

NOTICE

**CERTAIN DATA
CONTAINED IN THIS
DOCUMENT MAY BE
DIFFICULT TO READ
IN MICROFICHE
PRODUCTS.**

HANFORD
53011

UNCLASSIFIED



OSTI
INV
89



CLASSIFICATION CANCELLED

██████████ TO UNCLASSIFIED
BY AUTHORITY OF RLO-CG-4
S.E. Gydesen 10/12/87
DATE 11-15-92

Richland, Washington
May 27, 1952

Mr. R. J. Schier
Engineering Department
3703 Building
HANFORD WORKS

THIS DOCUMENT CONSISTS OF 10 PAGES

LIMITS - COOLING WATER CONTAMINATION

The question of maximum permissible levels of fission products or corrosion products in the pile effluent water which you raised* is not a simple problem that can be completely answered by a list of maximum permissible levels. This water is a complex mixture of various isotopes each of which contributes to the total hazard according to the amount present, its particular metabolic features, and its mode of radioactive decay. Unfortunately, also, application of maximum permissible limits determined for consumption by humans may give only a part of the picture since it is necessary to consider also the effect on the ecology of the Columbia River and the ultimate effect on the aquatic life.

With these considerations, we can make estimates of some limits which may be applied in design of new systems with, however, the reservation that practical application may depend on the mixture of isotopes actually encountered in operation.

*R. J. Schier to H. M. Parker. HW-23114, December 28, 1951.



UNCLASSIFIED MASTER

3058 001

I. Present Pile Effluent

The Radiological Sciences Department has endeavored in the last two years to obtain as complete information on the composition of the present effluent as possible. Although many questions, particularly on fission product concentrations, are as yet unanswered, the data in Table 1 present the best estimates available on the composition. These data are based on a decay time of four hours after leaving the unit.

TABLE 1
PRESENT PILE EFFLUENT COMPOSITION

Isotope	Percent	Concentration $\mu\text{c/cc} \times 10^4$
Mn ⁵⁶	24	4.5
Nb ²⁴	15	2.9
Cu ⁶⁴	27	5.0
As ⁷⁶	2.1	0.41
Si ³¹	6.4	1.1
P ³²	0.34	0.063
Rare earths	12	0.21
Cr ⁵¹	0.51	0.1
Ba ¹⁴⁰	0.027	0.005
Sr ⁸⁹	0.004	0.0008
Ca ⁴⁵	0.08	0.011
Mo ⁹⁹	0.2	0.033
Fe ⁵⁹	0.01	0.0019
I ¹³¹	0.04	0.0077

II. Fission Products

The presently available official maximum permissible levels for individual fission products are given in Table 2.

UNCLASSIFIED

TABLE 2
MAXIMUM PERMISSIBLE LEVELS FOR FISSION PRODUCTS IN WATER

Isotope	Critical Organ	MPC µc/cc
Ga72	Bone	9
Sr89	Bone	7 x 10 ⁻⁵
Sr90	Bone	8 x 10 ⁻⁷
Mo99	Bone	14
I-131	Thyroid	3 x 10 ⁻⁵
Xe133	Whole body	4 x 10 ⁻³
Xe135	Whole body	1 x 10 ⁻³
Ba140	Bone	2 x 10 ⁻³

These values are based on the assumption that only the one isotope is present in the water and that radiation is received from no other source. If a mixture of radioisotopes is involved, as in the pile effluent water, the maximum permissible concentration of the mixture is given by:

$$\sum \frac{(MPC)_M (\%)_i}{(MPC)_i} = 100$$

where (MPC)_M is the maximum permissible concentration of the mixture in µc/cc, (MPC)_i is the maximum permissible concentration of the individual isotope in µc/cc and (%)_i is the percentage of the total activity of the solution that is due to the individual isotope. Thus the maximum permissible concentration of any mixture may be obtained by dividing the individual percentage by the individual MPC, summing, and dividing into 100. If, however, radiation is received from other sources this must be factored into the final estimate of the allowable concentration.

