UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
631 PARK AVENUE
KING OF PRUSSIA, PENNSYLVANIA 19406

June 20, 1979

Docket Nos. 50-320
50-289

Metropolitan Edison Company
ATTN: Mr. J. G. Herbein
Vice President - Generation
P. O. Box 542
Reading, Pennsylvania 19640

Gentlemen:

This Information Notice is provided as an early notification of a possibly significant matter. It is expected that recipients will review the information for possible applicability to their facilities. No specific action or response is requested at this time. If further NRC evaluations so indicate, an IE Circular or Bulletin will be issued to recommend or request specific licensee actions. If you have questions regarding this matter, please contact this office.

Sincerely,

Robert T. Carlson
for Boyce H. Grier
Director

Enclosures:
1. IE Information Notice No. 79-17
2. List of IE Information Notices Issued in 1979

cc w/encls:
E. G. Wallace, Licensing Manager
J. J. Barton, Project Manager
R. C. Arnold, Vice President - Generation
L. L. Lawyer, Manager - Generation Operations
G. P. Miller, Manager - Generating Station - Nuclear
J. L. Seelinger, Unit 1 Superintendent
W. E. Potts, Unit 1 Superintendent - Technical Support
J. B. Logan, Unit 2 Superintendent
G. A. Kunder, Unit 2 Superintendent - Technical Support
I. R. Finfrock, Jr.
Mr. R. Conrad
G. F. Trowbridge, Esquire
Miss Mary V. Southard, Chairman, Citizens for a Safe Environment

ENCLOSURE 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

IE Information Notice No. 79-17
Date: June 20, 1979
Page 1 of 2

SOURCE HOLDER ASSEMBLY DAMAGE FROM MISFIT BETWEEN ASSEMBLY AND REACTOR UPPER GRID PLATE

Description of Circumstances:

Recently, the NRC was informed of a problem at two Westinghouse PWR facilities resulting from an apparent misfit between secondary source holder assemblies and the reactor upper grid plate.

The misfit problem was first identified by Carolina Power & Light, licensee for H. B. Robinson Unit 2, who informed the NRC on May 6, 1979, of the circumstances. During the current refueling outage at H. B. Robinson 2, CP&L determined that two secondary source holder assemblies had been damaged during the previous refueling in February 1978, by a misfit between the assembly and the reactor upper grid plate. The misfit resulted from insufficient clearance (i.e. 1/2 to 3/4 inch) between the source holder assembly hub and the grid plate at the core locations containing thermocouple mixing vanes. This lack of sufficient clearance caused minor deformation of the upper grid plate components at the core location and of the source holder assemblies. The deformation also resulted in some bending of the fuel rods in the assembly, however, in no case did this bending result in fuel cladding perforation.

On May 16, 1979, the licensee of D. C. Cook Unit 1 informed the NRC that the present refueling outage would be extended 15 to 20 days to remove the reactor head, which had already been reinstalled following completion of refueling, to correct this misfit problem. They learned of the problem from Westinghouse. Subsequently, the licensee's inspection revealed that the source holder assembly hubs were in contact with the vanes. The source holder was removed from one assembly readily with no apparent damage while in the other the source holder was found stuck in the assembly. The problem was corrected prior to return to operations.

The secondary source assembly rods are normally inserted into rod cluster control assemblies and placed at symmetrical locations in the core. Each such assembly contains a symmetrical grouping of four secondary source rods and between zero and twenty burnable poison rods. Locations in the assembly not filled with a source or burnable poison rod contain a thimble plug. The lack of sufficient clearance for these sourc[...] only at the core locations which contai[...]

This Information Notice provides the details of a significant occurrence that is still under review by the NRC staff. If further NRC review indicates, an IE Circular or Bulletin may be issued to recommend or request specific licensee actions.

No written response is required. If you desire additional information regarding this matter, please contact the Director of the appropriate NRC Regional Office.

