMC readings over previous shots, starting with 2×10^{16} yield.
3/17/67	Same HPRR Location as Before	1.03×10^{16}	0.9		Recorder trace from fast recorder has a spike of $\Delta = 25$ units, but generator was failing.
3/17/67	In HPRR Area	2.3×10^{16}	3 ms(?) (more likely 0.75 ms)		Recorder trace of $\Delta = 29$ units; generator steady. Calibration note, 3/19/67: A steady field of 1.2 r/hr from a calibration source gave a meter reading of 700 mr/hr and a recorder trace of 37.5. This calibration is for the 3/17/67 HPRR run only. Earlier calibrations of NMRs for HPRR and APR shots were much closer to the actual readings.

(1) HPRR- ORNL Health Physics Research Reactor
APR - Aberdeen Pulse Reactor

Figure 1. PLOT PLAN OF THE DOSAR FACILITY EXCLUSION AREA.

Table 2
DOSE RATES AT SELECTED POINTS WITHIN THE
HPRR 3000-FT EXCLUSION AREA

Position	Dose Rate (mrem/hr/kW)			Total Dose
	Gamma Rays	Thermal Neutrons	Fast Neutrons	
Inside Control Building				
A	0.6	1.1	0.4	2.1
B	0.7	0.9	1.3	2.9
C	0.5	0.6	0.4	1.5
D	0.5	0.6	0.7	1.8
E	1.4	1.7	3.1	6.2
F	0.03	0.01	0.03	<0.1
G	0.5	0.6	0.4	1.5
H	0.5	0.6	0.4	1.5
I	0.9	1.3	4.0	6.2
Outside Control Building				
J	0.02	0.01	0.05	<0.1
K	3	4	30	37
L	7	10	90	107
M	4	6	50	60
N	3	3	40	46
O (NMC Location)	4	5	60	69

the ideal detection. In both of these examples, the meter readings would undoubtedly have been higher; but, due to HPRR site regulations, it was not possible to have an observer present. The crude calibration attempt on March 17, 1967 gives about 550 mrem/hr which, assuming a burst yield of 2.3×10^{16} fissions, gives a sensitivity of only $550/3.07 \times 10^6 \simeq 1/5600$, if it is assumed that the burst was on a 1-msec time scale, or $\simeq 1/1860$ if on the 3-msec time scale. This calculation shows the sensitivity decreasing with power, as was the case for the Aberdeen Pulse Reactor (APR) shots, but there is no interest in the sensitivity at the high end of the scale. Rather, the interest lies in the low end, as in the 7.13×10^{14} fission example where it is seen that the sensitivity is at least 1/1900 of the steady-state value. Consequently, an arbitrarily selected value of 1/2500 is conservative with respect to the experimental results.

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