HEADQUARTERS
UNITED STATES ARMY NUCLEAR MEDICINE RESEARCH DETACHMENT, EUROPE
APO 180, US FORCES

11 June 1959

FIELD MEASUREMENT OF RADIOACTIVITELY
CONTAMINATED WATER. FTX DOWNWIND

I. INTRODUCTION

Nuclear weapons tests have shown that although water supplies may become contaminated with bomb debris the problem is a minor one for two reasons: (1) the level of contamination is, in most areas, small. (2) even in the unusual case in which the contamination is significant the water can still be consumed, albeit for a shorter time.

Even admitting the minor nature of the problem it is still necessary to be prepared to make some kind of measurement of the degree to which a water sample is contaminated. It is not anticipated that combat units will have to monitor their own water. The area Engineer and Area Preventive Medicine Officer can cover this requirement.

During FTX "Downwind", in the vicinity of Boblingen, Germany in the period 24-27 May 1959, the USAREUR Medical Laboratory brought into the field an end-window Geiger counter with lead pig and conventional laboratory type scaler. This equipment is kept on hand so that the laboratory will have a capability of measuring radioactive contamination in water and food at relatively low levels. Although the equipment was of the laboratory type they were successful in running the apparatus under field conditions, using a gasoline generator. A separate report will be made by members of the USAREUR Medical Laboratory on their phase of the work.

The mission of United States Army Nuclear Medicine Research Detachment, Europe in this exercise was to collaborate with the Medical Laboratory by furnishing the radioactive materials to "spike" the water samples used. We also brought into the field the standard portable beta-gamma survey meter (AN/PDR-27). Our purpose was to compare the usefulness and limitations of the AN/PDR-27 with the non-portable type equipment employed by the laboratory.

II. RELATIVE SENSITIVITY OF THE TWO TYPES OF EQUIPMENT

As a check the AN/PDR-27 was recalibrated in the field using a 9.9 mgm radium source. It was also shown that the instrument obeyed the inverse square law while reading in the range .10 to 500 mr/hr. The average natural back ground reading on this instrument, with no artifical sources in the vicinity, was .05 mr/hr.

Incl 3

A five gallon G.I. water can was filled with water and "spiked" with a gamma emitter, Chromium 51, to a level of 3 microcuries per liter of water. With the probe in contact with the outside of this can the AN/PDR-27 gave a reading of .10 mr/hr. The orientation of the probe did not effect the magnitude of the reading. As a general rule, in order to measure radioactivity with any reliability, the minimum reading must be at least twice the natural background reading. So we conclude from this that 3 µc of gamma emitter per liter is about the lowest limit of sensitivity of the portable type instrument.

In terms of permissible water consumption, which is the real point of interest in this work, water contaminated with bomb debris to a level of 3 µc per liter could be drunk by one individual for 90 days but no longer if militarily significant damage is to be avoided.[1] More heavily contaminated water should be drunk for a correspondingly shorter time and would be more readily detected with portable AN/PDR-27. However, as noted previously this will be a rare occurrance. Thus we see that under these conditions of measurement the portable instrument would be adequate for what one might call tactical purposes. This conclusion is based on the idea that tactical decisions are made on a time scale measured in hours, or at most a few days. A portable instrument which could give the ok on water consumption for periods up to 90 days seems adequate for tactical purposes.

The need for a more sensitive water monitoring device arises therefore only if one is concerned with water which must be used for periods longer than 90 days and possibly extending up to as long as 5 years. Such measurements obviously need not be made in a hurry and could be handled by the Area Engineer and Area Preventive Medicine Officer on a non-crash basis. This leads to the idea that each Field Army, or perhaps a large Corps, should have, at that level, a more sensitive device for assaying levels of contamination too low to be detected with the portable AN/PDR-27.

In view of these considerations, it was natural to attempt to compare the sensitivity of the AN/PDR-27 with that of the laboratory type equipment under field conditions.