ENCLOSURE 2

LISTING OF IE INFORMATION NOTICES
ISSUED IN 1979

Information Notice No.	Subject	Date Issued	Issued to
79-01	Bergen-Paterson Hydraulic Shock and Sway Arrestor	2/2/79	All power reactor facilities with an Operating License (OL) or Construction Permit (CP)
79-02	Attempted Extortion - Low Enriched Uranium	2/2/79	All Fuel Facilities
79-03	Limitorque Valve Geared Limit Switch Lubricant	2/9/79	All power reactor facilities with an OL or CP
79-04	Degradation of Engineered Safety Features	2/16/79	All power reactor facilities with an OL or CP
79-05	Use of Improper Materials in Safety-Related Components	3/21/79	All power reactor facilities with an OL or CP
79-06	Stress Analysis of Safety-Related Piping	3/23/79	All power reactor facilities with an OL or CP
79-07	Rupture of Radwaste Tanks	3/26/79	All power reactor facilities with an OL or CP
79-08	Interconnection of Contaminated Systems with Service Air Systems Used As the Source of Breathing Air	3/28/79	All power reactor facilities with an OL and Pu Processing fuel facilities
79-09	Spill of Radioactivity Contaminated Resin	3/30/79	All power reactor facilities with an OL
79-10	Nonconforming Pipe Support Struts	4/16/79	All power reactor facilities with a CP

LISTING OF IE INFORMATION NOTICES
ISSUED IN 1979

Information Notice No.	Subject	Date Issued	Issued to
79-11	Lower Reactor Vessel Head Insulation Support Problem	5/7/79	All power reactor facilities with an OL or CP
79-12	Attempted Damage to New Fuel Assemblies	5/11/79	All Fuel Facilities, Research Reactors, and Power Reactors with an OL or CP
79-13	Indication of Low Water Level in the Oyster Creek Reactor	5/29/79	All power reactor facilities with an OL or CP
79-14	Safety Classification of Electrical Cable Support Systems	6/11/79	All applicants for, and holders of a power reactor CP
79-15	Deficient Procedures	6/7/79	All power reactor facilities with an OL or CP
79-16	Nuclear Incident at Three Mile Island	6/22/79	All research and test reactors with an OL

J. Read, involvement in TMI-2 response

28 March – telephoned questions from IRC concerning chemical kinetics of water radiolysis.

30 March – at IRC, telephone calls to GPU, TMI, regarding coolant composition.

week of 2 April – attempts to calculate H_2–Zr balance, discussion with Bob Budnitz (RES) on possible borohydride formation, gas solubilities

Easter – telephone discussion with George Sealey at TMI regarding gas solubility

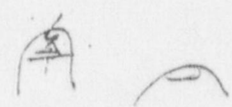
week of 9 April – discussions on telephone with radiochemists at Bettis, ORNL.

HENRY'S LAW $P_H = k X_H$

Partial pressure	k H_2 (23°C) atm
1.18 atm	—
2.63	7.76×10^4
3.95	7.77
5.26	7.81
6.58	7.89
7.90	8.00
9.20	8.16

55.6 m/l

5.56×10^4 m/m^3



200 m^3

1.1×10^7 m H_2O
in p y system

10^3 psi ≈ .70 atm

$.70 = 10^3 X$

7% mole fraction ~ 10^6 moles H_2

$\times .0224 = 2.2 \times 10^4\ m^3$

18 April 1979

Calculation of Xe

The three main stable Xe isotopes are

^{131}Xe 2.79 % of fission

^{132}Xe 4.16 % "

^{134}Xe 7.51 % "

14.4 % "

If 2.5×10^5 MWD of fission have occurred in core, at 3.2×10^{-11} J/fission, then 6.7×10^{26} fissions have yielded 9.7×10^{25} atoms of stable Xe, ie 160 moles. In addition there were initially 6 moles of ^{133}Xe.

If 300 tonnes of primary coolant received the Xe

$$\frac{166 \text{ moles}}{3 \times 10^5 \text{ Kg} \; 55.5 \frac{\text{moles } H_2O}{\text{Kg}}} = 1 \times 10^{-5} \text{ mole fraction}$$

Henry's Law for Xe is

$$P_{atm} = (2 \times 10^4)(\text{mole fraction})$$

$$\therefore \; P_{atm} = 0.2 \text{ atmospheres.}$$

Hence the partial pressure of Xe in the coolant was 3 psi. Total pressure was 900 psi ∴ 0.3 % of reactor vessel gas is Xe.

ARMS plane said ~20 Ci/sec of ^{133}Xe lost

$$\frac{\text{atoms}}{\text{Ci}} = \frac{3.7 \times 10^{10} \text{ dis/Ci}}{1.52 \times 10^{-6} \text{ sec}^{-1}} = 2.43 \times 10^{16}$$

$$\therefore \; 20 \text{ Ci/sec} = \frac{(20)(2.43 \times 10^{16})}{6 \times 10^{23}} = 8.1 \times 10^{-7} \text{ moles/sec}$$

$$\frac{166}{6} = 28$$

Absolute FY.

