Minimum Beryllium TQ (Metal or Oxide) for a Low Chemical Hazard Categorization at TA-21 MDA-B

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Abstract

During excavation of a 1940's landfill at the Department of Energy (DOE) Los Alamos National Laboratory (LANL), TA-21 Material Disposal Area (MDA) B, that had received hazardous and radiological contamination, on February 22, 2011, operators excavating a trench in Enclosure #9 observed a significant quantity of Beryllium (Be) in 16 glass (mason) jars. A conservative estimate of 20 pounds (lb) was assumed as a bounding inventory to evaluate the impact of the discovery on its chemical hazard categorization (HC). The MDA-B was earlier categorized as a chemical **Low** hazard facility, based on 170 chemicals, including one lb of Be inventory. At LANL, a facility is considered to be a **Low** hazard if the chemical quantity, based on consequences, is below the Protective Action Criteria (PAC)-3 Threshold Quantitiy (TQ) at 100 m, a **Moderate** if the quantity exceeds the PAC-3 TQ at 100 m, and a **High** if the quantity exceeds the PAC-3 TQ for the public at the site boundary (SB). The SB distance is 20 m which presents a unique situation because the TQs at 20 m are ~ 9 times lower than the TQs at 100 m.

EPIcode was used for spill, fire, and explosion scenarios to evaluate consequences assuming 90% Be metal and 10% Be oxide as conservative. PAC-3 for BeO is 11.1 mg/m^3 and Be metal is 0.1 mg/m^3. An Explosion of 6 lb TNT was used as the bounding scenario for MAR, because of its high respirable release fraction. Using a hazard index (HI) approach, results show that 100% Be metal yields a TQ of 32 lb and 100 % BeO yields TQ of 50 lb to maintain a **Low** chemical HC. Other % distributions of Be metal and oxide lie in between. The Low chemical HC was also verified by evaluating an aircraft crash impact plus fire. The NNSA/LASO approved a new TQ of 32 lb for Be metal. This exercise provides important information in establishing an operational procedure to limit the amount in future excavation in order to maintain Low CHC.

1.0 Introduction

This document focuses on: 1) Describe the beryllium discovery inside Enclosure # 9; 2) Account for the potential to unearth more beryllium; 3) Describe limited airborne release measured by air monitoring equipment inside Enclosure # 9; 4) Describe properties of beryllium and beryllium oxide (BeO); 5) Use bounding scenarios of fire, spill, explosion, and aircraft crash to calculate concentrations at receptor distances (e.g., site boundary); 6) Reevaluate chemical hazard categorization; and 7) Establish TQ for Be metal and BeO for different proportions.

MDA-B environmental restoration is a Below Hazard Category 3 nuclear facility (i.e., "radiological facility") per MDAB-ABD-1004, R.1.1, *Final Hazard Categorization Document for MDA* [1]. Chemical hazards were evaluated for the nuclear hazard categorization in terms of their impact on radiological releases that could affect the quantities of radioactive inventory or their release characteristics. Be cannot impact the radiological MAR. Therefore, the discovery of larger quantities of Be do not affect the Below Hazard Category 3 determination.

2.0 Incident Description

On February 22, 2011, MDA-B operators were excavating a trench (15 ft W x 15 ft deep) that is in the middle of Enclosure 9. At the dig-face, a significant quantity of beryllium (Be) was observed. Sixteen glass (Mason) jars from ~30 inches (in.) below grade were excavated from the trench, and then placed in the sorting area. An unknown number of jars were broken in the trench so this material was mixed with the soil. Also, as a priority, the project Industrial Hygienist removed a jar from the dig face, took to a nearby safe area, and took samples for evaluation.

