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UNC NUCLEAR INDUSTRIES

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Memorandum

To: File

Date: September 9, 1986

From: B. J. Carlson

Subject: VOLATILE ORGANIC AND ETHYLENE GLYCOL CONCENTRATION ESTIMATES FOR THE 183-H BASIN #2 SLUDGE WASTE CONTAINERS

As per S&EE's request, samples were taken from the 183-H Solar Ponds and analyzed for their volatile organics and ethylene glycol content. The purpose of these analyses were to characterize the amount of volatile organics and ethylene glycol present in the 183-H Basin #2 sludge waste containers (55-gallon drums). Because the liquid had already been removed from Basin #2 and pumped into Basins #3 and #4, the liquid and sludge from Basins #3 and #4 was sampled under the assumption that any volatile organics or ethylene glycol present in the Basin #2 sludge would have to be present in the liquid phase and should therefore be present in the liquid in Basins #3 and #4.

A total of 4 samples were obtained from Basins #3 and #4. A composite sample was taken in the northwest and southeast corners of each basin. Samples were taken using a sludge sampler. A sludge sampler was utilized to ensure that any heavy organics that might be present at the liquid/sludge interface were sampled. The entire column of liquid and sludge taken from each sampling location was carefully composited in large glass containers and then transferred into 40 ml glass vials. The glass containers and vials had been cleaned in accordance with the appropriate EPA protocols. Care was taken to eliminate air bubbles passing through the sample and to ensure that the sample bottles were sealed so that no air bubbles were entrapped inside. After the sample bottles were sealed, they were placed in an ice bath and transferred to U.S. Testing for analyses.

The results of the U.S. Testing analyses are attached. The following table lists the U.S. Testing Sample I.D., the HP Lab I.D. (Customer I.D.) and the corresponding sample locations.

UST I.D.	HP Lab I.D.	183-H Location
16001	86-170	Basin #3 NW corner
16002	86-171	Basin #3 SE corner
16003	86-172	Basin #4 NW corner
16004	86-173	Basin #4 SE corner

FEB 1992
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EDMC

9 2 1 2 5 0 1 1 3 8 4

Due to instrument malfunction, the volatile organic analysis results for sample #86-170 were lost. Only one of the remaining 3 samples showed volatile organic analysis results above detection limits. None of the ethylene glycol analyses indicated concentrations above detection limits.

Because only one sample indicated positive concentrations of volatile organics, the volatile organic and ethylene glycol concentrations present in the Basin #2 sludge containers (55-gallon drums) were estimated from these results. The estimate was performed using the following assumptions:

- Each 55-gallon drum contains approximately 6 ft^3 of sludge and absorbent. (4-1/2 ft^3 of sludge and 1-1/2 ft^3) of absorbent.
- The density of the sludge absorbent mixture is approximately 1.5 g/cc.
- Each 55-gallon drum contains approximately 3 gallons of liquid.
- The density of the liquid is approximately 1.25 g/cc.

The results of this estimate were as follows:

Compound	Concentration in 55-Gallon Waste Container
Ethylene Glycol	<1 ppm
Tetrachloromethane	<1 ppb
Methylethyl Ketone	<1 ppb
1,1,1-Trichloroethene	<1 ppb
1,1,2-Trichloroethene	<1 ppb
1,1,2-Trichloroethene	<1 ppb
Tetrachloroethene	1 ppb
Xylene (O,P)	<1 ppb
Xylene (M)	<1 ppb
Methylene Chloride	<1 ppb
Chloroform	<1 ppm
*2-Hexanone	3 ppb
*Acetone	4 ppb
*5-Methyl-2-Hexanone	1 ppb

*Tentatively Identified Compounds (Peaks >25% of Nearest I.S.)

