File / Fallout

# Observed Relations Between the Depositon Level of Fresh Fission Products from Nevada Tests and the Resulting Levels of I-131 in Fresh Milk

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## CONCLUSIONS

1. Measurements made during the summer of 1962 indicate that fallout from Nevada tests gives rise to levels of I-131 in fresh milk in the range of (25,000 $r_o$) to (100,000 $r_o$) $\mu\mu c$/liter, where $r_o$ is the open field, external gamma dose rate 24 hours following detonation, expressed in milliroentgens/hour. Milk levels reach this maximum value 4 days following deposition, and thereafter decrease exponentially with a typical half life of between 4 and 5.5 days. Daily consumption of 1 liter of this milk per day will lead to an infant thyroid dose of between 3.6 $r_o$ and 18 $r_o$ rads, on the further assumption of a 2 gram thyroid and 30% uptake of ingested I-131 by the thyroid gland.

2. There is evidence that the levels of I-131 in milk reached 200,000 $\mu\mu c$/liter, and perhaps 2 - 4 times higher, in limited rural areas east of Salt Lake City following fallout from Small Boy, although the highest measured level of I-131 in milk sampled by the Off-Site Radiological Safety Organization was 9,000 $\mu\mu c$/liter. There is also evidence that following the Des Moines and Sedan shots the monitoring of milk from family cows in isolated locations in the path of the fallout cloud was not accomplished soon enough or in sufficient locations to detect milk levels in the range of 10,000 to 100,000 $\mu\mu c$/liter.

3. Earlier test series frequently give rise to fallout levels on the order of 10 times those which were measured outside the test site area following Des Moines, Sedan, and Small Boy. If the conversion factors given in 1. above apply to the fallout from earlier series, then it follows that correspondingly higher levels of I-131 must have occurred in milk. For

example, subsequent to the firing of the 32 kt. HARRY shot on a 300 foot tower on May 19, 1953, an open field dose rate of 16 mr/hr. at H + 36 hours ($r_0$ = 27 mr/hr.) was noted in the St. George, Utah milkshed 125 miles from ground zero.[1/] Using the conversion factors derived from the 1962 tests leads to the conclusion that milk in the St. George area reached values in the range of from 675,000 to 2,700,000 μμc/liter, with associated doses to an infant thyroid in the range of from 76 to 380 rads.

1/ See pages 126, 157, 158 of WT-817, Biological Safety, Operation UPSHOT-KNOTHOLE.

1. A simple but useful measure of the amount of radioactive fallout from a nuclear test at the Nevada Test Site which is deposited on a given ranch or community within a few hundred miles of the point of detonation is the air ionization rate 3 feet above the ground at 24 hours following detonation. This quantity, herein expressed in milliroentgens/hour and designated by the symbol $r_o$, is also referred to as the open field dose rate at H + 24 hours.

The choice of 24 hours in the definition of $r_o$ is arbitrary. However the definition excludes the contribution to the open field dose rate due to airborne activity in the passing cloud of radioactive dust. This cloud frequently gives rise to a transient dose rate which is an order of magnitude greater than the dose rate at that time would have been due to the debris deposited at the given location by the time cloud passage is complete.

If the measurement of the open field dose rate has not been made exactly at 24 hours, the 24 hour rate, $r_o$, can be estimated by extrapolating to 24 hours along the decay curve obtained from a series of measurements at times before or after 24 hours, provided it is possible to separate out any transient effects due to cloud passage. If only a single measure of the dose rate is available, if it has been taken at a time when cloud passage is complete, and if the time of detonation is known, an estimate of the H + 24 hour dose rate may be made by assuming the dose rate follows a $t^{-1.2}$ fission product decay law.

The accuracy with which $r_0$ may be used as an indication of the unit area deposition of the fission product I-131 (half life 8 days) depends on the extent to which this nuclide is fractionated from the other gamma emitting fission products. There is some theoretical evidence, not considered here, that those fallout particles which come to earth from Nevada tests between 6 and 36 hours following detonation are largely in the size range of 20 - 50 microns diameter, and not severely fractionated with respect to I-131. For unfractionated fission products, an H + 24 hour open field dose rate of 1 mr/hr corresponds to a unit area I-131 deposition of about 100 $\mu\mu c/cm^2$. Based on the Windscale reactor accident in England in 1957, Garner has estimated that under the worst conditions of British agriculture, 100 $\mu\mu c$ I-131/$cm^2$ would lead to I-131 levels in milk of 160,000 $\mu\mu c$/liter.