One wipe sample was taken from the inside surface of this open container. The Lab analysis showed that the wipe sample contained 40 mg/100 cm^2 (standard size by NIOSH), which is interpreted as a combination of Be powder (i.e., small metal spheres) and dust (loose contamination), and loose soil (i.e, dirt). Proportion of Be powder, Be dust, and dirt is unknown. It is believed that loose material is mainly from the soil (not from Be-dust) because of the ongoing excavation and remediation activities in the landfill area.

Figure 1 includes 2 photos showing the condition of Be and jars. In these photos, dust is <u>un-noticeable</u> in glass jars. Jars contain mainly powder/chips with blue color appearance due to blue film. A bulk sample was taken from inside the jar. Analysis shows 97.2% beryllium shaving/ chip (2mm) and with lead and nickel comprising the remainder. From the appearance, Be metal chips look light and flaky in the glass jars. Weight information was not available. Operations personnel estimated that about 16 lb, in 16 jars (~ 1 lb/jar), was uncovered, so 20 lb was assumed to estimate a bounding inventory to reevaluate MDAB's chemical hazard categorization. Based on the earlier evaluation of the postulated inventory of170 chemicals, in which the Be inventory was estimated to be one lb, MDA-B was categorized as a chemical **Low** hazard site [1, 2].

Photo 1

Photo 2

Figure 1. Photos of Beryllium in Jars in MDA-B Enclosure #9.

3.0 Beryllium Properties, Oxidation, and PAC-1, -2, -3 Values

In brief, Be metal has a density of 1.85 g/cm^3, with a melting point at 1278 ^{0}C. Beryllium metal is hard, brittle and looks gray white. It is resistant to oxidation at ordinary temperatures but is susceptible to oxidation at higher temperature. Beryllium in reaction with acid and alkalies produces beryllium hydride (BeH_2) and hydroxide (Be $(OH)_2$ as white powder. On heating at 138 ^{0}C, beryllium hydroxide converts to stable beryllium oxide (BeO) white powder with a melting point of 2370 ^{0}C and density of 3.02 g/cm^3[3].

Beryllium metal has a strong affinity for oxygen (from air) to form oxide, so called oxidation ($2Be + O_2 \rightarrow 2BeO$). This oxide layer, called "blue film", is a thin (a few microns; 1.2% to 8.1% of coating), tight coating on the Be metal. It serves as a protective layer (vapor-diffusion barrier) that is continuous, non-porous and tightly-adherent (like an egg shell). In a fire, at elevated temperatures, Be vapors diffuses through the protective layer (blue oxide) and forms different physical characteristics of white "fluffy" material and leads to oxidation. <u>The oxidation depends on the temperature, duration of the fire, and the amount of material and its form</u>. Higher the temperature, higher is the degree of oxidation.

The Protective Action Criteria (PACs) are established from Acutre Exposure Guideline Levels (AEGLs), Emergency Response Planning Guidelines (ERPGs), or Temporary Emergency Exposure Limits (TEELs), based in that order of availability in the literature. The PAC values

are available from the DOE Subcommittee on Consequence Assessment and Protective Actions (SCAPA) database at: http://www.hss.doe.gov/HealthSafety/WSHP/Chem_Safety/teel.html

PAC values for beryllium metal and oxide are shown in Table 1.

Table 1. PACs for Beryllium and its Oxide*

Compound	PAC-1 (mg/m^3)	PAC-2 (mg/m^3)	PAC-3 (mg/m^3)
Beryllium metal, Be	0.0035	0.025	0.1
Beryllium oxide, BeO	0.2	1.39	11.1
Ratio of BeO/Be	57	55.6	111

* Values are taken from SCAPA PACs Rev 26; 1 mg/m^3 = 2.72 ppm.

On oxidation, Be is converted to BeO, which has 111 times larger threshold value than Be metal (11.1 vs. 0.1 mg/m^3), based on the comparison of PAC-3 values. Thus, in a major fire scenario, when Be is oxidized to BeO then it is less hazardous to a receptor.