UNCLASSIFIED

It is permissible in such a summation to consider those isotopes which have different limiting organs as separate groups thus allowing each organ to receive the maximum permissible dose. This may be of value in borderline cases but will seldom amount to more than a factor of two to three since in most mixtures the limit is set by one or two isotopes. Again in such a method of summation, the metabolic data must be taken into account since most isotopes deposit in several organs and thus contribute radiation to other than the limiting organ.

In the use of these values for pile effluent water, consideration must be given to the other components now present or possibly present in the future. In addition, since these limits are applied to drinking water, consideration must be given to concentrations at locations downstream where the water is to be used. For the latter application, an overall dilution factor of 100 is obtained for the present five piles at minimum river flow of 300,000 gallons per second. Addition of 100 C. and other possible reactors in the future will lower this value to possibly 50. In addition, general recommendations by the Atomic Energy Commission and others indicate that these limits should be decreased by a factor of 10 to 100 for use in locations available to the general populace. Thus any stream of waste discharged to the river should contain an absolute maximum of one to five times the maximum permissible concentration as calculated from Table 2, depending upon the number of piles in operation and the final factors applied to the MPC for general use. If short-lived isotopes are involved, a

UNCLASSIFIED

003 004

consideration of decay between release and first point of use of the water may be profitable.

For practical considerations, the present effluent is between ten and twenty percent of the plant MPC four hours after leaving the basin. Extrapolation to Pasco indicates that the river is four to eight percent of the MPC for general use. In view of the possibility of increased power levels, and the desire of the Hanford plant to remain as far as possible below the maximum permissible concentrations in the public domain, it is recommended that amounts of fission products added to the water should not add more than 20% to the present fraction of MPC. Actual working limits must be calculated from these assumptions and the ratios of fission products present with the various irradiation times.

One such calculation involving the distribution from immediate fission (time of exposure is essentially zero) using the values of Ballou* has been made by estimating the MPC of the individual fission products from available metabolic data and by comparison with accepted MPC's. The values obtained for various times after the fission and the extrapolations of these values to zero time are given in Table 3.

*H. F. Hunter and N. E. Ballou. ADC-65, April 22, 1949.

UNCLASSIFIED

TABLE 3
MPC OF GROSS FISSION PRODUCTS IN WATER AFTER IMMEDIATE FISSION

Time since fission	MPC in water at time t $\mu\text{c}/\text{cc}$	MPC in water at time zero $\mu\text{c}/\text{cc}$
3.5 hr	2×10^{-3}	6
12 hr	1×10^{-3}	10
1 da	6×10^{-4}	15
2 da	5×10^{-4}	25
4 da	4×10^{-4}	50
7 da	3×10^{-4}	80

These values do not contain the factor recommended for environmental concentrations. If it is considered that this distribution of isotopes corresponds to that obtained by recoil fragments, then a limit for such contamination would be $10^{-6} \mu\text{c}/\text{cc}$ at Pasco (12 hours after fission) or $10^{-4} \mu\text{c}/\text{cc}$ 3.5 hours after fission at the time of release from the basin. (Includes 10% of present 10% of MPC for off-plant use at Pasco, a factor of 50 for dilution, and a factor of two for decay during the flow to Pasco). This would allow a release of $0.3 \mu\text{c}/\text{cc}$ to the water at time zero.

This limit is applicable only to the recoil products. A complete evaluation of the distribution of isotopes for various irradiation times is being calculated and should be available for extension of this type of calculation to conditions such as the irradiation of uranium alloys in the near future.

III. Corrosion Elements

An estimate of the amounts of individual isotopes present in the water from the concentrations estimated from corrosion was made under the conditions that the material was irradiated for 200 days before removal.

UNCLASSIFIED

to the water. A total of 42 isotopes with cross-sections for n- γ or n-p reactions were listed. Of these nine included radioactive daughter products. In addition 34 possible n-p reactions leading to the same or different isotopes but with no cross-section data were found. Table 4 lists the isotopes possible from the irradiation of the elements listed as corrosion products along with an estimate of the activity density at an average flux of 10^{13} where cross-sections are available.