^{83}Kr	.548	
84 "	1.01	} 4.5 % fis Kr
85 "	1.31	
86 "	2.04	

131 Xe	2.79	8.d I → Xe
132	4.16	2h I → Xe
133	6.73 ⇐	21h I → 5d Xe → Cs
134	7.51	2y Cs → Xe ← 52m I

TMI-2 has 6.7×10^{26} fissions

2.79
4.16
7.51
14.40

$(0.144)(6.7 \times 10^{26}) = 9.71 \times 10^{25}$ atoms Xe stable

= 161 moles stable Xe

160 moles stable Xe + 5.7 moles ^{133}Xe

3×10^5 Kg H_2O $\quad \frac{160}{3 \times 10^5} = 1.5 \times 10^{-5}$

$(2 \times 10^4)(1.5 \times 10^{-5}) = 0.3$ atmospheres internal pressure

out of 60 atm ∴ 0.2% Xe

28 March – 5 April

13×10^6 Ci ^{133}Xe

14 Ci ^{131}I

140×10^6 Ci = initial core inventory

[illegible]

12 April estimate

$T_{1/2} = 5.29$ d.

$\lambda = 1.5166 \times 10^{-6}$ sec^{-1}

$= 0.131$ day^{-1}

	time	^{133}Xe	release rate	total core inventory	fraction released	
1	3/28 - 3/29	4.2 MCi	24 hr 48.6 Ci/sec (1.00)	140 MCi	3.47×10^{-7}	3.0
2	3/29 - 3/31	2.2 MCi	48 hr 12.7 (.769)	108	1.18×10^{-7}	1.0
3	3/31 - 4/1	2.1 MCi	22 hr 24.3 (.675)	94.5	2.57×10^{-7}	2.2
4	4/1 - 4/2	0.4	4.63 (.592)	82.9	0.56 "	.48
5	4/2 - 4/3	1.1	12.7 (.519)	72.7	1.75 "	1.51
6	4/3 - 4/4	0.07	0.81 (.456)	63.8	0.13 "	.11
7	4/4 4/5	0.2	2.3 (.400)	55.9	0.41	.357

900 mw

9×10^8

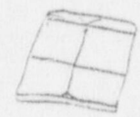
ARMS 20 - 50 Ci/sec CCC est.

$$\frac{\text{atoms}}{\text{Ci}} = \frac{3.7 \times 10^{10} \text{ dps}}{1.52 \times 10^{-6} \text{ sec}^{-1}} = 2.43 \times 10^{16}$$

6.2.2

140×10^6 Ci $= 3.4 \times 10^{24}$ atoms

$= 5.66$ moles



2.5×10^5 MWD $= 2.5 \times 10^{11}$ WD

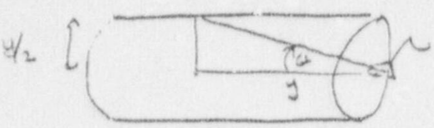
$= 2.5 \times 10^{11} \frac{J}{sec} \, 86{,}400 \frac{sec}{day} = 2.16 \times 10^{16}$ J

@ 200 MeV/fiss $\equiv (2.0 \times 10^8)(1.602 \times 10^{-19}) =$

3.20×10^{-11} J/fiss 3600 J = [illegible]

$\therefore 6.74 \times 10^{26}$ fissions 1.8×10^{-4} m³/kg

3×10



1.) counter is sphere of diameter d
2.) wall is t thick, $t\cos\theta$ is path in tank wall
3.) $y\cos\theta$ is distance between point and detector

area of detector $= \pi d^2$
area of sphere of radius $y\cos\theta = 4\pi y^2\cos^2\theta$

$\therefore$ fraction of decays at point (y,θ) getting to detector

$$= \frac{\pi d^2 e^{-\mu t\cos\theta}}{4\pi y^2\cos^2\theta}$$

integrate over ϕ $0 \le \phi \le 2\pi$

$$2\pi \frac{d^2}{4} \int_\theta \int_y \frac{e^{-\mu t\cos\theta}\, dy\, d\theta}{y^2\cos^2\theta}$$

let $x = \sin\theta$

$\frac{dx}{d\theta} = \cos\theta$

$x^2 + \cos^2\theta = 1$

$\cos\theta = \sqrt{1-x^2}$

$$\int \frac{e^{-\mu t\sqrt{1-x^2}}}{\sqrt{1-x^2}}\, dx$$

let $q = \sqrt{1-x^2}$ $\quad \frac{dq}{dx} = \frac{-2x}{\sqrt{1-x^2}} = \frac{-2\sqrt{1-q^2}}{q}$