4.0 Facility Hazard Category Criteria

P 111-1, *Facility Hazard Categorization* [4] provides specific categorization guidance for chemical hazards using PAC-3 values. PAC-3 is defined as the "the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects".
A facility is considered to be a Low hazard category if the chemical quantity, based on consequence, is below the PAC-3 level at 100 m, a Moderate if the chemical quantity exceeds the TQ at 100 m for a non-involved worker, and a High if the chemical quantity exceeds the PAC-3 for the public.

The PAC-3 values are used to calculate TQs that represent the maximum inventory (lbs) that will not exceed the PAC-3 concentration at the selected receptor location from an airborne release. Site boundary distance is typically farther than 100 m distance for most of the facilities, and thus TQs for the public are usually higher than TQs at 100 m, evaluated for the collocated workers. However, the situation in the MBA- B is unusual. The site boundary is only 20 m from the facility, which is 5 times shorter than the collocated worker location. The TQs of a chemical based on PAC-3 value at 20 m for the public are about 9 times lower than the TQs of the same chemical at 100 m for the workers [2]. Therefore, EPIcode chemical dispersion model as discussed below is used to determine appropriate TQs for chemical HC at MDA-B.

5.0 Beryllium: Airborne Release Fractions/ Repirable Fractions (ARF/RF)

Mishima et al (2006, 2008) [5, 6] provided comprehensive reports on the airborne release fractions and respirable fractions (ARFs/RFs) based on the literature review on the physical and chemical properties of beryllium metal and its oxide, oxidation and ignition of beryllium metal, and accidents involving beryllium releases. The reports include the experimental findings and discussion of earlier report (2001) [7]. Most importantly, the reports provide the size fraction information (<8.0 µm to <100 µm in 12 increments) that was used to calculate the ARF/RF values for different forms of beryllium [large coherent metal, powder (i.e., small metal

sphere)/chips, turnings/swarfs, and dust layer (BeO)] under various accident conditions, summarized in Table 2.

Table 2. Summary of ARF X RF Values for Encased Be Metal*

Condition	Airborne Release Fraction (ARF) x Respirable Fraction (RF) Values			
	Large, Coherent Items	**Powder/Chips**	**Turnings/Swarfs**	**Dust Layer**
Explosion, detonation	1E-1/0.3	1E-2	1E-2	4E-1
Explosion, deflagration	<1E-6	1E-2	1E-2	4E-1
Explosive Release [a]	<1E-6	1E-3	1E-2	1E-1/0.7
Fire, Be heated	3E-6	1.5E-5	2E-4	3E-4
Fire, Be ignited		4E-1	4E-1	4E-1
Fire, packaged combustible waste, waste ignited, Be heated	-	1.5E-5	-	3E-4
Fire, packaged combustible waste, waste and Be ignited	-	-	-	4E-1
Free-fall Spill	<1E-6	<1E-6	<1E-6	2E-3/0.3
Crush-Impact	<1E-6	<1E-6	<1E-6	1E-3/0.3
Shock-Vibration	<1E-6	<1E-6	<1E-6	1E-3/0.3
Resuspension	<1E-6	<1E-6	<1E-6	4E-5/hr

*Taken from Jofu Mishima et al [2006, 2008] – see its footnotes for explanations. Oxidation largely depends on the fire temperature, duration of the fire, and the amount of material involved and its form; [a]. For overpressure 500-psig and less.

Oxidation: Typically beryllium is present as a metal with a few micron (1-8%) blue oxide film, which is tightly-adherent and contributes negligible mass. Corrosion leading to oxidation is a slow process. However, over time (~ 70 years) in the presence of moisture in soil can contribute noticeable oxidation and thus this evaluation assumes a significant proportion of beryllium oxide (BeO). It was also noted in MDA-B *Final Hazard Categorization* document [1] that "beryllium and mercury may exist as contamination in the landfill and thus were not evaluated. However, elemental beryllium was scarce enough in the 1940s that BeO was used where possible; recovery of scraps and turnings of both was recorded". In view of this consideration, both BeO and Be metal are used for calculations in accidental releases. As a conservative estimate, 90% Be metal and 10% BeO as dust were assumed for fire, spill and explosion scenarios. The selection of ARF/RF of Be metal and BeO with their corresponding PAC-3 values are listed In Table 3.