BJC/cas

Attachment

cc: VD Apple LL Crass BJC-File/LB

92125011385

VOLATILE ORGANIC COMPOUND (VOC) REPORT

ANALYSIS CODE 730

UST-RD I.D.: 16000 DATE ANALYZED: 29 AUG 86

CUST I.D.: 86-170 DILUTION: -

ANALYST: FWG MATRIX: WATER/SLUDGE

ALIQUOT: 5ml BILL DILUTION: ☐ YES ☐ NO

COMPOUND	CODE	MDL SOIL	MDL WATER	RESULT
TETRACHLOROMETHANE	A61	< 0.01 ug/g	< 10 ppb	
METHYLETHYL KETONE	A64	< 0.01 ug/g	< 10 ppb	
1,1,1-TRICHLOROETHANE	A67	< 0.01 ug/g	< 10 ppb	
1,1,2-TRICHLOROETHANE	A68	< 0.01 ug/g	< 10 ppb	
1,1,2-TRICHLOROETHENE	A69	< 0.01 ug/g	< 10 ppb	
TETRACHLOROETHENE	A70	< 0.01 ug/g	< 10 ppb	
XYLENE (O, P)	A71	< 0.01 ug/g	< 10 ppb	
XYLENE (M)	B14	< 0.01 ug/g	< 10 ppb	
METHYLENE CHLORIDE	A93	< 0.01 ug/g	< 10 ppb	
CHLOROFORM	A80	< 0.01 ug/g	< 10 ppb	

TENTATIVELY IDENTIFIED COMPOUNDS (PEAKS >25% OF NEAREST I.S.)

COMPOUND	CODE	EST. CONC
T1:		
T2:		
T3:		
T4:		
T5:		

LOST

LOST DUE TO INSTRUMENT MALFUNCTION

9 2 1 2 5 0 1 1 3 8 6

DR2:17.9162P4

VOLATILE ORGANIC COMPOUND (VOC) REPORT

ANALYSIS CODE 730

UST-RD I.D.: 16002 DATE ANALYZED: 29 AUG 86

CUST I.D.: 86-171 DILUTION: —

ANALYST: FWG MATRIX: WATER / SLUDGE

ALIQUOT: 5 ml BILL DILUTION: ☐ YES ☐ NO

COMPOUND	CODE	MDL SOIL	MDL WATER	RESULT
TETRACHLOROMETHANE	A61	< 0.01 ug/g	< 10 ppb	ND
METHYLETHYL KETONE	A64	< 0.01 ug/g	< 10 ppb	↓
1,1,1-TRICHLOROETHANE	A67	< 0.01 ug/g	< 10 ppb	↓
1,1,2-TRICHLOROETHANE	A68	< 0.01 ug/g	< 10 ppb	↓
1,1,2-TRICHLOROETHENE	A69	< 0.01 ug/g	< 10 ppb	↓
TETRACHLOROETHENE	A70	< 0.01 ug/g	< 10 ppb	20
XYLENE (O, P)	A71	< 0.01 ug/g	< 10 ppb	ND
XYLENE (M)	B14	< 0.01 ug/g	< 10 ppb	↓
METHYLENE CHLORIDE	A93	< 0.01 ug/g	< 10 ppb	↓
CHLOROFORM	A80	< 0.01 ug/g	< 10 ppb	↓

TENTATIVELY IDENTIFIED COMPOUNDS (PEAKS >25% OF NEAREST I.S.)

	COMPOUND	CODE	EST. CONC
T1:	2-HEXANONE	J69	49 ppb
T2:	ACETONE	I01	70 ppb
T3:	5-METHYL-2-HEXANONE	J70	19 ppb
T4:			
T5:			