2. Under field monitoring conditions around the Nevada Test Site, the lowest open field dose rate which can be readily distinguished from natural background radiation is about 0.01 mr/hr. Natural background radiation in the area around the test site averages about 0.025 mr/hr (220 mr/year).

3. Available evidence suggests a single deposition of fresh fission products on pasturage causes I-131 levels in milk to rise to a maximum value at arrival time + 4 days, although by the end of the first day the milk is already 70% or so of its maximum value. After 4 days the data indicate that levels of I-131 in milk decrease exponentially with a half life of about 5 days. Half lives varying between 3.2 and 6 days were observed from the limited data available.

4. The thyroid dose from I-131 to a person consuming L liters of fresh milk every day from dairy cows grazing on a pasture which has been contaminated with fresh fission products may be approximated by the expression

thyroid dose = $(1.71 \times 10^{-4}) \frac{L\,T\,f\,I_o}{M}$ rads, where

T is the half reduction time of the I-131 in milk in days,

f is the fraction of ingested iodine reaching the thyroid, (here taken as 0.3)

M is the mass of the thyroid in grams, and

$I_o$ is a reference hypothetical initial level of I-131 in milk, expressed in µµc/L, and obtained by extrapolating back to arrival time + 2 days the exponential function describing the decrease of I-131 in milk for times greater than arrival + 4 days.

Note: If $I_{max}$ is the maximum level of I-131 in milk and occurs at arrival + 4 days, then a half reduction time of 5 days implies that $I_{max} = I_o\, e^{-\frac{\ln 2}{5} \times 2} = .75\, I_o$.

5. When fresh fission products from a nuclear test are deposited on pasturage, many different factors help determine the ratios $\frac{I_{max}}{r_o}$ and $\frac{I_o}{r_o}$. These include the design of the weapon, the conditions under which it is detonated, the physical and chemical form of the fallout particles, the degree to which the debris is fractionated, whether deposition takes place with or without precipitation, the type of herbage, the season of the year, the number of cattle per acre, and the amount of supplemental feed. For the locations at which measurements of both I-131 levels in milk and external gamma dose rates were available subsequent to fallout from the Small Boy and Sedan shots, the best estimates of the ratios $\frac{I_{max}}{r_o}$ and $\frac{I_o}{r_o}$ and of T and the rad dose to infants who daily consumed fresh milk from cows grazing on the contaminated pasture were:1/

1/ The units of $I_{max}$ and $I_o$ are µµc I-131/liter; the units or $r_o$ are mr/hr at 24 hours.

## Small Boy

| Location | $\frac{I_{max}}{r_o}$ | $\frac{I_o}{r_o}$ | T (days) | Rad Dose to 2 Gram Thyroid Assuming 1 liter/day Intake and 30% Uptake of I-131 by Thyroid Gland |
|---|---|---|---|---|
| Alamo, Nevada | 25,000 | 32,600 | 5.3 | .4 |
| Caliente, Nevada | 92,600 | 125,000 | 4.5 | 1.2 |
| Kamas, Utah | 53,000 | 67,000 | 5.5 | 1.4 |
| Oakley, Utah | 59,000 | 73,000 | 5.3 | 1.5 |
| Snyderville, Utah | 67,000 | 93,000 | 4.0 | 1.4 |

## Sedan

| Location | $\frac{I_{max}}{r_o}$ | $\frac{I_o}{r_o}$ | T (days) | Rad Dose to 2 Gram Thyroid Assuming 1 liter/day Intake and 20% Uptake of I-131 by Thyroid Gland |
|---|---|---|---|---|
| Twin Springs Ranch | 38,000 | 22,000 | 6.0 | 3.2 |
| Blue Eagle Ranch | 18,200 | 50,000 | 5.0 (est.) | 1.8 |
| Georgetown Ranch | 120,000 | 183,000 | 3.2 | 6.0 |

On the whole, the data from the Small Boy shot were more reliable than those obtained for Sedan. If one uses the limiting values of $\frac{I_{max}}{r_o}$ and $\frac{I_o}{r_o}$ obtained from Small Boy as the best available estimate of the range of values in which those ratios are likely to fall, and assumes limiting value of T of 4 and 5.5 days, it follows that an external gamma dose rate of $r_o$ mr/hr at H + 24 hours in off-site locations around the Nevada Test Site can be estimated to be associated with I-131 levels in milk of between 25,000 $r_o$ and 92,600 $r_o$ μμc/liter, and to a thyroid dose from I-131 for a child with a 2 gram thyroid who consumes 1 liter of fresh milk per day of between 3.6 $r_o$ and 16.9 $r_o$ rads.

