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EXPLOSIVES DEPARTMENT--TNX

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By Authority of

*CG-PR-2*THIS DOCUMENT CONSISTS OF 2 PAGES

To: L. Squires

From: J. L. Dreher

Re: Wind Dilution Required to Reduce to Tolerance Levels the Activity Due to Xenon and Iodine in H.E.W. Dissolver Off-gases

The radio-active xenon and iodine evolved during the dissolution of the uranium at H.E.W. may present a health hazard within certain areas around the base of the stack through which the dissolver off-gases are discharged. Since the concentration of these elements in the uranium metal is directly proportional to the power of the pile* and is related to the decay period of the metal in accordance with their half-lives, the maximum rate of discharge of these elements from the stack at H.E.W. can be estimated from existing Clinton data. The required wind dilution to reduce the discharging activities to tolerance levels can then be calculated. The time with respect to the start of the metal dissolution at which the maximum rates of discharge will be attained can also be roughly estimated from existing Clinton data.

Typical data from the Clinton plant is given in Figure 1, which shows the relation between the rate of discharge of xenon and iodine and elapsed time after start of dissolution. It is estimated that the maximum rate of discharge of xenon at H.E.W., as at Clinton, will be reached within a half hour after start of metal dissolution. However, as indicated by Figure 1 and by Figure 4 and 5, CN-1615, the maximum rate of discharge of iodine is not reached until about the time the acid has been consumed (batch of metal dissolved). Since the calculated rate of dissolution of a Hanford slug (1/2 hour) is approximately 35%** slower than that of a Clinton slug, (because of the increased volume to surface ratio) it is estimated that the time required to reach the maximum rate of iodine discharge at H.E.W. will be about 35% greater than at Clinton. If, however, the dissolution temperature at H.E.W. is higher than that at Clinton (105°C) the maximum rate of iodine discharge will probably be reached sooner than the above estimation indicates.

The effect of the power of the pile and the decay period of the uranium metal on the concentration of xenon and iodine, the maximum rate of discharge of the activities, and the required wind dilution to disperse safely the activities is shown in

* Provided the pile has operated for sufficient length of time (ca. 30 days) for the concentration of these elements to become constant.

** Cf. Appendix B, CN-566.

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Tables 1, 2, and 3, respectively. Sample calculations are shown beneath the tables. The relation between the required wind dilution factors and the age of the metal at various power levels of the pile is graphically shown in Figure 2. The attached nomograph also relates the power of the pile and the age of the metal with the required wind dilution factor. The calculations indicated that the liberation of iodine, because of its lower tolerance level, will present a greater health hazard than the liberation of xenon. Nevertheless, it appears that the iodine tolerance levels will not be exceeded even though the metal has been processed in the pile at 2500 KW/ton and has cooled only 30 days, if the normal wind dilution factor is 1000. In view of the assumptions listed below, however, it will be well to review these calculations when additional data concerning the rate of iodine evolution from the H.E.W. dissolver is available.

The assumptions upon which the above estimations were based are as follows:

- (1) After a pile has operated sufficiently long for the concentration of the xenon and iodine to reach a constant value, the concentration of the elements is in direct proportion to the power of the pile.
- (2) The amounts, in curies, of xenon and iodine at the time of shutdown of a pile is obtained by multiplying the fissions per second by the branching ratio of the element, and dividing by the number of disintegrations per second per curie.
- (3) The rate of liberation of xenon and of iodine is directly proportional to their concentration in the metal. (This assumption is probably correct for xenon, but may well be in considerable error for iodine.)
- (4) The characteristics of the Hanford dissolver approximate those of the Clinton dissolver.

In addition, the following data were used:

Half-life of xenon = 5.3 days
Half-life of iodine = 8.0 days
Branching ratio of Xe = 0.038 (CN-1998)
Branching ratio of I₂ = 0.017 (CN-1998)
Fissions/second/1000 KW = 3.1×10^{16} (CN-1615)
Disintegrations/second/curie = 3.7×10^{10}
Tolerance level for Xe = 5×10^{-11} curies/c.c. (CH-504)
Tolerance level for I₂ = 2.5×10^{-13} curies/c.c. (CE-690)
Maximum rate of discharge of xenon in Clinton dissolver off-gas line = 5.5×10^{-5} curies/cu. ft. (Weekly Clinton TNX Report 8-10-44)
Maximum rate of discharge of iodine in Clinton dissolver off-gas line = 10×10^{-6} curies/cu.ft. (Weekly Clinton TNX Report 8-10-44)
Concentration of xenon in the metal when the above maximum rate was obtained = 2.36 curies/2000 lb. (Weekly Clinton TNX Report 8-10-44)
Concentration of iodine in the metal when the above maximum rate was obtained = 10 curies/2000 lbs. (Weekly Clinton TNX Report 8-10-44)
Rate of Hanford stack gas = 60,000 c.f.m.