Table 3. Selection of ARF/RF Values for Be and BeO and PAC-3 Values*

#	Scenario	Form	ARF/RF	PAC-3 (mg/m^3)	Oxidation
1	Fire	Be metal powder/chips	1.5E-5	0.10	No
		BeO (dust)	3E-4	11.1	yes
2	Spill	Be metal powder/chips	1E-6	0.1	No
		BeO (dust)	6E-4	11.1	Yes
3	Explosive Release	Be metal powder/chips	1E-3	0.1	No
		BeO (dust)	7E-2	11.1	yes

*ARF/RF values are selected from Table 2.

For explosive release, DOE-HDBK-3010-94 (Section 4.4.2.2.2) cites lower values of ARF as 5E-3 and RF as 0.3 (ARF/RF = 1.5E-4 from pressure pulse generated) for oxide form of material [8]. However, 1E-3 is used for over-pressure 500 psig and less [5, 6]. Detonation and deflagration, although have higher value of ARF/RF (Table 2), are not considered credible from the peroxide or shock sensitive chemicals because there is no expectation that these chemicals would be disposed in direct contact with the beryllium bottles in the landfill based on common chemical safe handling practices followed in 1940s. Explosives are present in MDA-B and some beryllium was dispersed in soil and thus explosive release involving Be is considered credible and is evaluated here. The ARF/RF is possibly lower than 1E-3 because of Be mingled with soil, however, ARF/RF of 1E-3 is used as conservative. Explosive release also governs the MAR limit for the Low hazard categorization due to its higher ARFxRF and lower PAC-3 for Be metal.

6.0 Beryllium Concentration Calculations by EPIcode

It is assumed that the unearthed material is Be powder/chips (metal form) with 10% BeO as dust. Three bounding scenarios (20 lb each) are considered for quantitative estimation of the concentration for chemical HC. Damage ratio and leak path factor are assumed to be unity. The scenarios are fire, spill and explosive releases. An aircraft crash involving a spill and fire release was also evaluated as a confirmatory check of the chemical HC.

Because the PAC-3 values are different for Be and BeO, for simplification, each Be form is treated separately assuming 20 lb MAR and subsequently the results are normalized to their PAC-3 values to calculate a hazard index (HI) (see Section 7.1). For this re-evaluation of MDA B, a distribution of 90% Be powder/chips and 10% dust as BeO (see Section 7.1); other % distributions are evaluated in Section 7.2). Calculations are performed using EPIcode chemical dispersion model, which is an approved computer codes in DOE Toolbox [9]. EPICode's window version (7.0) is used for these bounding scenarios.

6.1 Parameters used for Modeling

Recommended parameters by DOE-EH-4.2.1.3-EPICode Code Guidance for safety analysis document [10] used for consequence calculations are as follows. These inputs are consistent with the original EPIcode evaluation presented in Appendix C of the MDA B Facility Safety Plan [2].

- Release type: Term release is used for fire and spill, which is modeled as a ground level release with no plume buoyancy and centerline plume concentration provides the maximum exposure to the receptor. Term release is highly conservative relative to a 5 or 10 MW fire that involves lofting. Explosive release is evaluated using 6 lb TNT [13].
- Stability Class: F, which is stable and a conservative estimate.
- Wind speed: 1-2 m/sec is assigned for F stability. 1.5 m/sec at 10 m height has historically been assumed for chemical dispersion and consequence evaluations by the U.S. Environmental Protection Agency (EPA) and the DOE.
- Deposition velocity of 0.3 cm/sec is recommended [10].
- Release effective height: 0 meter, which is ground level release.
- Receptor height 1.5 m, normally chest height and breathing zone.
- Release time (RT) and sampling time (ST) of 15 min each is recommended as the time weighted average (TWA) to compare with the ERPG/TEEL values, although they are defined

as exposure up to one hour [11, 12]. Calculations are performed using RT = 15 min and ST = 15 min for each case.