$q^2 = 1-x^2$

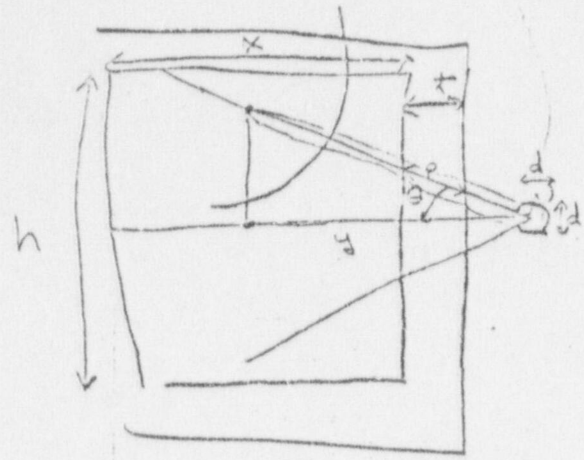
$x = \sqrt{1-q^2}$

$\sqrt{\frac{1}{q^4} - \frac{1}{q^2}}$

$$\int \frac{e^{-\mu t q}}{q}\left(-2\frac{\sqrt{1-q^2}}{q}\right) dq = -2\int e^{-\mu t q}\frac{\sqrt{1-q^2}}{q^2}\, dq$$

~~$\int u\, dv = uv - \int v\, du$~~ $\quad u = \frac{\sqrt{1-q^2}}{q^2}$ $\quad dv = e^{-\mu t q}\, dq$

$du =$ $\quad V = \frac{e^{-\mu t q}}{-\mu t}$



path length through tank wall = $\rho = t\cos\theta$

counter is sphere of diameter d

$\therefore$ area of counter = πd^2

$y\cos\theta$ = distance from point in tank to counter

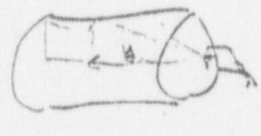
area of sphere of radius $y\cos\theta = 4\pi y^2\cos^2\theta$

$\therefore$ fraction of counts at point in tank that would "get" to detector if no shielding

$$= \frac{\pi d^2}{4\pi y^2\cos^2\theta}$$

$\therefore$ fraction with shielding

$$\frac{\pi d^2\, B(\theta)^{=1}\, e^{-\mu t\cos\theta}}{4\pi y^2\cos^2\theta}$$



$0 \le \phi \le 2\pi$
$0 \le \theta \le \sin^{-1}\left(\frac{7'}{y}\right)$
$0 \le y \le 14'$

$u^2 + \sin^2\theta = 1$
$\sin\theta = \sqrt{1-u^2}$

Let $u = \cos\theta$ $\quad du = -\sin\theta\, d\theta$ $\quad d\theta = -\frac{\sin\theta}{du} = \frac{-\sqrt{1-u^2}}{du}$

$$\therefore \frac{d^2}{4y^2}\int \frac{e^{-\mu t\cos\theta}}{\cos^2\theta}\,d\theta = \frac{d^2}{4y^2}\int \frac{e^{-\mu t u}}{u^2}\left(-\sqrt{1-u^2}\right)du$$

$$= -\frac{d^2}{4y^2}\int \frac{\sqrt{1-u^2}}{u^2}\, e^{-\mu t u}\,du$$

at time of SCRAM, total core had:

7.55×10^{24} atoms ^{140}Ba
1.04×10^{24} atoms ^{140}La

The amount of ^{140}La dissolved is equal to that fraction of ^{144}Ce which dissolved, i.e. at dissolution, one m^3 of coolant contained.

3.69×10^{19} atoms ^{140}Ba
and $(1.09 \times 10^{-6})(1.04 \times 10^{24}) \doteq 1.134 \times 10^{18}$ atoms ^{140}La

$$[^{140}La] = [^{140}La(t_0)]\, e^{-\lambda_2 \Delta t} + \frac{\lambda_1}{\lambda_2 - \lambda_1}[^{140}Ba(t_0)]\left[e^{-\lambda_1 (\Delta t)} - e^{-\lambda_2 \Delta t}\right]$$

where $\lambda_1 = 6.273 \times 10^{-7}\ sec^{-1}$
$\lambda_2 = 4.786 \times 10^{-6}\ sec^{-1}$ $\qquad \frac{\lambda_1}{\lambda_2 - \lambda_1} = 0.1508$

for $\Delta t = 340$ hours. $\qquad e^{-\lambda_1 \Delta t} = 0.4640$
$e^{-\lambda_2 \Delta t} = 2.857 \times 10^{-3}$