9 2 1 2 5 0 1 1 3 8 7

DR2:17.9162P4

VOLATILE ORGANIC COMPOUND (VOC) REPORT

ANALYSIS CODE 730

UST-RD I.D.: 16003 DATE ANALYZED: 29 AUG 86

CUST I.D.: 86-172 DILUTION: -

ANALYST: FWG MATRIX: WATER

ALIQUOT: 5ml BILL DILUTION: ☐ YES ☐ NO

COMPOUND	CODE	MDL SOIL	MDL WATER	RESULT
TETRACHLOROMETHANE	A61	< 0.01 ug/g	< 10 ppb	ND
METHYLETHYL KETONE	A64	< 0.01 ug/g	< 10 ppb	
1,1,1-TRICHLOROETHANE	A67	< 0.01 ug/g	< 10 ppb	
1,1,2-TRICHLOROETHANE	A68	< 0.01 ug/g	< 10 ppb	
1,1,2-TRICHLOROETHENE	A69	< 0.01 ug/g	< 10 ppb	
TETRACHLOROETHENE	A70	< 0.01 ug/g	< 10 ppb	
XYLENE (O, P)	A71	< 0.01 ug/g	< 10 ppb	
XYLENE (M)	B14	< 0.01 ug/g	< 10 ppb	
METHYLENE CHLORIDE	A93	< 0.01 ug/g	< 10 ppb	
CHLOROFORM	A80	< 0.01 ug/g	< 10 ppb	

TENTATIVELY IDENTIFIED COMPOUNDS (PEAKS >25% OF NEAREST I.S.)

COMPOUND	CODE	EST. CONC
T1: NONE		
T2:		
T3:		
T4:		
T5:		

92125011338

DR2:17.9162P4

VOLATILE ORGANIC COMPOUND (VOC) REPORT

ANALYSIS CODE 730

UST-RD I.D.: 16004 DATE ANALYZED: 29 AUG 86

CUST I.D.: 86-173 DILUTION: —

ANALYST: FWG MATRIX: WATER

ALIQUOT: 5ml BILL DILUTION: ☐ YES ☐ NO

COMPOUND	CODE	MDL SOIL	MDL WATER	RESULT
TETRACHLOROMETHANE	A61	< 0.01 ug/g	< 10 ppb	ND
METHYLETHYL KETONE	A64	< 0.01 ug/g	< 10 ppb	
1,1,1-TRICHLOROETHANE	A67	< 0.01 ug/g	< 10 ppb	
1,1,2-TRICHLOROETHANE	A68	< 0.01 ug/g	< 10 ppb	
1,1,2-TRICHLOROETHENE	A69	< 0.01 ug/g	< 10 ppb	
TETRACHLOROETHENE	A70	< 0.01 ug/g	< 10 ppb	
XYLENE (O, P)	A71	< 0.01 ug/g	< 10 ppb	
XYLENE (M)	B14	< 0.01 ug/g	< 10 ppb	
METHYLENE CHLORIDE	A93	< 0.01 ug/g	< 10 ppb	
CHLOROFORM	A80	< 0.01 ug/g	< 10 ppb	

TENTATIVELY IDENTIFIED COMPOUNDS (PEAKS >25% OF NEAREST I.S.)

COMPOUND	CODE	EST. CONC
T1: NONE		
T2:		
T3:		
T4:		
T5:		

9212501139

DR2:[7,9]62P4

ETHYLENE GLYCOL

ANALYSIS CODE: C81

UST-RD I.D.: 16001 DATE RECEIVED: —

CUST I.D.: 86170 DILUTION: —

ANALYST: LW DATE ANALYZED: 9-3-86

ALIQUOT: 2µL.

COMPOUND	CODE	MDL	RESULT
ETHYLENE GLYCOL	C81	< 10 ppm	<10 ppm

9211250113390

ETHYLENE GLYCOL

ANALYSIS CODE: C81

UST-RD I.D.: 16002

DATE RECEIVED: –

CUST I.D.: 86171

DILUTION: –

ANALYST: LW

DATE ANALYZED: 9-3-86

ALIQUOT: 2μL

COMPOUND	CODE	MDL	RESULT
ETHYLENE GLYCOL	C81	< 10 ppm	<10 ppm

9 2 1 2 5 0 1 1 3 7 1

ETHYLENE GLYCOL

ANALYSIS CODE: C81

UST-RD I.D.: 16003 DATE RECEIVED: –

CUST I.D.: 86172 DILUTION: –

ANALYST: LW DATE ANALYZED: 9-3-86

ALIQUOT: 2µL

COMPOUND	CODE	MDL	RESULT
ETHYLENE GLYCOL	C81	< 10 ppm	<10 ppm

9212711392

ETHYLENE GLYCOL

ANALYSIS CODE: C81

UST-RD I.D.: 16004

CUST I.D.: 86173

ANALYST: LW

ALIQUOT: 2µL

DATE RECEIVED: –

DILUTION: –

DATE ANALYZED: 9-3-86

COMPOUND	CODE	MDL	RESULT
ETHYLENE GLYCOL	C81	< 10 ppm	< 10 ppm

9 2 1 2 0 1 1 3 9 3

severity of accidents and injuries, with special regard to the needs of industrialising countries.