- RF =1.0, because ERPG/TEEL-3 assumes total concentration exposure to a receptor.
- Terrain Standard: Open country which is more conservative than City terrain.
- Downwind X-meter: Plume centerline, Y-meter 0.

The results for each scenario are summarized in Table 4. Distances taken for evaluation are 30 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m, 100 m, 200 m, 400 m, 700 m, and 1000 m. Oxidation (yes/no) for Be metal and BeO are also shown in Table 4.

Table 4. Summary of Beryllium Concentrations at Different Distances

	Fire (Term release) Release Time = 15 min; Sampling Time = 15 min		**Spill (Term Release) Release Time = 15 min; Sampling Time = 15 min**		**Explosive Release Release Time = 15 min; Sampling Time = 15 min**	
MAR	20 lb	20 lb	20 lb	20 lb	20 lb	20 lb
Be Form	Powder/Chips	Dust (BeO)	Powder/Chips	Dust (BeO)	Powder/Chips	Dust (BeO)
ARFxRF	1.5 E-5	3E-4	1E-6	6E-4	1E-3	7E-2
Source Term	3.0E-4	6.0E-3	2E-5	1.2E-2	2E-2	1.4
Deposition Velocity	0.3 cm/sec	0.3 cm/sec	0.3 cm/sec	0.3 cm/sec	0.3 cm/sec	0.3 cm/sec
					6 lb TNT, Cloud Top 119 m	
Concentration	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3
30 m	6.6E-4	0.013	4.4E-5	0.026	0.063	4.4
40 m	3.0E-3	0.060	2.0E-4	0.12	0.060	4.2
50 m	5.0E-3	0.10	3.3E-4	0.20	0.058	4.1
60 m	**5.7E-3**	**0.11**	**3.8E-4**	**0.23**	0.056	4.0
63 m*, max conc.	**5.8E-3**	**0.12**	**3.9E-4**	**0.23**	--	--
70 m	**5.7E-3**	**0.11**	**3.8E-4**	**0.23**	0.055	3.8
80 m	5.2E-3	0.10	3.5E-4	0.21	0.053	3.7
90 m	4.7E-3	0.094	3.1E-4	0.19	0.052	3.6
100 m	4.1E-3	0.082	2.7E-4	0.16	0.051	3.5
200 m	1.3E-3	0.025	8.5E-5	0.051	0.041	2.8
400 m	3.1E-4	6.2E-3	2.1E-5	0.012	0.030	2.1
700 m	9.7E-5	1.9E-3	6.4E-6	3.9E-3	0.022	1.5
1000 m	4.7E-5	9.4E-4	3.1E-6	1.9E-3	0.017	1.2
Oxidation	No	Yes	No	Yes	No	yes
ERPG-3 mg/m^3)	**0.10**	**11.1**	**0.10**	**11.1**	**0.10**	**11.1**
ERPG-2 mg/m^3)	0.025	1.39	0.025	1.39	0.025	1.39
ERPG-1 mg/m^3)	3.5E-3	0.2	3.5E-3	0.2	3.5E-3	0.2
Hazard Category	**Low**	**Low**	**Low**	**Low**	**Low**	**Low**
*Bold values at 63 m are used for 30 m public receptor. It should also be noted that previous LANL χ/Q of SB for calculating TQs is ~46% higher than χ/Q by EPIcode, indicating that EPIcode results are conservative.						

