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HANFORD ATOMIC PRODUCTS OPERATION – RICHLAND, WASHINGTON

DOCUMENT NO.

HW-SA-2612

COPY NO. [redacted]

DATE

5-25-62

ISSUING FILE

TITLE

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54-3000-030 (9-56)

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GWM - Health Issues
3.19.90 (DD-PP)

Acc# 989
8490

HW-SA-2612

DETERMINATION OF LOW LEVEL I^{131} IN HUMAN THYROIDS RESULTING FROM NUCLEAR TEST FALLOUT

H. E. Palmer and F. Swanberg, Jr.

A 3" x 3" NaI scintillation counter was found to be capable of detecting as low as approximately 17 pc of I-131 in the human thyroid. Following U.S.S.R. tests in the Fall of 1961, I-131 was detected in subjects who regularly drank fresh milk. The body burdens were 18-150 pc.

Development of Counting Method

Much work has been done on measuring the amount of I^{131} in the thyroid gland after administration of the radionuclide to subjects for diagnostic and therapeutic purposes.(3) Far less work has been done on measuring very small amounts of I^{131} in the thyroid. Burch(4) measured nanocurie (nc) amounts (10^{-9} curies) in residents in the vicinity of Windscale following the reactor accident there and Comar, et.al.(5) measured I^{131} in the thyroid originating from fallout of weapons debris.

A study was made to find a sensitive detector and calibrate it for measuring picocurie (10^{-6} μc) quantities of I^{131} in the thyroid gland. A small pressed-wood neck phantom was made for measuring the relative sensitivities of different detectors. Ten nanocuries of I^{131} were placed at the thyroid position in the neck phantom. The source and the phantom were then counted using each of five different detectors. The background at the neck of a subject was measured with each detector. The detectors tried were:

1. A 3" x 3" NaI(Tl) crystal positioned directly in front and in contact with the neck at the position of the thyroid lobes.
2. Two 2" x 2" NaI(Tl) crystals, each centered over a lobe of the thyroid and in contact with the neck.
3. Two 3" x 3" NaI(Tl) crystals, each centered over a lobe of the thyroid and in contact with the neck.

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4. Two 1/4" x 2-1/2" NaI(Tl) crystals, each centered over a lobe of the thyroid and in contact with the neck.

5. A 4" x 9-3/8" crystal located directly in front and as close to the neck as possible and centered opposite the thyroid lobes.

The results of these trials are listed in Table I.

Table I

SENSITIVITY OF SEVERAL DETECTORS FOR COUNTING I^{131} IN THE THYROID

Detector No.	Counts Per 5 Min. From Source In Neck Phantom	Background Count Per 5 Min. At The Neck Of A Subject	Minimum Detectable Amount For 5 Min.*
1	11,390	181	15 pc
2	13,274	172	17 pc
3	28,822	362	13 pc
4	5,478	40	23 pc
5	75,884	1,388	9.8 pc

* The minimum detectable amounts were calculated from the equation:

$$MDA = \frac{K}{C} \sqrt{B}$$

where K = probability constant, taken to be 1

C = counts per picocurie in the counting time

B = background count in the counting time

The MDA values listed are figure of merit values rather than actual values since the conditions around the source are not exactly the same as that of a human thyroid. Detector No. 5 gives the lowest MDA using the neck phantom. In counting a subject the MDA will not be as low. The 9-3/8" diameter crystal cannot be placed sufficiently close to the thyroid because it touches the chin or chest first. The 3" x 3" or 2" x 2" detectors yield the best practical MDA. We thought that the 1/4" x 2-1/2" crystals would give the best sensitivity since they would absorb most of the I^{131} gamma rays, but would count less background because of their reduced thickness. The resolution of these detectors was half as good as the 2" x 2" and 3" x 3" detectors, however, and the smaller thickness resulted in fewer of the counts in the photopeak. These two factors greatly reduce the sensitivity of the thin crystals.