c) Occupational health: the specific objective is to promote control of occupational health risks in the modern, the informal and the traditional sectors of the economy.

d) Working conditions: the specific objective is to promote and support, at the national, regional and international levels, the improvement of working conditions and the welfare of workers, including work organisation, working time and workers' participation.

e) Underserviced workers and vulnerable groups: the specific objective is to extend to workers in the rural sector and the informal urban sector of developing countries, and to women workers, migrant workers, and other underserviced groups, the benefit of measures to improve the working environment, by using, inter alia, primary health care approaches.

LARRÉ, D.,

Uranium, alloys and compounds

Uranium (U)

atomic nr	19
m.p.	1 132.2 ± 0.8 °C
b.p.	3 818 °C

a hard, silvery-white metal.

TLV OSHA	0.05 mg/m³ (soluble compounds)
	0.25 mg/m³ (insoluble compounds)
TLV ACGIH	0.2 mg/m³ (U natural, soluble and insoluble compounds)
MAC USSR	0.015 mg/m³ (soluble compounds)
	0.075 mg/m³ (insoluble compounds)

Radionuclide	Critical organ	MPC in air for 40 h/week (ICRP, IAEA 1962) (µCi/cm³)	Maximum permissible annual intake (ICRP, IAEA 1967)
$_{92}U^{nat}$ (soluble)	kidney	7×10^{-11}	5.5×10^{6} µg
(insoluble)	lung	6×10^{-11}	4.8×10^{6} µg
$^{238}_{92}U$ (soluble)	kidney	7×10^{-11}	1.8×10^{-1} µCi
(insoluble)	lung	10×10^{-10}	3.4×10^{-1} µCi

Uranium metal is not quite as hard as steel; it is ductile, malleable, can be melted and extruded at high temperatures; it takes a high polish after cold working. It is exceptionally reactive and tarnishes rapidly in air due to the formation of an oxide coating which, however, does not prevent further oxidation of the underlying metal. This heavy metal is found in valencies from 2 to 6.

Uranium is a radioactive element which, in the natural state, is a mixture of three isotopes $^{238}_{92}U$ (99.28%), $^{234}_{92}U$ (0.006%) and $^{235}_{92}U$ (0.711%). Uranium 238 is the father of the uranium family. It has a half-life of 4.49×10^{9} years and, in disintegrating, emits α-particles with an energy of 4.18 MeV and γ-rays with an energy of 48 keV. The uranium series includes such radioactive elements as $^{234}_{90}Th$ (half-life–24.1 days), $^{234}_{91}Pa$ (1.17 min), $^{234}_{92}U$ (2.48×10^{5} years), $^{230}_{90}Th$ (1 622 years), $^{222}_{86}Rn$ (3.82 days) and radium disintegration products. The end product of the series is stable lead ($^{206}_{82}Pb$). Nine radionuclides of the uranium family emit α-particles and six β-particles. Certain members of the series also emit a weak γ-radiation when disintegrating.

When $^{238}_{92}U$ captures neutrons, the uranium nucleus disintegrates and forms new transuranium elements:

$$^{238}_{92}U + n \rightarrow ^{239}_{92}U + \gamma$$
$$^{239}_{92}U \rightarrow ^{239}_{93}Np + \beta$$
$$^{239}_{93}Np \rightarrow ^{239}_{94}Pu + \beta$$

Occurrence. Uranium is widely distributed in nature and accounts for $3\text{-}4 \times 10^{-4}$% of the earth's crust. It is present in a variety of minerals and is also encountered in sea water, etc. Of the 144 known uranium minerals, only relatively few are of industrial importance. According to their composition, uranium minerals can be divided into oxides (uraninite, pitchblende, etc.) and oxygenous salts (carnotite, tyuyamunite, etc.), the latter having a more complex composition and containing, in addition to uranium, vanadium, phosphorus, arsenic, copper and other metals. The minerals contain all the disintegration products of uranium in a state of radioactive equilibrium and present by weight in proportion to their half-life. The radium content of uranium ores is 0.34 g/t. The equilibrium between the elements may shift somewhat towards uranium or radium as a result of groundwater leaching.