7.0 Discussion of Results

The EPIcode term release plot for fire is shown in Figure 2, and follows the same pattern for spill. With 1.5 m receptor height, the initial plume rises to peak plume concentration at 60-70 m, and the value at 30 m may have significant uncertainty. The highest value at 63 m (in bold in Table 4), which is ~ 9 times higher than at 30 m, is taken for the 30 m public receptor as a conservative estimate (Figure 2). It should be noted that if a fire scenario with lofting (5 or 10 MW) is considered, Be concentration at 60 m is 1 to 2 orders of magnitude lower as compared to the values listed in Table 4 for the term release, which is highly conservative.

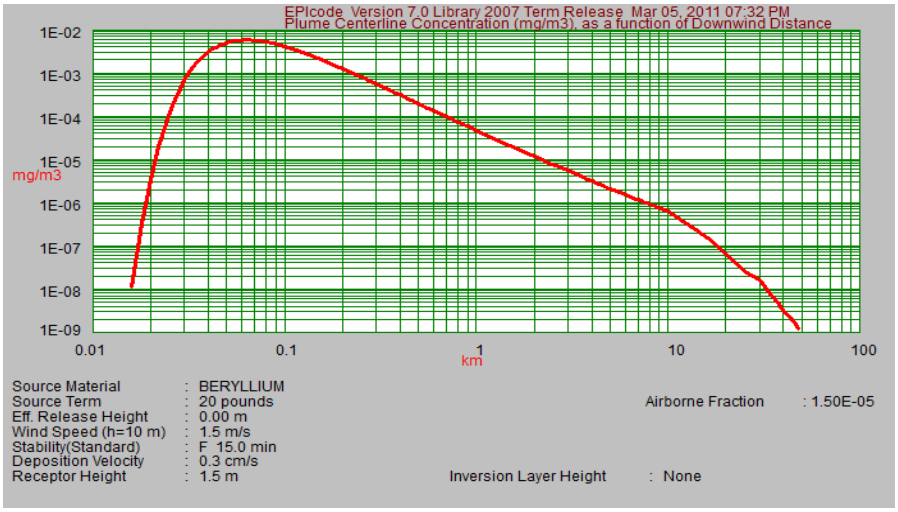

Figure 2. Concentration vs Distance Plot for Powder/Chips for Fire as Term Release.

Figure 3 shows a plot of explosive release with a 6 lb TNT equivalent, based on a 9-liter bottle of 10% peroxide and 90% diethyl ether solution (peroxide and shock sensitive chemicals) [13]. The debris cloud top is 119 m. The concentration is about constant from 30 m to 100 m and gradually declines to 1 km, and rapidly beyond 1 km. The MDA-B CHC on Be metal powder/chips and dust-BeO under fire, spill and explosive releases is a Low hazard category (Table 4). Section 7.2 provides a further evaluation of different distribution of metal and oxide.

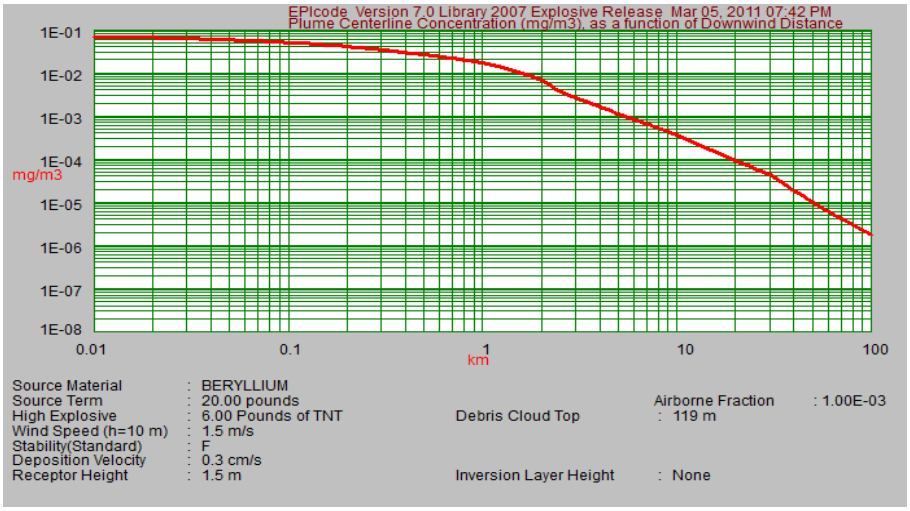

Figure 3. Concentration vs Distance Plot for Powder/Chips for Explosive Release.

