OAK RIDGE Y-12 PLANT INFORMATION CONTROL FORM ChemRisk 7/18 3229

DOCUMENT DESCRIPTION (Completed By Requesting Division)

Document No	Author's Telephone No	Acct. No.	Date of Request
Y-D4-6	6-0263	23366-0002	7/11/96

Unclassified Title: HANDLING OF NORMAL URANIUM METAL

Author(s) Requested by Steve Wiley

TYPE ☐ Formal Report ☐ Informal Report ☐ Progress/Status Report ☐ Co-Op Report ☐ Thesis/Term Paper

☐ Oral Presentation (identify meeting, sponsor, location, date):

☐ Journal Article (Identify Journal):

☒ Other (Specify): To Be Released for Phase II of HSA

Document will be published in proceedings ☑ No ☐ Yes

Document will be distributed at meeting ☑ No ☐ Yes

Document has patent or invention significance ☑ No ☐ Yes (Identify)

Document has been previously released ☑ No ☐ Yes (Reference)

DIVISION REVIEW AND APPROVAL (Completed By Requesting Division)

TECHNICAL CLASSIFICATION REVIEW (Divisional Classification Representative)

Title(s): U Abstract: NA

DOCUMENT: Level U Category –

R J Fraser 7/16/96
Signature Date

DOCUMENT REQUEST APPROVED (Division or Department)

S. W. Wiley 7/11/96
Signature Date

Signature Date

THE REMAINDER OF THIS FORM TO BE COMPLETED BY THE TECHNICAL INFORMATION OFFICE

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Distribution:	UCN-7721B	DOE F-1332.15	Document
Y-12 Central Files	Y-12 RC	Y-12 RC	Y-12 RC
TIO File	L.L. McCauley		
	S.W. Wiley		
	R.M. Keyser		

Distribution Remarks: Unlimited (ChemRisk)

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APPROVAL AND RELEASE

Date Received | Date Initiated 7/11/96

☑ CLASSIFICATIONS:
Title(s): Unclassified Abstract –
DOCUMENT:
Level Unclassified Category –
Weapons Data – Sigma –
L.F. Quigley 16 July 1996
Y-12 Classification Office Date

☐ Editor Date
☒ Waived / P. McKenney Patent Office Date
☐ Other Date
☐ Other Date

APPROVED FOR: ☐ Declassification ☐ Release subject to use of the following admonitory markings and conditions:

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P. L. McKenney 7/17/96
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Conditions/Remarks:

3229

C-1139 (3-45)

Index No. Y-D4-6

[redacted]

and _____ plates of figures.

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Classification

Y-12 CENTRAL FILES
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[illegible]	4/15/48				
Classification Cancelled					
~~Or Changed To~~					
By Authority Of	DOC				
By [illegible]	Date 4-12-72		INVENTORIED	AUG 26 1963	

SPECIAL REREVIEW ___
FINAL DETERMINATION: UNCLASSIFIED ___
DATE: 12/17/81 [illegible] ___

DECLASSIFICATION CONFIRMED BY Y-12 CLASSIFICATION OFFICE REVIEW 1979

7-24-6

[redacted]

[redacted]

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File

DATE May 4, 1948

ANSWERING LETTER DATE

SUBJECT Handling Of Normal Uranium Metal

APPROVED FOR PUBLIC RELEASE
P. L. McKenney 7/17/96
Technical Information Office Date

I. Activity of Uranium Isotopes

	Percent Abundance in Natural Uranium	Relative Alpha Disintegrations in Natural Uranium	Specific Activity in d/μg/minute per 4π Solid Angle
U-238	0.99274	1000	0.739
U-235	0.00719 .705	46	4.77
U-234	0.0000518	1000	14,500.00

None of these isotopes is beta active. The uranium isotopes emit only alpha particles, yet approximately 270 mrep of beta and gamma activity can be measured at the surface of normal uranium metal.* How is this to be explained? The simplest explanation is found in a study of the Uranium Series of radioactive decay which shows how the original isotopes are transformed into new isotopes (growth elements, daughter elements) which are beta active.

$$_{92}U\text{-}238 \xrightarrow[4.51\times10^{9}\text{yrs.}]{\alpha} {}_{90}Th\text{-}234 \xrightarrow[24.5\text{days}]{\beta} {}_{91}Pa\text{-}234 \xrightarrow[1.14\text{min.}]{\beta}$$

$$_{92}U\text{-}234 \xrightarrow[2.33\times10^{5}\text{yrs.}]{\alpha} \qquad (1)$$

$$_{92}U\text{-}235 \xrightarrow[7.07\times10^{8}\text{yrs.}]{\alpha} {}_{90}Th\text{-}231 \xrightarrow[24.6\text{hrs.}]{\beta} {}_{91}Pa\text{-}231 \xrightarrow[3.2\times10^{4}\text{yrs.}]{\alpha} \qquad (2)$$

* The roentgen equivalent physical (rep) is that quantity of ionizing radiation which is capable of producing 1.615×10^{12} ion pairs per gram of tissue or that will suffer an absorption in tissue of 83 ergs per gram. The tolerance level for total or limited body exposure is at present 0.1 rep (100 mrep) in any 24 hour period, and no individual shall knowingly expose himself or cause others to be exposed to greater than this quantity in any 24 hour period.[1]

[redacted]

[redacted]

Both U-234 and Pa-231 disintegrate further but this fact is of no particular concern here since the succeeding growth elements are alpha active and are present only in small amounts.