Two sources of near background activity were placed over the two lobes of the thyroid of a subject. The subject was counted with detectors 2, 3, 4 and 5. Figure 1 shows how the 0.36 mev peak is visible above the background of the subject. The peaks of Cs^{137}, Zn^{65}, and K^{40} are also present. The results confirm the previous experiment showing detectors 2 and 3 give the best sensitivity, detector 5 is less sensitive, and detector 4 is so insensitive the peak is not visible.

The single 3" x 3" crystal was selected as the detector for use. The arrangement of two 3" x 3" crystals is only slightly more sensitive and is much more trouble to set up geometrically and electrically, for routine counting. The detector was calibrated using an Alderson Research Laboratory Remab phantom. The phantom was filled with water and the two lobes of the thyroid built into the neck were filled with a calibrated solution of I^{131}. The thyroid I^{131} was then measured with the detector directly in front of and in contact with the neck to obtain a calibration factor. This factor was 3.72 counts per 30 minutes per picocurie in the thyroid gland. With the detector very close to the thyroid some errors will occur due to the difference in the size, shape and location of the thyroid glands in people. To get the maximum sensitivity it is necessary to position the detector as close as possible to the thyroid gland. The difference observed in measuring I^{131} in the thyroid gland of the Remab phantom with the thyroid one third full compared to the gland completely full was less than 3%. This indicates a small effect of different gland sizes and shapes on the measurement of I^{131} in man.

Detection of I^{131} in Residents of the Northwest

In the Fall of 1961, the fallout debris from the U.S.S.R. weapons tests caused the I^{131} content in milk to rise. During October, 1961 the concentration of I^{131} in a sample of milk produced in a Washington coastal area was reported as 840 picocuries per liter(6). Shortly after this the cold weather began, and cows were taken off pasture and were fed stored hay. The I^{131} content in milk dropped to an almost undetectable level by early December.

Attempts to measure I^{131} taken up from fallout of weapons debris in the thyroid of subjects did not begin until November. At that time I^{131} was detected in all subjects who regularly drank fresh milk and it could not be detected in subjects who did not drink milk or who drank reconstituted dry milk. The thyroid burdens ranged from 18 to 150 picocuries. Table II lists the results obtained from examination of 11 subjects.

Table II

DETERMINATION OF I^{131} IN SEVERAL SUBJECTS

Subject	Amount of Milk Consumed Per Day	pc I^{131} In Thyroid
1	None	Not Detectable
2	1 quart	75
3	1 quart	138
4	3 glasses	135
5	1 quart	54
6	1 quart	63
7	None	Not Detectable
8	1 quart	18
9	None	Not Detectable
10	2 glasses non-fat milk	Not Detectable
11	None	Not Detectable

One subject who did not drink milk and in whom I^{131} could not be detected began drinking one quart of milk per day. This milk was purchased from local commercial supplies, but was produced in the Washington coastal area and was known to have higher than the local average I^{131} content. Table III shows the amounts of I^{131} detected in the thyroid of this subject.

Table III

I^{131} INCREASE IN THE THYROID DUE TO CONSUMPTION OF ONE QUART OF MILK PER DAY

Time Interval After Beginning Milk Diet	pc I^{131} Detected In The Thyroid	Remarks
0	Not Detectable	
2 hours	24	
20 hours	54	
4 days	108	
6 days	99	Stopped drinking milk after five days
12 days	69	
15 days	27	
18 days	18	
26 days	Not Detectable	

The milk drunk on the first day was analyzed and found to contain 80 picocuries per quart. Milk on succeeding days was not analyzed, but it appears that the I^{131} content was probably lower. The gamma spectrum of the subject's neck on three days during the experiment is shown in Figure 2. The background has not been subtracted from these spectra. Several other subjects drank the same brand of milk at the rate of one quart per day. The results observed were similar to the ones described. After December 15, the I^{131} concentration in milk was so low that it could not be detected in residents of the local area.

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The detection limit of the method described is about 17 picocuries. This was calculated assuming an average background of 1000 counts per 30 minutes over the energy range of 0.33 to 0.39 mev for a subject containing no I^{131}. Using a probability constant of 2, the minimum detectable amount is

$$\text{MDA} = \frac{2}{3.72 \text{ count/pc}} \sqrt{1000 \text{ bkg. counts}} = 17 \text{ pc}$$

This value is reasonable in the opinion of the operators of the counter.