6. There is evidence that actual milk levels as high as 200,000 μμc/liter, and perhaps 2 - 4 times higher, occurred in limited rural areas east of Salt Lake City following fallout from the Small Boy shot. On the basis of 5. above, and $I_{max}$ of 200,000 μμc/liter may be associated with an infant thyroid dose from I-131 of 34 rads, assuming a 2 gram thyroid, 30% I-131 uptake by the thyroid, the consumption of 1 liter of fresh milk per day, and a half life for I-131 in the milk supply of 5 days.

7. The H + 24 hour gamma dose rates measured following the Des Moines and Sedan shots indicates the montioring of milk for I-131 was not accomplished soon enough or in sufficient locations to detect levels of I-131 in the range of 10,000 to 100,000 μμc/liter in milk from family cows at isolated locations in the path of the fallout cloud. (See Table V). From the results presented above it may be calculated that this amount of fallout can be associated with a thyroid dose to 1 year old child from internal I-131 of (.44) (3.6 rads - 16.9 rads), or 1.6 rads - 7.4 rads. On this basis the thyroid dose to a child from internal I-131 can be on the order of 50 to 250 times the thyroid (and whole body) dose to the child from external gamma radiation.

8. It is of interest to make a rough comparison of the dose to an infant thyroid due to external gamma radiation from fresh fission products deposited on the ground with the dose to the thyroid from I-131 obtained from the consumption of fresh milk from cows grazing in the contaminated area. Suppose, for example, that fallout arrrives at about 12 hours and is deposited in sufficient quantity to produce as external gamma dose rate at that time from deposited debris of 1 mr/hr ($r_o$ = .44 mr/hr). Then the infinite plane infinity dose from external gamma radiation will be about 5 X 12 X 1 = 60 mr,1/ and the average dose to people, including the effect of cloud passage will be about 30 mr.

9. The presence of I-131 in fresh milk is a most sensitive indication of the presence of new fission products. After the external gamma dose rate due to fresh fission products has fallen below 0.01 mr/hr, it is not feasible under field monitoring conditions to separate the dose rate due to fission products from that due to natural background radiation. However a dose rate of 0.01 mr/hr at H + 4 days can correspond to levels of I-131 in milk in the range of 1000 - 5000 μμc I-131. Such levels are in the range of 50 to 250 times the minimum levels of I-131 detectable by the standard milk analysis procedures of the Public Health Service.

1/ If the dose rate $r(t) = r_o t^{-1.2}$, then $\int_t^{\infty} r(t)dt = 5 r_o t^{-.2}$
$= r t r (t)$.

## Recommendations

1. That plans for further tests at Nevada include the regular use of airborne radiological survey flights to locate hot spots such as the one which developed unexpectedly east of Salt Lake City following the atmospheric Small Boy shot, or which might result from an unexpected venting such as occurred following the Des Moines shot.

2. That monitors assigned to collect milk samples from dairys or from family cows which are located in the path of the fallout cloud be equipped with one of the currently available portable instruments for speedy detection of I-131 in milk at levels in the range of 10,00 to 100,000 μμc/liter.

3. Then an inventory be made of all family cows and dairy herds within 150 miles of the test site, and that procedures be developed for the rapid location of family cows and dairy herds in areas within 500 miles of the test site where hot spots similar to the one which developed east of Salt Lake City following Small Boy may unexpectedly occur.

4. That at least until better information becomes available, whenever the regular monitoring results at the end of the first day (or subsequent days) indicate that the H + 24 hour open field dose rate exceeds 0.2 mr/hr, in locations where dairy herds or family cows are grazing,

(a) the owners be advised that the I-131 content of their milk may reach levels of 5,000 to 20,000 μμc/L,

(b) That milk samples be collected at least every other day starting not later than H + 4 days.