From this it can be seen that the beta radioactive isotopes are not uranium isotopes, but Th-234, Th-231 and Pa-234. Furthermore, it can be shown that approximately 90% of the beta particles being emitted come from the Pa-234. The amount of Pa-234 depends, in turn, on two other factors: 1. The amount of U-238 available to produce the Pa-234 (by the process shown in equation (1); and 2, the length of time the Pa-234 has had to build up.[2]

Thus it is that, when uranium metal assumed to be pure U-238 has had a chance to build up the Pa-234 to a point where the alpha and beta disintegrations are in equilibrium, viz., about 100 days, beta activity becomes a problem in the handling of uranium metal. It should also be pointed out that, of the 270 mrep of beta and gamma activity, approximately 5 mr is gamma radiation from U-235 and its daughter elements. It is important to realize that the beta activity arises largely in the U-238 disintegration series. Hence, in the handling of normal uranium metal, one has to contend with beta and gamma activity, while in the case of enriched metal the problem is effectively reduced.

II. Uranium Handling Rules

The proposed rules are predicated on a basic philosophy of striving for minimum exposure rather than maximum allowable and prevention of general area contamination. If one is tempted to justify the rules, it is well to bear in mind a few facts concerning the attendant radioactivity: (1) Approximately 30 feet of travel (in air) is required to stop the beta particles of maximum energy; (2) It is possible to receive the maximum allowable exposure (100 mrep) by holding the hand on the metal surface for a period of approximately 22 minutes; (3) Exposure of the hands in contact with the surface can be reduced to the tolerance level (12.5 mr/hr.) if 1/16" thick leather faced gloves are worn; (4) Exposure of the hands in contact with the surface can only be reduced to 22.8 mr/hr.(almost twice m.a.e.) if rubber gloves of 0.037" thickness (medium weight) are worn.

1. Store the material, such that people are not unnecessarily and unknowingly exposed, by whatever means can be used to advantage, i.e., distance, shielding, restricted areas, etc.

2. Operators and Handlers should wear protective clothing. Cloth hats should be worn in those locations where there is a dust hazard.

   a. Service personnel, visitors and "roamers" depending on the nature of their business, should wear protective clothing and equipment if they enter an area where such protection measures are required of permanent personnel.

3. Operators and Handlers should wash hands before smoking or eating.

[redacted]

4. Operators and handlers should take hand counts before smoking or eating, and at the end of each work day. Record a minimum of two (2) hand counts each day on the Hand Score cards provided, i.e., before eating and at end of work day. Wash hands thoroughly if the count is above the warning level on the counter, i.e., 500 d/minute.

    a. Service personnel, visitors, and "roamers", having handled contaminated material, should take hand counts before leaving the area.

5. Operators and handlers should change to clean protective clothing each day, if gross contamination occurs. The Health Physics representative will investigate and adjust the contamination limit in line with safe practices at other sites.

6. Operators and handlers should wear gloves when handling metal in <u>any</u> form.

    a. 0.090" -- 0.100" thick leather-faced gloves are recommended when handling bare metal.

7. Operators and handlers should wear film patches. The Health Physics Group is making a study of hand exposure by means of this method of monitoring.

8. Operators and handlers should wear respiratory protective equipment in areas where there is a dust hazard.

9. Gloves should be checked at least once a day. Any glove giving more than 4 mrep/hr. at the surface should be discarded and treated as contaminated waste.

10. Tools and equipment to be removed from an area should give less than 4 mrep/hr. at the surface. Any material or item giving more than 4 mrep/hr. should be decontaminated to this level before unconditional release.

11. Air-borne uranium should be maintained at less than 150 μgms/M^3.

    a. Respirators should be worn in locations where this tolerance level is exceeded. Assuming respirators to be 99% efficient, a concentration over 15,000 μgms/M^3 is <u>unsafe when wearing a respirator</u>.

Edward G. Struxness
Health Physics and Industrial
Hygiene Section

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1. Atomic Energy Commission, "Regulation, Safety No. 3, " April 28, 1947, pp.2[illegible]
2. Morfitt, J. W., "Factors in Measuring Beta Activity in Plant Material", A-7.300.17, October 31, 1946