$$[^{140}La]_{\text{at 340 hrs.}} = (1.134 \times 10^{18})(2.857 \times 10^{-3}) + (0.1508)(3.69 \times 10^{19})\left(\underset{0.461}{\underline{0.464 - 0.003}}\right)$$

$$= 3.24 \times 10^{15} + 2.565 \times 10^{18} = 2.57 \times 10^{18}$$

$$\frac{\lambda_2 (2.57 \times 10^{18})}{3.7 \times 10^{10}} = 332\ Ci$$

Memo to: Jack Kudrick

Thru: Wayne Houston

From: J. Read

Not sent or typed

Subject [illegible] Noble Gas Releases

Xenon is somewhat more soluble in water than either hydrogen or nitrogen, and, as TMI-2 has demonstrated, is susceptible to transport in aqueous solutions. — ?
Lange's Handbook lists the Henry's Law constant for xenon in water as 2×10^4 atmospheres, and the standard atmosphere at sea level is 80 ppb xenon. — ? It follows, therefore, that any solution containing a mole fraction of xenon isotopes greater than 4×10^{-12} will effervesce xenon until it descends to that concentration, after which it will undergo isotopic exchange. At present there is no method in place to control rare gas releases to a building atmosphere other than total isolation, i.e., control by low exfiltration rate.

Xenon is a comparatively abundant fission product, being present in the 131, 132, 133, 134, 135, and 136 mass chains. In the 133 and 135 mass chains it is also present as the daughter of iodine isotopes of appreciable half-lives (8 days and 7 hours, respectively).

isotope	cumulative chain yield	half-life
^{131}Xe	2.91%	stable
^{132}Xe	4.26	" "
^{133}Xe	6.69	5.27 days
^{134}Xe	7.8	stable
^{135}Xe	6.3	9.2 hours
^{136}Xe	6.46	stable

Stable xenon is produced at the rate of 21.4 atoms per 100 fissions, or 2.4×10^{13} atoms per watt-hour (thermal), or 2.2×10^{-5} m^3 (STP) per megawatt day. TMI-2 had a core inventory of about 6 m^3 (STP) of xenon. The preliminary analyses by

EEB/DOR indicates that about 10% of this inventory (13 out of 140 megacuries of ^{133}Xe) was transported outside containment and released during the first two weeks of the accident, with the remainder still presumably in the reactor vessel and containment. The initial specific activity of this xenon was of the order of 23 MCi/m^3 (ST [illegible] 1 cc/sec.

To understand this loss rate, assume that 30%, or 2 m^3, of xenon, was released to containment prior to containment spray actuation. The containment volume, about 36,000 m^3, would then have a partial pressure of 6×10^{-5} atm. xenon. The containment sprays would bring the sump solution to equilibrium, which by Henry's Law would be a xenon mole fraction of 3×10^{-9}, or a dissolved xenon concentration of 4×10^{-9} m^3 (STP) per Kg of solution. If 10,000 gal. of this solution, i.e., 35,000 Kg were then pumped onto the auxiliary building floor, then 1.3×10^{-4} m^3 (STP) of xenon, or 3 kilocuries, would be released.

If the original 270 moles of xenon were initially dissolved in 3×10^5 Kg of primary coolant (1.7×10^7 moles of water), its mole fraction would be 1.6×10^{-5}, corresponding to a partial pressure of 0.3 atm within the reactor vessel. The primary coolant xenon concentration would then be 2×10^{-5} m^3 (STP)/Kg, or 460 Ci ^{133}Xe per Kg of primary coolant.

In addition, the initial core inventory contained about 850 MCi of ^{133}I, which, by decay into ^{133}Xe, was producing 1 cc/sec of ^{133}Xe, or 1.3 kilocuries/sec. Indeed, the release rates during the first few days of the accident strongly suggest the 20.8 hour half-life of decay of ^{133}I. A 50 Ci/sec ^{133}Xe release rate corresponds to 33 MCi of ^{133}I. ^{135}Xe would be similarly produced by the 6.58 hour ^{135}I, but its release rate would fall markedly with time. The EEB estimates for the first few days, therefore, suggest 3 to 4% of the core iodine inventory was in the auxiliary building.

The only feasible method of controlling this xenon would have been cryogenic charcoal absorption. In theory, 1000 cubic feet per minute of auxiliary building air could be compressed isothermally to 300 atmospheres, expanded isoenthalpicly by the Joule-Kelvin effect, and routed through an insulated charcoal bed. The reversible thermodynamic energy requirement would be about 4 megawatts. A search of the Thomas catalogues indicates this would need a unit about an order of magnitude larger than offered for sale. The public safety benefits of such larger units in place at all potential rare gas fission product release points would, however, argue strongly in favor of promoting their development and production.

