Radiological Assessments Suggestion for Improvement on Regulatory Radioactive Waste Clearance Level of the Scrap Metal and Concrete Shell at Radioactive Waste Management in Indonesia

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Abstract

Since it first was operated in 1988, the facility of radioactive waste management installation in National Nuclear Energy Agency (BATAN) Indonesia has many radioactive waste packages in cementation form 1070 of drums 200 liters, 148 of concrete shell 950 liters and 10 of wooden box which is contain with contaminated scrap metal. The waste package has been stored in the interim storage building that the capacity is very limited, so in order to ensure the sustainability of the storage of radioactive waste treatment, it is necessary to discharge waste packages that have fulfilled the regulatory clearance level of radioactive waste. As the wastes have been stored more than 28 years, some of them can be regulatory cleared. Before such regulatory clearance, radiological characteristics of the waste should be analyzed first. In this assessment, the procedure for representative sampling and analysis waste was developed. According to the analysis result, Cs-137 and Co-60 were major radionuclide while some of wastes were contaminated with Th-234, Ra-226, and U-238 with an extremely low concentration. Based on IAEA GSR Part 3, the analysis result shows that radioactive wastes in concrete shell have activity concentration of Cs-137 and Co-60 far as below 0.1 Bq/g. The contaminated scrap metal also have radioactivity α contamination as below 0.37 Bq/cm^2. It was estimate individual dose as below 10 μSv/years. This assessment can be applied as suggestion for improving on National Energy Regulatory Agency (BAPETEN) regulatory regarding clearance level of the scrap metal and concrete shell at radioactive waste management in Indonesia.

Keywords: *radiological assessment, scrap metal waste, concrete shell waste, regulatory clearance*

1. Introduction

Since it was first operated in 1988, the facility of the radioactive waste management installation - National Nuclear Energy Agency (BATAN) annually always treats and manages the radioactive waste from internal and external BATAN. The results of radioactive waste treatment in Center for Radioactive Waste Technology - BATAN are radioactive waste packages in the cementation form of radioactive waste in 200 liters drums and 950 liters concrete shell liters. There is also radioactive waste resulting from decommissioning of phosphoric acid purification facility of Petrokimia Gresik Inc., which has done decontamination effort in the form of scrap metal.

The waste package that has been processed so far is radioactive waste packages in cementation form 1070 of drums 200 liters, 148 of concrete shell 950 liters and 10 of wooden box which is contain by contaminated scrap metal. The waste package is stored in the Interim Storage building (IS-1 and IS-2). The storage capacity of IS-1 and IS-2 Buildings are very limited, so in order to ensure the sustainability of the storage of radioactive waste treatment, it is necessary to expend/ discharge waste packages that have fulfilled the clearance level.

In the effort of expenditure or release of waste packages, measurement, calculation and asessment of the clearance level on radioactive waste of processed products has been done. Against the radioactive waste that has reached the level of the clearance together this is requested for release of supervision through mechanism of stipulation of the clearance by BAPETEN. Radioactive waste proposed for the determination of clearance shall be in the form of:

- Relatively large pieces of metal originating from the activity of decommissioning of phosphoric acid purification facility of Petrokimia Gresik, Inc which has done decontamination efforts in Center for Radioactive Waste Technology - BATAN.
- Package of processed waste in the form of a 950 liters concrete shell containing the cementation result of the evaporative concentrate.

2. Role and Regulations

The role and regulation regarding clearance level and radioactive waste management are :

- International Atomic Energy Agency (IAEA) - General Safety Requirements (GSR) Part 3, "Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards" [8].
- Government Regulation of the Republic of Indonesia No. 61/2013 on the Radioactive Waste Management[6].

- Government Regulation on the Republic of Indonesia No. 101/2014 on the Management of Hazardous and Toxic Waste[7].
- BAPETEN Chairman Regulation No. 16/2012 on Clearance Level of Radioactive Waste[1].
- BAPETEN Chairman Regulation No. 08/2016 on the Low and Medium Level Radioactive Waste Treatment[3].