The chief natural sources are hydrothermal veins in Saxony, Zaire and Canada; sedimentary rocks in Colorado, Utah and New Mexico; and pyritic conglomerate beds of the Precambrian Age in the Witwatersrand and Ontario.

Production. The ores are obtained by normal mining methods, but the processing methods differ according to the composition of the uranium minerals. In general, the extraction of uranium from the ores involves concentration, lixiviation followed by the separation of the solid and liquid phases, and then the precipitation, filtration, purification and drying of the salts. Two leaching operations are commonly applied to the finely ground ore after it has been roasted to expel sulphur and arsenic: the acid process and the carbonate process. In the former, sulphuric acid is used and oxidants are added to ensure that the uranium will go into solution as the uranyl ion. When the ore is carbonate leached, the action of the sodium carbonate produces a water-soluble uranyl tricarbonate ion. The concentrate from the leaching operation is treated to produce uranyl nitrate, which is further purified by solvent extraction.

Uranium metal can be obtained from its halides by fused salt electrolysis.

Uses. Although discovered by Klaproth as early as 1789, uranium for many years had no practical uses. However, with the discovery of radium, uranium ores began to be used as a source of radium salts. At that time radium was much used in medicine, in the preparation of radioactive luminous paints, for radiological flaw detection, etc. Uranium salts are used for staining glass, glazing ceramics and in photographic processes. The discovery of the disintegration of the uranium nucleus made it possible to use it also in the field of nuclear energy. At present it is one of the most important raw materials for the production of nuclear reactor fuels.

Uranium compounds

Four stable oxides are known. They are uranium dioxide (UO_2)–the constituent of uranite; uranium oxide (U_3O_8)–present in pitchblende; uranium trioxide (UO_3); and uranium peroxide (UO_4). The hydride (UH_3) is obtained by reaction with hydrogen at 200-300 °C; it is pyrophoric and is often used to produce a highly reactive powdered metal.

The uranium halides constitut[illegible] portant group of compounds. Uranium tetrafluoride (UF_4) is an intermediate in the separation of the metal, and the hexafluoride (UF_6) is used in the separation of $^{235}_{92}U$ and $^{238}_{92}U$ by gas diffusion. The above compounds are only slightly soluble in water. Uranyl nitrate is obtained as the hexahydrate from concentrated nitric acid. Uranyl sulphate is precipitated as the trihydrate. These two salts and the acetate ($UO_2(CH_3COO)_2.2H_2O$) are readily soluble in water.

HAZARDS

Pure uranium does not constitute an external radiation exposure hazard since it emits mainly α-radiation at a low energy level. It does, however, constitute an internal radiation hazard if it enters the body. Uranium compounds carry a chemical hazard, being liver and kidney poisons, and uranium hexafluoride can cause injury because of the irritant action of fluorine. Uranium metal may ignite spontaneously.

Radiation hazard. Exposure may occur in the course of mining uranium ores, although the silicosis hazard to which the uranium miner is exposed is more severe than the radiation hazard (see also RADON AND THORON; RADIOACTIVE ORE, MINING AND MILLING OF).

Danger may also be present during ore processing and when using the metal and its compounds. Where ores are stored and treated or where uranium salts are produced by selective solvent extraction, the air may be contaminated by uranium, radium, radon and their disintegration products. In the salt and metal production processes that follow the separation of radium from uranium, radon is no longer a hazard and the main danger is that of uranium aerosols. Metallic uranium and uranium oxides obtained from natural uranium are not sources of radon or γ-radiation.