The MDA-B chemical hazard categorization based on Be metal powder/chips and dust-BeO under fire, spill and explosive releases is a Low hazard category (Table 4). Section 7.2 provides a further evaluation of different distribution of metal and oxide.

It should be noted that the EPIcode calculates concentration at 30 m (minimum distance), while the site boundary (public) is at 20 m. This is because the Gaussian atmospheric dispersion calculation method may not be valid at 20 m. However, there is a precedent to use results at 30 m in the DOE-STD-1027 [14] basis for Hazard Category-3 thresholds based on the EPA Reportable Quantity methodology, and DOE Order O 151.1 C for emergency planning [15]. Thus, results used at 30 m are valid and the conclusion reached at 30 m can also be used for 20 m.

7.1 Hazard Index

A hazard index (HI) is defined as the ratio of chemical concentration to PAC-3 value at the receptor distance [16]. For two or more chemicals, this ratio is adjusted with the % proportions of each chemical, and the sum of HIs or fractions (Sum of Fractions [SOF], similar concept used in DOE-STD-1027) should be less than 1.0 for a Low HC (i.e., < PAC-3 for both the public and 100 m non-involved worker). For example, concentration for Be metal powder/chips at 60 m is 5.7E-3 mg/m^3. This value is divided by PAC-3 value of 0.1 mg/m^3 to yield a ratio of 0.057. This ratio is multiplied by 0.90 to yield a value of 0.051. BeO dust 10% contribution is also calculated in the same manner with a HI ratio of 0.001 with PAC-3 value of 11.1 mg/m^3. Then the sum of two HI ratios or SOF (0.051 + 0.001) is 0.052, which is less than unity for a **Low** HC. These calculations are shown in Table 5.

Table 5. Final Calculations using HI and % Proportion for Chemical HC

Scenario	Be Form	Concentration (mg/m^3)	HI= Conc. / PAC-3	Ratio	Total HI
Fire	Power/chips at 60 m Dust (BeO) at 60 m	5.8E-3 0.12	5.8E-3/0.1= 5.8E-2 0.12/11.1 = 1.1E-2	5.8E-2x0.90= 0.052 1.1E-2x0.10= 1.1E-3	0.053
Spill	Power/chips at 60 m Dust (BeO) at 60 m	3.9E-4 0.23	3.9E-4/0.1=3.9E-3 0.23/11.1 = 0.021	3.9E-3x0.9 = 3.51E-3 0.021x0.1 = 2.1E-3	5.61E-3
Explosion	Power/chips at 30 m Dust (BeO) at 30 m	0.063 4.4	0.063/0.1=0.63 4.4/11.1= 0.396	0.63x0.9=0.567 0.396x0.1= 0.04	0.607
				Low chemical HC	<1.0

The above evaluation did not evaluate an aircraft crash for the CHC, consistent with the MDA-B FSP methodology in its Appendix C. The Below HC-3 MDA-B Final HC [1] could not conclude that a small aircraft crash into an excavation area was below the frequency screening threshold, therefore evaluated its extent of involving radioactive MAR. For perspective, an aircraft crash involving impact and a subsequent fire was also evaluated, accounting for a distribution of 90% Be metal and 10% Be oxide as evaluated above for the operational accidents involving spills and fires. Neither concentration individually exceeds its respective PAC-3 values of 0.1 mg/m^3 for Be metal and 11.1 mg/m^3 for Be oxide. The combined effect was evaluated using the Hazard Index methodology. This results in a HI of 0.058 (see Table 6), and since < 1.0, it is concluded that the aircraft crash consequence to the public does not exceed ERPG-3. This Hazard Index is less than 10% increase to the operational fire evaluated above, but is still bounded by the explosion analysis. This conclusion also applies to the consequences for the non-involved workers evaluated at a distance of 100 m from a release.