3. Equipment and Working Procedure

3.1. Equipment

The type of radiation measurement monitor likes contamination monitor, dose rate monitor and gamma spectrometer. Contamination Monitor: Canberra MCB2 sn.0144 and 0161, Ludlum 2241 sn.139617 Pr.143882 and CoMo 300 Sn.0352. Doserate Monitor: Surveymeter Terra sn.1500089, and Gamma Spectrometer: Gamma spectrometer portable BNC SAM 945N sn. HHADA8-G B, Gamma spectrometer portable identiFINDER Mirion HDS-101 G sn. 600201 and Multichannel Analyzer (MCA) Ortec Model A 66 B 32 Ver. 6.09

3.2. Working Procedure

The flow chart of the process procedure for determining clearance of radioactive waste is as follows:

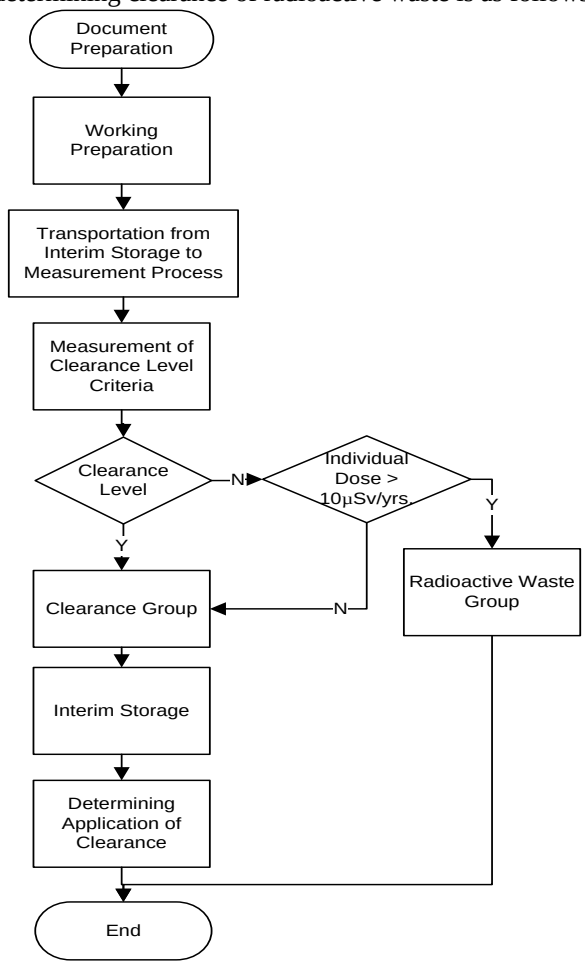

Figure 1. The Working Procedure for Determining Clearance of Radioactive Waste

The data requirement compliance of clearance level for scrap metal and concrete shell 950 liters or radioactive waste is as follows:

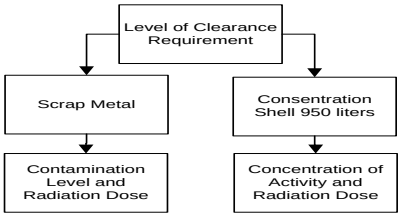

Figure 2. Data Requirement Compliance of Clearance Level for Scap Metals and Concrete Shell 950 liters Radioactive Waste

Measurement of clearance level of metal scraps work instructions: The scrap metal to be measured at the level of clearance is placed on the measuring table. Metal cutting surfaces are divided into 9 parts (grid), marked using permanent markers. The level of surface contamination is measured on all parts of the metal cut surface. The distance between the metal cutting surface and the surface contamination measuring detector is 3 mm. The highest value recorded as a result of measurement of the level of surface contamination on each grid. The dose rate is measured using a surveymeter by combing all metal cutting surfaces. The highest dose rate recorded from every metal surface then the position of the metal piece is reversed. The measurement steps are repeated as before.

The calculation and measurement of kasteens level of processed waste package in the form of a 950 liters concrete shell containing cementation of evaporated concentrate work instructions: The basic calculation activity and concentration of radionuclide activity in concrete cementation of evaporated likes result of enumeration concentration activity of evaporated concentrate before dissapation, date of enumeration, volume concentrates, the volume of concrete shell, concrete density of cementation result. The concentration of concrete activity of cementation result of evaporative concentrate compared with radionuclide clearance level in BAPETEN Chairman Regulation of No.16/2012 on Clearance Level of Radioactive Waste. The concrete shell which according to the calculation already meets the level of clearance is removed from the storage warehouse and put in areas that have a low dose rate dose. The dose rate of the entire surface of the 950 liters concrete shell is measured by combing the entire surface, the highest dose rate is recorded, the level of surface contamination of the 950 liters concrete shell is measured by combing the entire surface. The level of surface contamination is recorded.