A. RELATIVE GAMMA SENSITIVITY

A Co^{60} gamma source, disc shaped and covered with lead to screen out the .306 MEV beta gave a reading of .45-B.G. = .40 mr/hr on the 27. The same source gave a count rate of 1918 cpm in the lead pig using the laboratory equipment. The natural background for the lab equipment was 15 cpm at this time. So we see that the same source gave

$\frac{1918}{15}$ = 128 x natural B.G. on the lab equipment

and $\frac{.40}{.05}$ = 8 x natural B.G. on the AN/PDR-27

(1) USNRDL-TR-182 NS 083-001, Teresi & Newcombe Aug. 57

B. RELATIVE BETA SENSITIVITY

With fission products, it is likely that the laboratory equipment would be used to detect beta rather than gamma. A beta source was available in the form of a piece of purified uranium which is a beta emitter because it is in equilibrium with two beta emitting daughter products, UX_1 (Thorium) and UX_2 (Proactinium). The source was covered by one layer of scotch tape to screen out the uranium alpha. The absolute beta calibration on this source was done at Los Alamos Laboratories on a flow counter and gave a value of 8400 cpm. This value was verified on the Nuclear Medicine Research Detachment, Europe flow counter at Landstuhl Army Medical Center, Germany. This source gave a count of 3235 cpm in the laboratory equipment at FTX Downwind and a reading of .40 - BG = .35 "mr/hr" on the AN/PDR-27. The counter background on this day was 21 cpm. In terms of their background the sensitivities of the two systems with respect to beta emitters is therefore

$\frac{3235 \text{ cpm}}{21 \text{ cpm}} = 154 \times$ BG for the lab equipment and

$\frac{.35 \text{ "mr/hr"}}{.05 \text{ "mr/hr"}} = 7 \times$ BG for the AN/PDR-27

and the lab equipment is $\frac{154}{7} = 22 \times$ as sensitive as the portable equipment.

III. THE HIGH GAMMA BACKGROUND PROBLEM

In all of the foregoing it was assumed that one had only the natural background of .05 mr/hr or 21 cpm. In the event of any serious conflict it is enevitable that the gamma background all over the theatre would be elevated. This would have an important and unfortunate effect on the capability of the AN/PDR-27. Suppose for instance, that the ambient background was .10 mr/hr instead of being able to approve water for periods up to 30 days one would be limited to only 15 days. With a background of 5.0 mr/hr*, which is quite possible, the AN/PDR-27 would be of little value. The only practical answer for this problem at the moment is to find a sheltered place in which to use the 27. By under-cutting a foxhole or in a basement, protection factors of 1000 or 10,000 can be achieved. This should take care of most gamma background problems.

Since the lead pig provides two inches of lead shielding for the laboratory type counter this apparatus may be less sensitive to rises in background. The set-up used to investigate this involved placing the 27 probe and the lead pig side by side and equidistant from the 9.9 radium source. By varying the distance the data of Table I were obtained.

*

There is in existence an adaption kit which enables one to hook the third scale (50 mr/hr) to the probe tube.

Table I Response Of The Two Systems
To A Rising Gamma Background

Distance Source To Detectors In cm	Calculated mr/hr	mr/hr read On AN/PDR-27	cpm on Lab Equipment
91.2	10	15	2397
64.4	20	20	4600
52.5	30	30	7074
45.6	40	37	7375
40.8	50	48	8833
28.5	100	150	18305
Estimated		500	19200

Plotting this data (Fig I) shows a linear relationship between mr/hr measured with an AN/PDR-27 and cpm on the laboratory counter up to about 18000 cpm after which the mechanical register begins to jam. The slope of the line in Fig I indicates that a one mr/hr increase in gamma background gives an additional 188 cpm. Doubling the natural background from .05 mr/hr to .10 mr/hr would give an additional $\frac{188}{20}$ 9.4 cpm and it would require an increase of .08 mr/hr to double the normal counter background of 15 to 20 cpm. These data lead to the curves of Fig 2 which show the manner in which background gamma interferes with sample measurement.

IV. DISCUSSION

The many short comings in these measurements are recognized. Most importantly is the fact that radium gamma rays, Co^{60} gamma, fission product beta and gamma, uranium beta, and natural background radiations all have different spectra. In spite of this difficulty it is still felt that the measurements have some value and do indicate the relative capabilities of the portable vs the laboratory type equipment.

V. CONCLUSIONS

Conventional laboratory counting equipment may be used in a field laboratory without modification and its sensitively is such that can measure either heavily or lightly contaminated water in a manner satisfactory for both long and short range military objectives.

VI. RECOMMENDATIONS.

1. In view of the exploratory nature of the present effort it is recommended that the procudure be repeated at the next field exercise.