Table 6. Aircraft Crash Hazard Index

Aircraft Crash	Impact/Spill		Fire		Impact + Fire	
	Metal	Oxide	Metal	Oxide	Metal	Oxide
Form distribution	90%	10%	90%	10%	90%	10%
MAR (lb)	18.0	2.0	18.0	2.0	18.0	2.0
Airborne Release Fraction (ARF)	1.0E-06	2.0E-03	1.5E-05	3.0E-04		
Respirable Fraction (RF)	1.0	0.3	1.0	1.0		
Source Term, ST (lb)	1.8E-05	1.2E-03	2.7E-04	6.0E-04	2.9E-04	1.8E-03
Type of release	ground level		no buoyancy			
Public concentration (mg/m^3)					5.5E-03	3.4E-02
PAC-3 (mg/m^3)					0.1	11.1
Concentration / PAC-3					0.055	0.003
Hazard Index					0.058	

Concentration at 63 m determined by EPIcode unit release of 19 mg/m^3 per lb of ST

7.2 Threshold Limits (TQs) for Low Chemical Hazard Categorization

Explosive release governs the TQ for Low CHC . Total HI is 0.607 with 90% Be metal and 10% BeO. TQ is calculated as follows:

$$TQ = (1/HI) \times 20 \text{ lb or } 1/0.607 \times 20 = 32.9 \text{ lb}$$

With other % proportions of Be metal and BeO and values from Table 4, TQs are shown in Table 7.

Table 7. TQs using Different Proportions of Be metal and BeO

Be Metal (%)	Be Metal Value (mg/m^3)	HI-1 (metal)	BeO (%)	BeO Value (mg/m^3)	HI-2 (BeO)	HI-1 + HI-2	TQ = lb $\frac{1 \times 20 \text{ lb}}{[\text{HI-1 + HI-2}]}$
100%	0.063	0.63	0%	4.4	0	0.63	31.7
90%	0.0567	0.567	10%	0.44	0.0396	0.607	32.9
80%	0.0504	0.504	20	0.88	0.0793	0.579	34.5
70%	0.0441	0.441	30%	1.32	0.119	0.560	35.7
50%	0.0315	0.315	50%	2.2	0.198	0.513	39.0
0%	0	0	100%	4.4	0.396	0.396	50.4
PAC-3	0.10			11.1			

As Table 7 shows, 100% Be metal is most bounding. The explosion release is bounding because of higher ARFxRFs for both metal and oxide than fire and spill releases. All Be metal involved in an explosion results in a TQ of approximately 32 lb for a chemical Low hazard facility, and all Be oxide involved in the explosion results in a TQ of 50. Other % distributions of metal vs. oxide are shown on Table 7 and provide guidance for chemical HC purpose, however, may be important in establishing an operational procedure to limit the amount of Be that can be exposed in future excavations in order to maintain Low HC.

8.0 Conclusion

MDA-B was previously categorized as a chemical Low hazard site. With new finding of Be metal and BeO in Enclosure # 9 and depending on their metal vs. oxide percent proportions, revised TQs range from 32 lb for Be metal to 50 lb for BeO to preserve a Low chemical hazard categorization. Be inventory being excavated and sorted, or in waste containers staged in a single location, must be controlled to less than the TQ values shown in Table 7 based on the distribution of Be metal vs. oxide in order to preserve the Low chemical hazard categorization.

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