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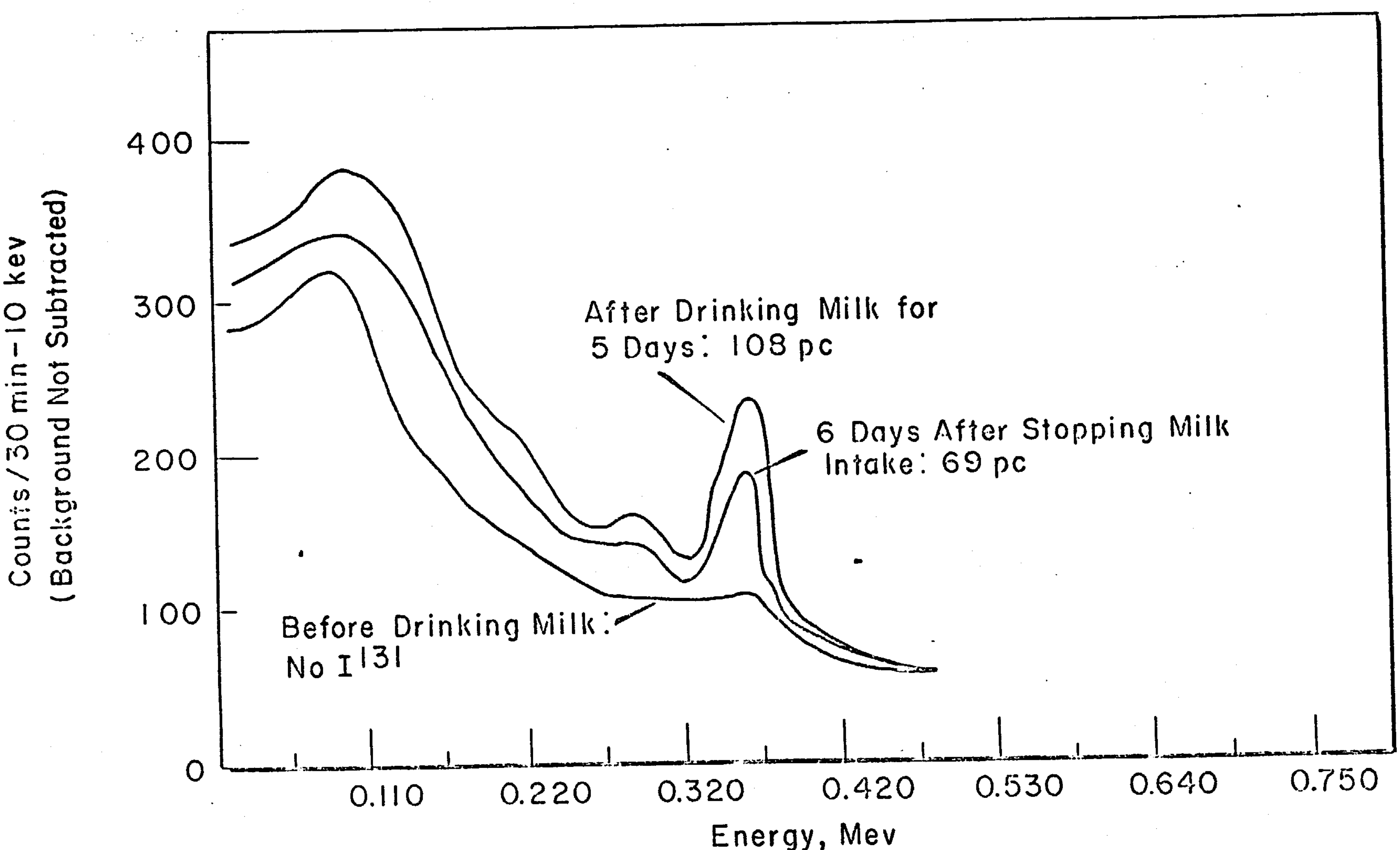
DIFFERENCES OF I^{131} IN THE THYROID DUE TO CHANGES IN MILK INTAKE