4. Analysis Result

According the analisis result, radionuclide major in scrap metal and consentrate shell:

Table 1. The Scrap Metal of Radioactive Waste for Clearance Level.[11]

No. Sample	Weight (kg)	Volume (cm^3)	Average Activity (Bq/cm^2)	Doserate (μSv/hr)
1	26	4896	0.55	0.12
2	34	3627	0.29	0.13
3	36	3220	0.29	0.13
4	15	1935	0.26	0.13
5	27	2115	0.08	0.12
6	55	5775	0.33	0.13
7	15	1892	0.02	0.13
8	38.6	4688	0.31	0.14
9	26	2253	0.06	0.12
10	33	2763	0.24	0.14
11	30.6	4092	0.2	0.13
12	13	1951	0.42	0.13
13	36	4270	0.34	0.13
14	22	3000	0.3	0.13
15	41.6	4278	0.34	0.13
16	36.5	4305	0.29	0.13
17	27.4	3477	0.21	0.13
18	25	3200	0.27	0.13
19	30	4367	0.33	0.13
20	35	4209	0.32	0.13
21	31.6	4402	0.28	0.13
22	39	4836	0.25	0.13
23	35	4563	0.36	0.12
24	39	4526	0.43	0.13
25	20	2790	0.36	0.13
26	11	744	0.32	0.12
27	3	230	0.66	0.13
28	30	3720	0.36	0.12
29	14	20170	0.56	0.11
30	40	13950	0.3	0.12
31	34	4375	0.58	0.13
32	9	75	0.97	0.12
33	18	175	0.11	0.12
34	39	4526	0.17	0.13
35	42	824	0.03	0.13
36	18	408	0.54	0.12

Radiation doserate background= 0.12μSv/hr.

Table 2. The Concrete Shell of Concentrate Radioactive Waste for Clearance Level.[11]

No. Shell	Nuclide	Activity Consen-tration (μCi/ml)	Compo-site Activity Consen-tration (Bq/g)	Dose-rate (μSv/ hr)
1A	Cs-137	5.00.E-06	0.010168	0.14
2A	Cs-137	9.50.E-07	0.001955	0.16
3A	Cs-137	9.09.E-07	0.001905	0.16
4A	Cs-137	6.81.E-07	0.001448	0.15
5A	Cs-137	2.50.E-07	0.000527	0.15
6A	Cs-137	9.00.E-06	0.019067	0.15
7A	Cs-137	2.50.E-05	0.053753	0.15
10A	Co-60	7.70.E-06	0.001378	0.15
11A	Co-60	1.27.E-05	0.002336	0.15
12A	Cs-137	3.42.E-06	0.007657	0.15
13A	Cs-137	3.97.E-06	0.008981	0.16
14A	Cs-137	3.77.E-06	0.009446	0.16
15A	Cs-137	2.14.E-06	0.004855	0.15
16A	Cs-137	3.50.E-05	0.08997	0.16

Radiation doserate background= 0.12μSv/hr.

5. Radiological Dose Assessment

The clearance criterion was applied for a determination of range of the waste for regulatory clearance[5] and also the effective dose and contamination level threshold criteria. The criteria clearance, effective dose and contamination level are shown in Table 3. The analysis result shows that radioactive wastes in concrete shell have a radioactivity far as below 0.1 Bq/g[8][9]. The contaminated scrap metal also a radioactivity α contamination as below 0.37 Bq/cm^2. It was estimate the individual dose as below 10 μSv/years[8]. The radiological doses assessment results are shown in Table 3.

Table 3. The Radiological Doses Assessment Result

Waste	Assessments	Criteria	Actual
Concrete Shell	Composite Activity Concentration	Co-60 < 1 Bq/g Cs-137 < 1 Bq/g (IAEA GSR Part3[8], BAPETEN[1])	Co-60 0.002336 Bq/g Cs-137 0.08997 Bq/g
Scrap Metal	Average Activity	α < 0.37 Bq/cm^2 (BAPETEN[2])	0.97 Bq/cm^2
Concrete Shell and Scrap Metal	Individual Dose	< 10 μSv/years (IAEA GSR Part 3[8])	6 μSv/years