J. L. Dreher
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Figure 1

Discharge of Xenon and Iodine into Off-gas Line of Clinton Dissolver
(Runs 176-178 on 7-10 and 7-11-44)

INV.
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(From private communication
J.B. Work to L. Squires.)
(Dotted lines indicate doubtful data)

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TABLE I

Effect of the Power of the Pile and the Decay Period of the
Metal on the Concentration of Xe and I₂ in the Metal

Power of the Pile ($\frac{KW}{ton}$)	1000		2500	
Activity	Xe	I ₂	Xe	I ₂
Decay Period(days)	(curies/ton)	(curies/ton)	(curies/ton)	(curies/ton)
30	625	1100	1560	2750
40	170	460	425	1150
50	46	195	115	490
60	12.5	83	31	210

Sample Calculations:

$$\frac{3.1 \times 10^{16} \times 0.038}{3.7 \times 10^{10}} = 3.2 \times 10^4 \text{ curies of Xe/1000 KW, at shutdown.}$$

$$\frac{3.1 \times 10^{16} \times 0.017}{3.7 \times 10^{10}} = 1.42 \times 10^4 \text{ curies of I}_2\text{/1000 KW, at shutdown.}$$

$$3.2 \times 10^4 \div \frac{1}{2 \frac{30}{5.3}} = 625 \text{ curies of xenon after 30 days decay.}$$

$$1.42 \times 10^4 \div \frac{1}{2 \frac{30}{8}} = 1100 \text{ curies of iodine after 30 days decay.}$$

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TABLE 2

Effect of the Power of the Pile and the Decay Period of the
Metal on the Maximum Discharge Rate of Xenon and Iodine
from H.E.W. Stack

Power of the Pile ($\frac{KW}{ton}$) Activity Decay Period (days)	1000		2500	
	Xe (curies/cu.ft.)	I ₂ (curies/cu.ft.)	Xe (curies/cu.ft.)	I ₂ (curies/cu.ft.)
30	2.2×10^{-5}	1.7×10^{-6}	5.5×10^{-5}	4.3×10^{-6}
40	6.0×10^{-6}	7.2×10^{-7}	1.5×10^{-5}	1.8×10^{-6}
50	1.6×10^{-6}	3.0×10^{-7}	4.0×10^{-6}	7.5×10^{-7}
60	4.4×10^{-7}	1.3×10^{-7}	1.1×10^{-6}	3.2×10^{-7}

Sample Calculations:

$$\frac{625}{2.36} \times \frac{2000}{2200} \times \frac{5.5 \times 10^{-5} \times 100}{60,000} = 2.2 \times 10^{-5} \text{ curies of Xe/cu.ft. of stack gas, 30 days}$$

after shutdown of pile operating at 1000 KW/ton of uranium.

$$\frac{1100}{10} \times \frac{2000}{2200} \times \frac{10 \times 10^{-6} \times 100}{60,000} = 1.7 \times 10^{-6} \text{ curies of I}_2\text{/cu.ft. of stack gas, 30 days}$$

after shutdown of pile operating at 1000 KW/ton of uranium.

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TABLE 3

Effect of the Power of the Pile and the Decay Period of the Metal on the Wind Dilution Required to Disperse Safely the Xenon and Iodine

Power of the Pile (KW/ton)	1000		2500	
Activity				
Decay Period (days)	Xe	I ₂	Xe	I ₂
30	15.5	240	62.5	600
40	4.2	100	10.5	250
50	1.1	43	2.8	110
60	0.3	18	0.8	45

Sample Calculations:

$$\frac{2.2 \times 10^{-5}}{5. \times 10^{-11} \times 2.83 \times 10^4} = 15.5 \text{ required wind dilution for Xe after pile has operated } 1000 \text{ KW/ton and the metal has decayed } 30 \text{ days.}$$

$$\frac{1.7 \times 10^{-6}}{2.5 \times 10^{-13} \times 2.83 \times 10^4} = 240 \text{ required wind dilution for I}_2 \text{ after pile has operated at } 1000 \text{ KW/ton and the metal has decayed } 30 \text{ days.}$$

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Figure 2

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NOMOGRAPH I

Effect of the Power of the Pile and the Age of the Metal on
the Required Wind Dilution Factor for Iodine and Xenon.

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