The handbook value of the Henry's Law constant for hydrogen solubility in water is 8×10^4 atm. The major source of H_2 is

$$Zr + 2H_2O \rightarrow ZrO_2 + 2H_2$$

such that the oxidation by steam of 1 Kg of Zr yields 0.49 m^3 (STP) of H_2, or 21.9 moles. If 10^4 Kg of Zr were oxidized, 2.2×10^5 moles of H_2 would be produced. The mole fraction of dissolved H_2, given 10^3 psi, or 70 atm, of system pressure by Henry's Law would be of the order of 10^{-3}. Upon being let down to ambient pressures, the primary coolant would effervesce 1.2 times its volume of H_2 (STP).

Zirconium is chemically unique in that ZrO_2 is soluble in the metal, hence the oxidation is a homogeneous solid-state reaction in which a Zr object slowly swells and emits H_2 while oxidizing.

The appearance of a 28 psig pressure pulse due to hydrogen deflagration suggests the release of about 10^9 Joules of thermal energy. Since the oxidation of H_2 releases 2.4×10^5 J/mole, this pressure pulse argues for the combustion of $\geq 4.2 \times 10^3$ moles of H_2, which would, in turn, require the oxidation of about 200 Kg of Zr. It is, of course, extremely likely the deflagration did not produce the

pressure peak with 100% thermodynamic efficiency, in which case the H_2 consumed would be much greater. Hydrogen balance may summarized

28 psig pressure pulse	> 4×10^3 moles
2% of containment	3×10^4 "
dissolved in primary coolant	2×10^4 "
lost by diffusion	?

Hence an absolute minimum of 2 tonnes of Zr has been oxidized.

It should be noted that the radiolysis of water is greatly effected by the presence of dissolved gases. The high concentration of dissolved H_2 in the primary coolant will greatly reduce the concentration of hydroxyl radicals via

$$H_2 + \cdot OH \rightarrow H_2O + H\cdot$$

Since the hydroxyl radicals govern the path by which O_2 is generated, the O_2 evolution rate is undoubtedly negligible.

Several metals, notably titanium and platinum, form interstitial hydrides, i.e. H_2 is soluble in these metals and passes through them readily. In degassing the primary coolant, it is not necessary to reinject the H_2 into containment, since it may be totally separated from all radioisotopes (except tritium) by passage through titanium.

Jaqua

MEMORANDUM
OF CALL

TO: J. Reed

- [x] YOU WERE CALLED BY—
- [ ] YOU WERE VISITED BY—

Bob Bulerty

OF (Organization)

- [x] PLEASE CALL → PHONE NO. CODE/EXT. 74338
- [ ] FTS
- [ ] WILL CALL AGAIN
- [ ] IS WAITING TO SEE YOU
- [x] RETURNED YOUR CALL
- [ ] WISHES AN APPOINTMENT

MESSAGE

If you are in over the weekend + would like to talk to him about 3-Mile Island have the NRC operator give you his home phone #.

RECEIVED BY: [illegible] | DATE: 4-1-79 | TIME: 4[40]

63-109

STANDARD FORM 63 (Rev. 8-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.6

*USGPO:1978:281-184/11

MEMORANDUM OF CALL

TO: Reed

☐ YOU WERE CALLED BY— ☐ YOU WERE VISITED BY—

Budnitz

OF (Organization)

Off. of Research

☐ PLEASE CALL → PHONE NO. CODE/EXT. x 74338 ☐ FTS

☐ WILL CALL AGAIN ☐ IS WAITING TO SEE YOU

☒ RETURNED YOUR CALL ☐ WISHES AN APPOINTMENT

MESSAGE

BO_3 $Zr(BH_4)_4$

BH_3

RECEIVED BY	DATE	TIME
cnl	4-10	11:05

63-109

STANDARD FORM 63 (Rev. 8-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.6

*USGPO:1978:261-184/11

at IRC — 30 March 1979

Greg [illegible] — 717-944-4057 — [illegible]

[illegible] water sample — [illegible] 3/29

[illegible] to [illegible] — [illegible] but will [illegible] ?

$Zr \rightarrow Zr^{+3}$

$\frac{3}{2}$ — Geo Kenighton

Ed Zebroski EPRI chemist at site

GPU { Bob Cutler — Dick Maxwell

N.J.