UNCLASSIFIED

TABLE 4
POSSIBLE ACTIVE ISOTOPES FROM CORROSION PRODUCTS

Isotope	Half-Life	Parent Element	Estimated Conc. at one hour $\mu\text{c}/\text{cc}$
C ¹⁴	5720Y	C, N	10 ⁻¹²
N ¹⁶	7.35S	N	< 10 ⁻¹⁶
N ²⁴	14.9H	Mg	-
N ²⁵	62.5S	Mg	-
Mg ²⁷	9.58M	Mg	5 x 10 ⁻¹⁴
Al ²⁸	2.30M	Si, Al	9 x 10 ⁻¹⁴
Al ²⁹	6.56M	Si	-
Si ³¹	2.62H	Si	2 x 10 ⁻¹⁰
Si ³⁵	87.1D	Cl	10 ⁻¹⁰
S ³⁷	5.04M	Cl	-
Cl ³⁶	4.4 x 10 ⁵ Y	Cl	10 ⁻¹⁴
Cl ³⁸	38.5M	Cl	2 x 10 ⁻¹¹
K ⁴²	12.44H	Ca	-
K [?]	18M	Ca	-
Ca ⁴⁵	152D	Ca	3 x 10 ⁻¹⁰
Ca ⁴⁷	5.8D	Ca	-
Ca ⁴⁹	8.5M	Ca	-
Sc ⁴⁶	85D	Ti	-
Sc ⁴⁷	3.43D	Ti	-
Sc ⁴⁸	1.83D	Ti	-
Sc ⁴⁹	57M	Ti	-
Ti ⁵¹	6M	Ti	3 x 10 ⁻¹⁰
V ⁵²	3.74M	V, Cr	2 x 10 ⁻⁹
Cr ⁵¹	28.5D	Cr	2 x 10 ⁻⁵
Cr ⁵⁵	1.3H	Cr	3 x 10 ⁻⁹
Mn ⁵⁶	2.59H	Mn, Fe	3 x 10 ⁻⁸
Fe ⁵⁹	46.3D	Fe	3 x 10 ⁻¹¹
Co ⁵⁸	72D	Ni	-
Co ⁶⁰	10.7M	Ni	-
Co ⁶¹	1.75H	Ni	-
Co ⁶²	13.9M	Ni	-
-	1.6M	Ni	-
Co ⁶⁴	4-5M	Ni	-
*Ni ⁵⁹	2 x 10 ⁵ Y	Ni	2 x 10 ⁻¹⁵
Ni ⁶³	85Y	Ni	7 x 10 ⁻¹³
Ni ⁶⁵	2.564H	Ni, Cu	6 x 10 ⁻¹²
Cu ⁶²	9.9M	Cu	-
Cu ⁶⁴	12.88H	Cu, Zn	5 x 10 ⁻⁹
Cu ⁶⁶	4.34M	Cu, Zn	4 x 10 ⁻¹³
Zn ⁶⁵	250D	Zn	3 x 10 ⁻¹⁰
Zn ⁶⁹	13.8H	Zn	4 x 10 ⁻¹⁰
-	52M	-	2 x 10 ⁻¹²
Zn ⁷¹	2.2M	Zn	< 10 ⁻¹⁶
Y ⁹⁰	61H	Zr	-
Y ⁹¹	51M	Zr	-