2. Fission product samples should be available soon from Oak Ridge and these should be used whenever possible.

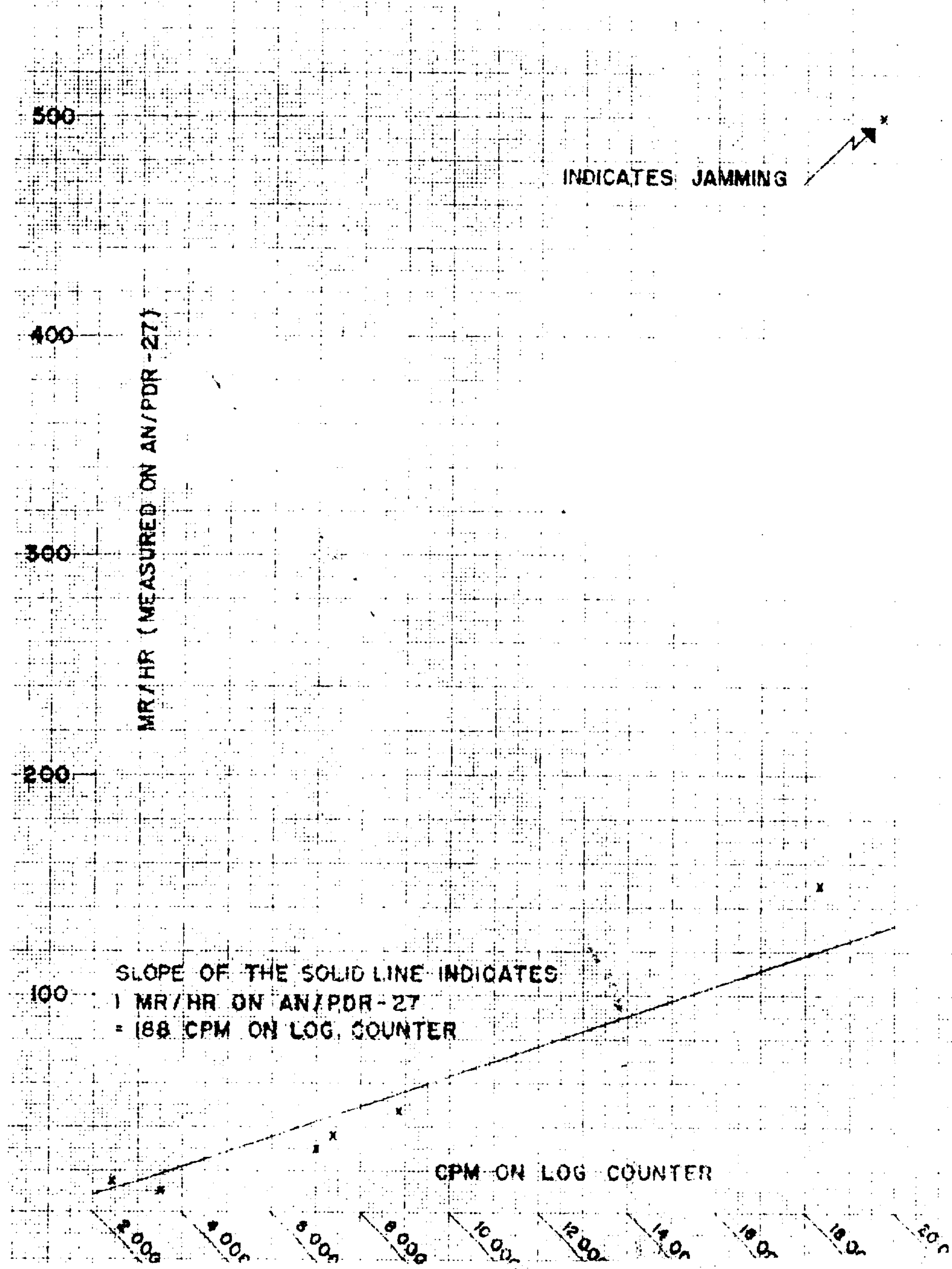
3. An effort should be made to measure the age of the contaminant by means of absorption and decay studies. Ultimately a simple gamma spectrometer is desireable because one cannot establish an allowable consumption period unless the age of the fission products can be established.

4. It is unlikely that additional shielding will be needed for the laboratory equipment but shielding of the AN/PDR-27 in the field digging it in should be studied if possible.