All processes, both wet and dry, may give rise to surface contamination of premises, equipment, clothing, footwear and skin by α- and β-emitters. Operations such as the storage and transport of enriched uranium ores, radium precipitation and the storage of waste products may be attended by external γ-radiation. During the processing of the metal and the handling of charges, slag and ingots, there may be intense β-radiation due to the presence of $^{234}_{90}Th$ and $^{234}_{91}Pa$, which tend to concentrate at the surface of the molten metal. The intensity of the radiation depends on the state of the radioactive equilibrium and the dimension of the exposed surface area of the metal.

Under conditions of occupational exposure, uranium and its disintegration products may enter the body through the respiratory system in gaseous and aerosol form, through the skin as solutions of radon and uranium and radium compounds, and to some extent through the digestive tract.

Chemical toxicity. Uranium and its compounds are highly toxic substances, the highest toxicity being possessed by those compounds that are soluble in water and body fluids.

The LD_{50} is 1.12 mg/kg body weight for rats and 0.55 mg/kg for rabbits. Inhalation of uranyl salts at concentrations of 4.5-20 mg/m³ proved fatal in 80% of rabbits. Uranium hexafluoride is exceptionally toxic, and atmospheric concentrations as low as 0.3 mg/m³ killed 14% of a group of rabbits. The less toxic insoluble compounds include uranium dioxide, uranium oxide and uranium tetrafluoride; however, these too may cause serious damage if absorbed.

Once absorbed, uranium rapidly leaves the blood and is deposited in the tissues; hexavalent uranium has a predilection for kid[illegible] bone tissue whereas the tetravalent form shows a preference for liver, kidney (cortex) and bone (epiphyseal tissue). The critical organs are the kidneys, bones and, in the case of inhalation, the lungs. In experimental animals, uranium was recovered from the placenta, foetus and milk of females and from the tissues and urine of progeny fed milk from exposed females. Soluble compounds are rapidly eliminated in the urine (up to 50% in the first day) but tetravalent compounds are found more in stools. Insoluble compounds are not readily eliminated.

Uranium poisoning is characterised by generalised health impairment. The element and its compounds produce changes in the kidneys, liver, lungs and cardiovascular, nervous and haemopoietic systems, and cause disorders of protein and carbohydrate metabolism. Uranium poisoning may be acute or chronic. The acute form (caused by soluble compounds) is characterised by kidney lesions with damage to the convoluted tubules and necrotic nephrosis. Urinalysis reveals leucocytes, renal epithelium, and hyaline cylinders. Inhalation of uranium hexafluoride causes changes in upper respiratory tract mucosae, pneumonia, pulmonary oedema and emphysema, and hepatic lesions.

Chronic poisoning results from prolonged exposure to low concentrations of insoluble compounds and presents a clinical picture different from that of acute poisoning. The outstanding signs and symptoms are pulmonary fibrosis, pneumoconiosis, and blood changes with a fall in red cell count; haemoglobin, erythrocyte and reticulocyte levels in the peripheral blood are reduced. Leucopenia may be observed with lymphopenia and leucocyte disorders (cytolysis, pyknosis and hypersegmentosis). There may be damage to the nervous system. Morphological changes in the lungs, liver, spleen, intestines and other organs and tissues may be found, and it is reported that uranium exposure inhibits reproductive activity and affects uterine and extra-uterine development in experimental animals. Insoluble compounds tend to be retained in tissues and organs for long periods.

Prolonged irradiation of the thorax, at sites of uranium accumulation, may result in osteosarcoma and lung cancer. Experimental inhalations of uranium oxide (31-91 mg/m³) for 5 days led to the appearance of pneumosclerosis 10 months later at points where α-tracks were concentrated. After 22-23 months, there was hyperplasia of the bronchial epithelium and, after 56 months, lung cancer was diagnosed.

Exposure to very soluble uranium compounds gives rise to pronounced changes in the kidneys (nephrosis), and urinalysis reveals proteins, erythrocytes, cylinders and uranium. Particularly serious cases of poisoning have been observed after exposure to uranium hexafluoride. When a container with this compound exploded, 18 persons were poisoned; two of them died. The survivors suffered from irritation of the upper airways, and one of them from pulmonary oedema. Changes of the gastrointestinal tract were also observed. Radiographs revealed a diffuse inflammatory process in the lungs and pronounced kidney lesions. These cases of acute poisoning were due to the effect of uranium and its hydrolysis products.