(c) That the open field dose rate in the contaminated pasture area be monitored at least once a day for the 2nd, 3rd, 4th day following deposition, and at least once a week thereafter for as long as it may be measurable.

(d) That a herbage sample be collected from the grazing area at some time during the first 4 days following deposition, and that the sample weight, and type, and collection procedure be carefully described and standardized.

(e) That at each station where milk is monitored, the monitor record:

1. the number of cows on pasture and milking;
2. a description of the pasture (newly mown, type of grass):
3. the weather conditions at the time of deposition and for two weeks thereafter:
4. the amount and type of supplemental food, if any,
5. the names and ages of persons who consume <u>fresh</u> milk from the pasture, and any information they are willing to provide on their daily consumption of milk.

(f) That the water supply of the cattle be sampled for I-131 at the same time the milk is sampled.

(g) That any fallout collection trays placed in the area be placed, if possible, in such a way as to measure the amount of debris deposited on the pasture.

(b) the rate and mechanism by which I-131 is removed from the herbage by wind, rain, or sublimation,

(c) the amount of fresh milk and related dairy products consumed by rural residents of different ages, particularly infants and very young children,

(d) The relative I-131 content of the milk of cattle and goats grazing in the same area, and the amount, if any, of goat's milk and cheese consumed by rural residents in the off-site area.

(e) the potential daily intake of I-131 by rural residents from the consumption of fresh fruits and vegetables, drinking water, and fresh eggs following a single deposition of nuclear test fallout. The Casey ranch (formerly the Bordoli ranch) has a large family garden in addition to a family cow, and would be a particularly good location to study in detail.

(f) the fractionation of I-131 with respect to $Sr^{95}$, in fallout from the Nevada Test Site, and its dependence on detonation conditions and particle size.

6. That sufficient study be done to determine, for typical situations and locations the relative contributions to the total open field external gamma dose of the airborne activity in the passing cloud, and of material actually deposited on the ground in the vicinity of the location where the dose rate is measured.

It may be noted that much of the data now reported by the Off-Site

Radiological Safety Organization would be of considerable research value to other investigators except for the fact that it is not reported in sufficient detail just where or under what conditions a dose rate reading was reported (e.g. beside the road, or in an adjoining field, or whether the hand monitoring results or those of the automatic recorders are likely to be most accurate), or whether the estimated integral of the dose rate readings or the results of a film badge give the best indication of the open field dose in a given area, or just what a sample of herbage looks like, and whether or not the samples collected are sufficiently standardized to attempt to correlate them with milk and gamma levels. There are, in addition, some data reported which do not appear consistent. For example, on pages 29 and 30 of the interim report of the Small Boy event (5) it is indicated that at time of collection (7 hrs 32 min - 24 hrs 40 min) the net gross beta activity of a 440 cubic meter sample of air at the Alko Cafe was 900 $\mu\mu c/meter^3$. The contribution of a limited number of individual nuclides was as follows:

| I-131 | Te-132 | Ba-140 - La-140 | Ru-103 | Zr-95 | TOTAL |
|---|---|---|---|---|---|
| 230 | 470 | 150 | 98 | 26 | 974 |

The theoretical contribution of I-131 to the total beta activity in unfractionated debris between 6 hrs and 24 hrs increase from about 0.20% to about 1.0%. Thus it is difficult to understand either the fact that the reported activity of some of the components of the fallout exceeds the total, or that the I-131 should be indicated as constituting 26% of the total activity. There may be a simple explanation of this apparent discrepancy, but unless and until such things are clarified the great potential application the data as reported for a variety of unsolved problems is thrown in doubt.

There is also a need to compare and calibrate the various dose rate measuring instruments used to monitor fallout. There were some discrepancies between the readings of the automatic recorder and the readings taken with hand-held instruments at the Alko Cafe following Small Boy, and there appears to be possible systematic differences by a factor of 2 and 3 between the measurements of dose rate reported by Larson et al (8), (13), and those reported by the Off-Site Radiological Safety Organization.

The contribution of university scientists to measurements of milk and fallout levels -- e.g. those of Dr. Robert Pendleton at the University of Utah -- would be more useful if it were possible to give the scientists greater advance notice of impending shots, and to give them an opportunity to calibrate their instruments in advance against the same standards used by the Public Health Service monitoring organizations.