201-263-4900 X 410/411

→ Bettis {

Primary coolant chemistry

[illegible]

[illegible] John [illegible]

or John [illegible]

B_2O_3? ←

[illegible] (H_2 [illegible]) hot

sampling lines?

update

yesterday

At time of "dissolution"

$^{140}La_{0}$ = $(7.55 \times 10^{24})(1.09 \times 10^{-6}) = 8.23 \times 10^{18}$

$\lambda_1 = 6.273 \times 10^{-7}$

$\lambda_2 = 4.786 \times 10^{-6}$ $\qquad \lambda_2 - \lambda_1 = 4.159 \times 10^{-6}$

$$x(La) = 8.23 \times 10^{18} e^{-\lambda_1 \Delta t} + \frac{6.273 \times 10^{-7}}{4.159 \times 10^{-6}} 3.69 \times 10^{19} \left(e^{-\lambda_1 \Delta t} - e^{-\lambda_2 \Delta t}\right)$$

$$= \left(8.23 \times 10^{18} + 5.57 \times 10^{18}\right) e^{-\lambda_1 \Delta t} - 5.57 \times 10^{18} e^{-\lambda_2 \Delta t}$$

$\frac{1}{2.155}$ $\qquad \frac{1}{350.0}$

$$= \frac{1.380 \times 10^{19}}{2.155} - 1.59 \times 10^{16}$$

$6.40 \times 10^{18} - .02 \times 10^{18} = 6.38 \times 10^{18}$

$$\text{Ci at 340 hours} = \frac{(4.786 \times 10^{-6})(6.38 \times 10^{18})}{3.7 \times 10^{10}}$$

826 Ci ^{140}La

ORNL = 160 Ci = 1.237×10^{18} } ^{140}La at 340 hours

SRL 135 Ci = 1.044×10^{18}

" $x_2(t)$)

$x_2(t) = 5.57 \times 10^{18} e^{-6.273 \times 10^{-7} \Delta t}$

ORNL = 0.222 = $e^{-\lambda_1 \Delta t}$, $\lambda_1 \Delta t = 1.5047$ $\quad \Delta t = 2.399 \times 10^{6}$

SRL = 0.1874 = $\quad \lambda_1 \Delta t = 1.674 \quad 2.67 \times 10^{6}$

$$^{140}\underset{x_1}{Ba} \xrightarrow{\lambda_1} {}^{140}\underset{x_2}{La} \xrightarrow{\lambda_2}$$

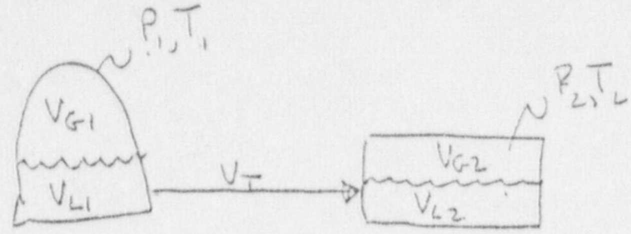
$$x_1 = x_1(0)\, e^{-\lambda_1(t-t_0)}$$

$$\frac{dx_2}{dt} = -\lambda_2 x_2 + \lambda_1 x_1(0)\, e^{-\lambda_1(t-t_0)}$$

$$e^{\lambda_2 t} \frac{dx_2}{dt} = -\lambda_2 x_2 e^{\lambda_2 t} + \lambda_1 x_1(0)\, e^{\lambda_2 t - \lambda_1(t-t_0)}$$

$$\therefore \frac{d(x_2 e^{\lambda_2 t})}{dt} = \lambda_1 x_1(0)\, e^{\lambda_2 t - \lambda_1(t-t_0)}$$

$$x_2 = x_2(0)\, e^{-\lambda_2(t-t_0)} + \frac{\lambda_1 x_1(0)}{\lambda_2 - \lambda_1}\left[e^{-\lambda_1(t-t_0)} - e^{-\lambda_2(t-t_0)}\right]$$



$$V_1 = V_{G1} + V_{L1}$$

$$V_2 = V_{G2} + V_{L2}$$

c_1, the concentration of gas Q in V_T is the same as that in L1

$P_2 = P_Q + P_{N_2}$, assuming letdown (or makeup) tank originally filled with N_2

amount of Q in V_2 = $X_{2Q}\,(\overset{M}{\text{moles liquid}}) + \frac{P_{Q2}}{P_2}(\text{moles gas})$