Chronic poisoning may develop after prolonged exposure to slightly soluble uranium compounds. Its degree depends on the level and duration of exposure; there are changes in the peripheral blood, such as leucopenia, lymphopenia and neutropenia, and symptoms of vegetative dystonia. These changes may to a large extent be due to the radioactive properties of uranium and its disintegration products, but the toxic effects of both the metal and its compounds may also

result in kidney involvement, chronic hepatitis, gastritis and other conditions. If slightly soluble uranium is retained for long periods in the body, it may have delayed effects, such as the development of lung cancer.

The changes observed in chronic uranium poisoning are similar to those caused by ionising radiation; the lesions produced by the prolonged action of uranium are due both to the chemical and radioactive properties of the metal – a fact that must be allowed for when planning preventive measures and acceptable levels of exposure.

Fire and explosion. The health hazard associated with the machining of uranium metal may be accompanied by a fire and explosion hazard due to the pyrophoric nature of the element. A dust cloud of uranium metal dust may ignite explosively at ordinary temperatures. Small fires or explosions may spread dangerous radioactive material in an uncontrolled manner.

SAFETY AND HEALTH MEASURES

For work with uranium and its compounds, vigorous precautions must be taken to prevent the contamination of the environment. Wet processes should be used wherever possible; equipment should be contained in enclosures that are airtight or provided with exhaust ventilation according to circumstances; operations should be mechanised to the greatest possible extent and provided with remote control. Materials used for equipment should be smooth and impervious so that the surfaces may be effectively cleaned.

To limit the danger of fire or explosion in processes where finely divided, pyrophoric dust, waste or powder is produced, contact of this material with the air should be avoided by covering the metal scrap with oil until it can be eliminated under controlled conditions. Graphite chips and asbestos blankets may be used to control fires. Comminution or machining may have to be performed in an atmosphere of inert gas such as argon. The material will burn in carbon dioxide, which is therefore unsuitable as an inert gas.

During work with natural uranium, radium, radon and other disintegration products, external irradiation by β- and γ-rays may occur. Special protection against γ-radiation should only be provided after thorough assessment of the possible level of irradiation. Protection against β-rays can be provided quite satisfactorily at workplaces by using screens or goggles of acrylic sheet or other material that is a good absorber of β-rays.

The dose of γ-radiation can be reduced by shortening working time near the source, increasing the distance from it and, where necessary, using screens and containers for accommodating materials emitting intense γ-radiation. In such conditions it will be necessary to monitor the doses of β- and γ-irradiation, and to measure the radiation levels at workplaces.

Personal protective equipment (respirators, protective clothing, footwear, etc.) should be used by workers exposed to aerosols and to the hazard of radioactive skin contamination, and systematic arrangements should be made for cleaning the skin and the protective equipment. The workers must strictly observe the rules of personal hygiene and be familiar with ways and means of working carefully and correctly with uranium and its compounds. To this end all workers should be given medical and technical instruction with demonstrations of equipment and processes by means of models.

Where industrial workers are in contact with uranium, as in storeplaces and auxiliary premises, it is very important to organise the systematic medical supervision and selection of newly engaged workers because of possible contraindications. It is necessary to monitor the atmospheric concentrations of aerosols of uranium, radon and disintegration products, and also the level of contamination of surfaces by radioactive substances (premises, clothes, footwear, skin).

It is also necessary to arrange for periodic medical examination of persons in contact with uranium and its disintegration products. Monitoring of the uranium content of biological media is required. Persons employed in dusty operations with uranium and exposed to the action of radon should have periodical chest X-ray examinations. The intervals between examinations should be planned with regard to the conditions of work.

TARASENKO, N. Ju.

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"Review of uranium inhalation cases". Heid, K.; Fugua, P. *Health Physics* (New York), 1974, 26/5 (399-403).

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