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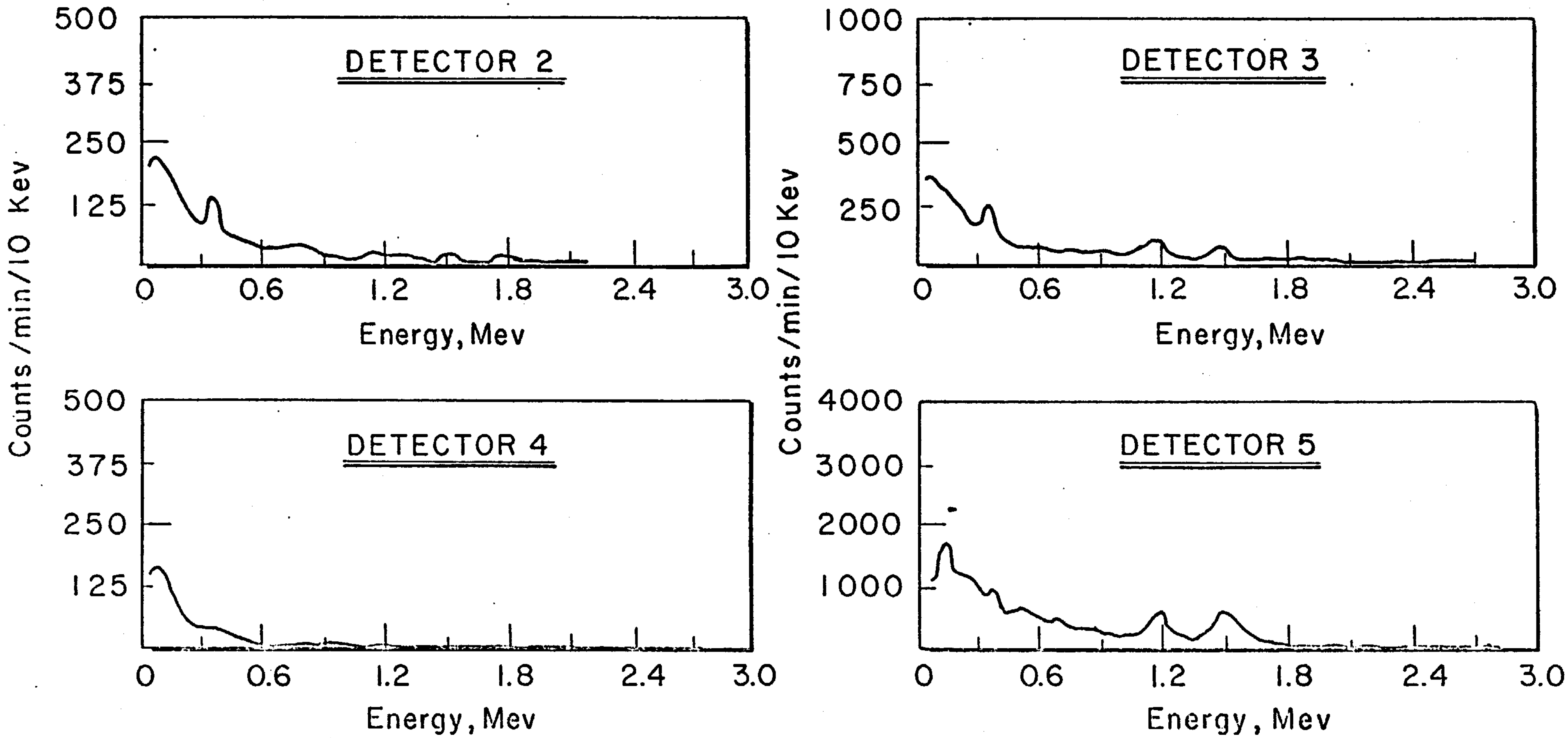
TESTS OF I^{131} COUNTERS



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