Using the data parameter assessment likes 40 hours/weeks = 1920 hours work effective per years and inhalation rate 7,400 m^3/year, thickness of cover soil 15 cm/day, 60 cm (final) [5], activity concentration maximum of Co-60 = 0.002336 Bq/g, and Cs-137 = 0.08997 Bq/g, and also no dose due to ingestion was considered but an inhalation pathway and external dose was considered, the total annual dose individual dose due the cleared was estimated around 6 μSv/years. The general criteria for clearance are that the radiation risks arising from the cleared material are sufficiently low as not to warrant regulatory control, and there is no appreciable likelihood of occurrence for scenarios that could lead to a failure to meet the general criterion for clearance; or continued regulatory control of the material would yield no net benefit, in that no reasonable control measures would achieve a worthwhile return in terms of reduction of individual doses or reduction of health risks. The material may be cleared without further consideration under the terms provided that in reasonably foreseeable circumstances

the effective dose expected to be incurred by any individual owing to the cleared material is of the order of 10 μSv or less in a year [8]. To take into account low probability scenarios, a different criterion can be used, namely that the effective dose expected to be incurred by any individual for such low probability scenarios does not exceed or over than 1 mSv in a year [10].

6. Assessment and Results

6.1. Waste scrap or Metal scrap

In the early stages, screening of the entire sheet metal plate is performed. There were some sheets with high surface contamination levels. After samples of the inherited contaminants were analyzed using a Multi Channel Analyzer, the contaminant radionuclides were found in Th-234 and Ra-226, which were daughter from U-238. Based on the operating history of the Phosphoric Acid Purification Facility and the results of the contaminant analysis, it is certain that the radionuclides contaminating the metal plate are U-238 and it is child. Thus, the range of clearance levels used is 1 Bq/cm^2. There are approximately 65 sheet metal plates (carbon steel and stainless steel) that meet the limits of kiturens below 1 Bq/cm^2, with total weight of about 1,226 kg and volume of approximately 0.3 m^3. For radiation exposure measurements, the average approaches to background radiation exposure is about 0.12 μSv/hr.

6.2. The Concentrated Immobilization of Shell Waste Package Result

Concentrates derived from the effluent evaporation treatment of the BATAN research reactor (GA Siwabessy Multipurpose Reactor) is a radioactive waste containing the dominant Cs-137 and Co-60 radionuclides. The concentrate has a concentration of activity during processing (1989 - 2002) between 2.5×10^{-7}μCi/ml - 3.6×10^{-4} μCi/ml around (9.2×10^{-3} Bq/ml - 1.3×10^{1} Bq/ml). With a concentrate volume in each of the 235 liters concrete shells, total activity can be calculated in 1 concrete shell which is range from 0.059 μCi - 84.60 μCi around (2.18×10^{3} Bq - 3.13×10^{6} Bq). With the half-life of the dominant radionuclides, the volume, and the density of the cemented waste product, it can be calculated the activity concentration of each of the concrete shell waste packages at the present time. In accordance with BAPETEN Chairman Regulation of No.16/2012 on Clearance Level of Radioactive Waste, for artificial radionuclides Cs-137 and Co-60 are 0.1 Bq/g[1]. In addition to calculations and asessment for the current concentration of activity, the most recent radiation exposure measurements to complete the clearance determination application to BAPETEN were fulfilled. From the calculations, measurements and asessment, there are 14 concrete waste shell packages of 950 liters of concentrate immobilization results meet the clearance limits. If the request for clearance on 14 concrete waste shell packages needs approval by National Energy Regulatory Agency (BAPETEN), the waste storage space that can be reused for another around 22.53 m^3 waste package. This assessment can be applied as suggestion for improving on BAPETEN regulatory regarding clearance level of the scrap metal and concrete shell at radioactive waste management in Indonesia.

7. Conclusions

Based on the dose assessment results, that radioactive wastes in concrete shell have a radioactivity far as below 0.1 Bq/g and the contaminated scrap metal have radioactivity α contamination as below 0.37 Bq/cm^2 and also it was estimate individual dose as below 10 μSv/years, so it was considerate for clearance. The analysis assessment result shows that radioactive wastes in concrete shell and scrap metal are above meets the limits of clearance level in BAPETEN Chairman Regulation No. 16/2012[1], so there is no need for radiology study such as effective dose calculation to critical group.

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