Donald H. Behrens for
JAMES T. BRENNAN, LT COL, MC
CHARLES E. CONER, CAPT, MSC

2 Incl.
1. CPM vs Rise In Gamma Background
2. Effect of High Gamma Background on Sensitivity

FIG. I CPM VS RISE IN GAMMA BACKGROUND



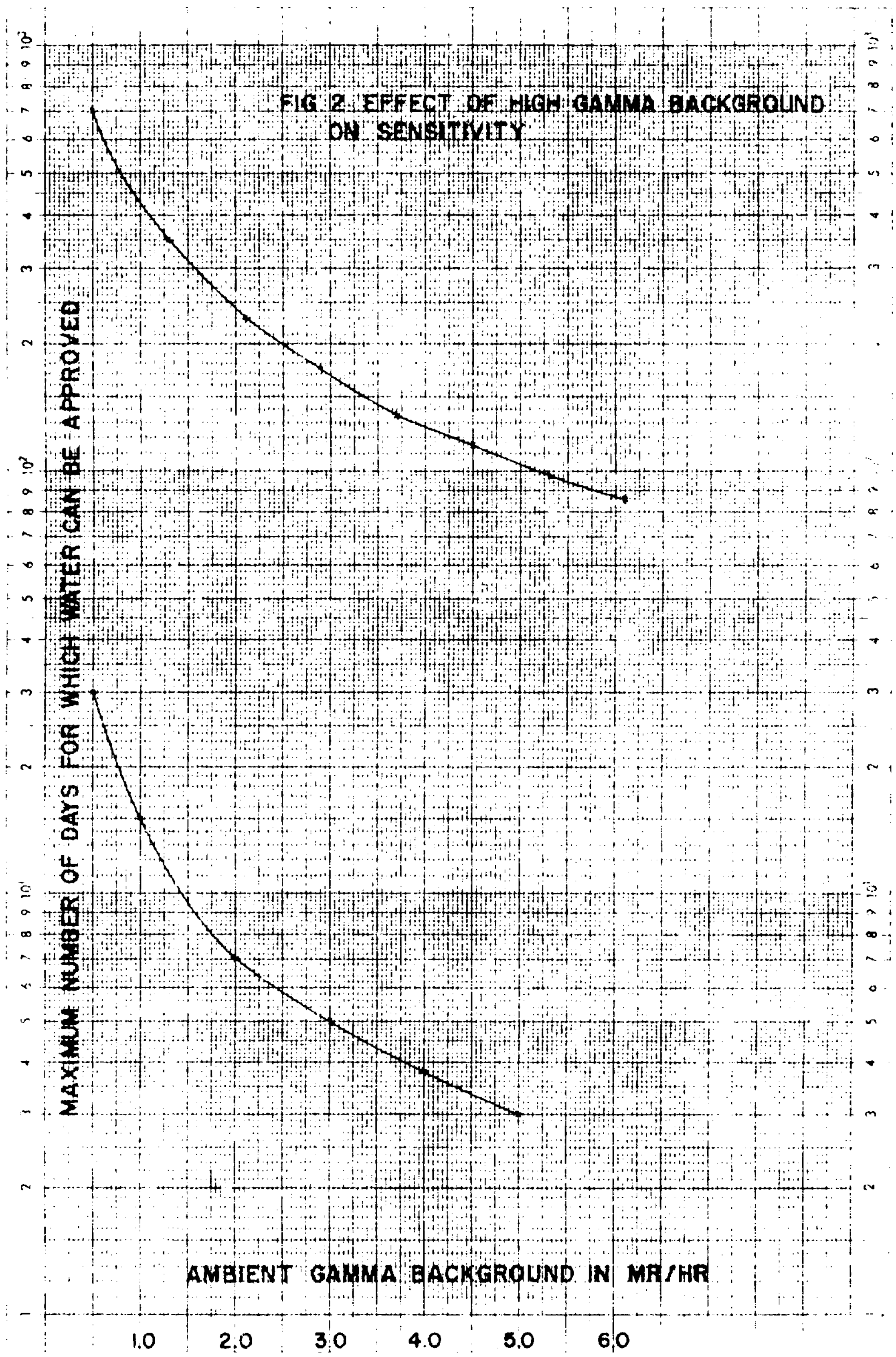


FIG 2 EFFECT OF HIGH GAMMA BACKGROUND ON SENSITIVITY
MAXIMUM NUMBER OF DAYS FOR WHICH WATER CAN BE APPROVED
AMBIENT GAMMA BACKGROUND IN MR/HR
1.0
2.0
3.0
4.0
5.0
6.0