TABLE 4 (Continued)
 POSSIBLE ACTIVE ISOTOPES FROM CORROSION PRODUCTS

Isotope	Half-Life	Parent Element	Estimated Conc. at one hour $\mu\text{c}/\text{cc}$
	57D	Zr	-
Y ⁹²	3.5H	Zr	-
Y ⁹⁴	16.5M	Zr	-
Zr ⁹³	4 x 10 ⁶ Y	Zr	< 7 x 10 ⁻¹⁴
*Zr ⁹⁵	65D	Zr	2 x 10 ⁻⁷
*Zr ⁹⁷	17.0H	Zr	3 x 10 ⁻⁸
Zr?	6M	Zr	3 x 10 ⁻¹³
Nb ⁹⁴	6.6M	Nb	-
Nb?	21.6H	Nb	-
Mo ⁹³	6.75H	Mo	< 10 ⁻⁹
*Mo ⁹⁹	68.3H	Mo	2 x 10 ⁻⁶
*Mo ¹⁰¹	14.6M	Mo	5 x 10 ⁻⁸
*Sn ¹¹³	33M	Sn	8 x 10 ⁻¹⁵
	112D	Sn	1 x 10 ⁻¹²
Sn ¹¹⁷	14.5D	Sn	8 x 10 ⁻¹³
Sn ¹¹⁹	100D	Sn	7 x 10 ⁻¹³
Sn ¹²¹	27.0	Sn	10 ⁻¹¹
	4000	Sn	< 1 x 10 ⁻¹⁴
Sn ¹²³	39.5M	Sn	5 x 10 ⁻¹³
*Sn ¹²⁵	10.0D	Sn	1 x 10 ⁻¹²
	9.5M	Sn	6 x 10 ⁻¹⁴
Hf ¹⁷⁵	70D	Hf	3 x 10 ⁻⁹
Hf ¹⁷⁹	19S	Hf	-
Hf ¹⁸¹	46D	Hf	3 x 10 ⁻⁹
Ta ¹⁸²	16.4M	Ta	2 x 10 ⁻¹²
	117D	Ta	1 x 10 ⁻⁸
W ¹⁸³	5.5S	W	-
W ¹⁸⁵	73.2D	W	5 x 10 ⁻⁸
*W ¹⁸⁷	24.1H	W	8 x 10 ⁻⁷
*Pb ²⁰⁹	3.32H	Pb	3 x 10 ⁻¹⁴

*Indicates radioactive daughter product.

These concentrations appear lower than would be expected from such products but the values indicate the relative amounts to be expected.

Again, values are not immediately available for the maximum permissible

concentrations of all of these materials in water. Table 5 presents the values given by the National Committee on Radiation Protection. (2)

TABLE 5
MAXIMUM PERMISSIBLE CONCENTRATIONS OF CORROSION PRODUCTS

Isotope	Critical Organ	MPC μc/cc
C ¹⁴	Fat	3 x 10 ⁻³
Na ²⁴	Whole body	8 x 10 ⁻³
P ³²	Bone	2 x 10 ⁻⁴
S ³⁵	Skin	5 x 10 ⁻³
Cl ³⁶	Whole body	2 x 10 ⁻³
K ⁴²	Muscle	1 x 10 ⁻²
Ca ⁴⁵	Bone	5 x 10 ⁻⁴
Cr ⁵¹	Kidneys	0.5
Fe ⁵⁵	Blood	4 x 10 ⁻³
Fe ⁵⁹	Blood	1 x 10 ⁻⁴
Mn ⁵⁶	Kidneys	0.15
Ni ⁵⁹	Liver	0.25
Co ⁶⁰	Liver	2 x 10 ⁻²
Cu ⁶⁴	Liver	8 x 10 ⁻²
Zn ⁶⁵	Bone	6.1 x 10 ⁻²
Ga ⁷²	Bone	9
As ⁷⁶	Kidneys	0.2
Mo ⁹⁹	Bone	14

Again the same considerations as to the use of these values in mixtures as were discussed under the fission products apply. If the concentrations calculated in Table 4 are correct, little difficulty should be encountered with these materials. The values, however, appear low and if past experiences in such calculations is any criterion the actual values will be much higher.

Again the concentrations of these materials should not exceed 10% of the contribution to the radiological hazard already present. In this case, it will be necessary to consider each jacketing and operating condition as a separate problem in the application of limits preferably with actual experimental data on the concentrations expected.

All calculations presented here should be taken as general guides only. As your program advances, more steering information could be developed, if we are kept informed of the direction that your studies take.

J. W. Healy

ENVIRONMENTAL HAZARDS AND GENERAL STUDIES

JWH:L

END

DATE FILMED

12 / 05 / 90