and $P_{Q2} = K_Q X_{2Q}$

amount of Q in V_T = $X_{1Q}\,(\overset{M}{\text{moles liquid}})$ = amt in V_2

but, initially

$$P_{Q1} = K_Q X_{1Q}$$

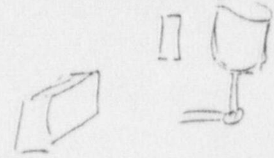
$$\therefore \quad X_{1Q} = \frac{P_{Q1}}{K_Q}$$

$$\therefore \; c(V_T) = c(V_2) = \frac{M P_{Q1}}{K_Q} = M X_{2Q} + \frac{P_{Q2}}{P_2}(\text{moles G})$$

$$= X_{2Q}\left(M + \frac{P_{Q2}}{P_2}\,\text{moles G}\right)$$

$$\therefore \; P_{Q1} = \frac{K_Q}{M} X_{2Q}\left(M + \frac{P_{Q2}}{P_2}\,\frac{P_2(V_2 - V_{L2})}{RT_2}\right) \qquad \text{moles G} = \frac{P_2(V_2 - V_{L2})}{RT_2}$$

5,000 kg 100 m Bettis TMI-2



2.5-10^7 Fong 8-721-6527

95 & 147 chains

Any sign of gelatinous ppt? off-color?

Mass chains 95 & 147 Nd

1.5

1 ml

95 Zr

Radiochemistry

721-5527

NH_3

O_2 3

$P(atm) = 8 \times 10^4 X$

$X = \frac{0.8}{8 \times 10^4} = 0.1 \times 10^{-4} = 10 \text{ ppm}$

H_2O_2

290 m^3

25 cc → 2 cc. Kg

H• 3.6×10^8 ml

H_2

2.9 ppm

330

H•

H_2

.4 cc cc/Kg

12

I_2

I_2

23 cc/Kg

N_2

14N

7 PPM

BNL

717
944 0301

no ^{16}O ^{15}N

Gas Sizing

0.4 cc/Kg H_2

2.9 cc/Kg O_2

total 25 cc/Kg

3.8×10^8 ml

$\therefore 3.8 \times 10^5$ Kg

↓ per 1 cc/Kg

3.8×10^5 cc (STP)

380 l.

× 25 cc = 9.5×10^3 cc

$\frac{9.5\ l}{380}$ /l

$$\frac{\frac{9.5}{22.4}}{55.5\ \frac{380}{55.5}} = \frac{0.42}{21{,}000}$$

$\therefore X_{gas} = 2 \times 10^{-5} \times 8 \times 10^{4} =$ 1 atm

mass chain	% fission ~~Kgs/10^3 MW-years~~	Kg 10^3 MW-years
85	1.33	Kr 0.75
6	1.94	Kr
7	2.56	Rb
8	3.7	Sr
9	4.8	Y
90	5.9	Sr 18
1	5.9	Zr, Y
2	6.0	Zr
3	6.4	Zr
4	6.5	Zr
5	6.5	Mo, Zr, Nb
6	6.3	Zr
7	5.9	Mo
8	5.8	Mo
9	6.1	Tc 27.5
100	6.3	Mo
1	5.1	Ru
2	4.2	Ru
3	3.1	Rh, Ru 14.8
4	1.83	Ru
5	.95	Rh
6	.39	Ru
7	.12	Pd
8	.07	Pd
9	.03	Ag
110	.02	Pd
1	.018	Cd, Ag
2	.013	Cd
3	.013	Cd
4	.013	Cd
5	.011	In, Cd
6	.011	Cd
7	.016	Sn
8	.015	Sn
9	.013	Sn

120	.013	Sn	
1	.018	Sb	
2	.015	Sn	
3	.024	Sb, Sn	
4	.02	Sn	
5	.025	Te(Sb)	
6	.05	~~[illegible]~~ Sn	
7	.014	I	
8	.40	Te	
9	.9	I	
130	2.0	Te	
1	2.77	Xe, I	
2	4.13	Xe	
3	6.77	Cs	
4	7.19	Xe	
5	6.7	Cs	
6	6.12	Ba, Xe	
7	6.23	Cs	
8	6.7	Ba	
9	6.6	La	
140	6.3	Ce(La)(Ba)	
1	5.9	Ce	
2	6.0	Ce	
3	6.0	Nd	
4	5.45	Nd (Ce)	50.
5	3.95	Nd	
6	3.00	Nd	
7	2.26	Pm (Nd)	
8	1.69	Nd	
9	1.07	Pm	
150	.65	Nd	
1	.423	Pm	
2	.265	Sm	
3	.16	Sm	
4	.071	Sm	
5	.033	Eu	
6	.013	Gd, Eu	