ENTERED

FW: Class 2 pmr for AMWTP

Maestas, Ricardo, NMENV
Sent: Friday, January 18, 2013 2:10 PM
To: Allen, Pam, NMENV
Attachments: EDF-0768 Rev 1.pdf (1 MB) ; EDF-0783 Rev 0.pdf (4 MB)

Email & attachment for December WIPP

From: Kliphuis, Trais, NMENV
Sent: Tuesday, December 18, 2012 4:34 PM
To: Maestas, Ricardo, NMENV; Holmes, Steve, NMENV
Subject: FW: Class 2 pmr for AMWTP

fyi

From: Pete.Johansen@deq.idaho.gov [mailto:Pete.Johansen@deq.idaho.gov]
Sent: Tuesday, December 18, 2012 3:40 PM
To: Robert.Bullock@deq.idaho.gov; Kliphuis, Trais, NMENV
Subject: RE: Class 2 pmr for AMWTP

Trais,
Here are the EDFs related to the permit modification that we will be receiving later this week.

Pete Johansen, P.E.
Waste Management & Remediation Division
Idaho Department of Environmental Quality
1410 N. Hilton
Boise, ID 83706
(208)373-0230
(208)373-0154 fax

From: Robert Bullock
Sent: Monday, December 17, 2012 4:25 PM
To: 'trais.kliphuis@state.nm.us'
Cc: Pete Johansen
Subject: Class 2 pmr for AMWTP

Trais,

Thank you for calling this afternoon.

Contrary to what I had indicated in our conversation, the documents supporting the changes to include aerosol cans for treatment in the super-compactor are actually EDFs. Although we do have hard copies of the EDFs, we will be receiving them electronically from the Permittee no later than Wednesday of this week.

We were informed that DOE signed the necessary documentation this morning.

121221

Rather than send you what we have now, Pete will send you an electronic copy of both the modification request, and the supporting EDFs when we receive them later this week.

Glad to hear that you were able to ski so early in the season.

Looking forward to doing the same here when we get enough snow.

Thanks.

Bob Bullock

EDF No.: EDF-0768	Revision No.:1	FMP No. (*if any*): N/A
Title: Analysis of Compacting Lead and Aerosol Cans	**Building/System No.:** WMF676/410	

Summary:

1. Calculations show that the Supercompactor will compact and deform solid lead, thus proving that solid lead objects will not prevent the destruction of adjacent objects during compaction.
2. Forty expended aerosol cans containing residual pressure but no propellant, in a single compaction will not challenge the Supercompactor glovebox pressure design criteria.
3. The equivalent of forty unused aerosol cans (still containing a full propellant charge) in a single compaction will challenge the Supercompactor glovebox pressure design criteria.
4. The equivalent of three fully charged aerosol cans can be simultaneously compacted without causing a loss of depression in the glovebox.

References:

1. www.matweb.com, Mechanical Properties for lead (Pb).
2. Mechanical Engineering Design, 5th Ed., Shigley & Mischke
3. TRUPACT-III PREx, Rev. 0, June 2007
4. BNFL Supercompactor Glovebox drawings
5. Air Liquide Gas Encyclopedia (online), CO_2 properties attached

Originator:	John Godak	[signature]	9/18/12
		Signature	Date:
Technical Review:	Kevin Bake	[signature] FOR KEVIN BAKE VIA TELECON	9/18/12
		Signature	Date:

Additional Reviewers: (by title)

Print Title	Signature	Date

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Print Title	Signature	Date

Distribution List:

Ron Todd, Ron Warnecke, Dave Haar, Carol Anderson, Catherine Madore, Quin Blackburn, David Young, John Godak, Kevin Bake

Approval: Quin Blackburn

Printed Name: Engineering Lead

Printed Title:

Signature: [signature] Date: 9/13/2012

Scope:

It is desired to compact certain items that have previously been prohibited from being processed through the Supercompactor. This EDF analyzes the effectiveness of compacting a lead brick, and the effects of compacting pressurized aerosol cans. Specifically addressed is the pressure transient that could be experienced from compacting these pressurized cans and how that pressure relates to the Supercompactor glovebox design criteria.

Analysis:

<u>The Compaction of Lead:</u>

The question has been raised as to whether a brick of solid lead could feasibly prevent the compaction of an adjacent object (more specifically an aerosol can) so as to cause the can to survive a compaction. The Ultimate Tensile Strength of lead is given in reference 1 as 2610 psi. Note that this tensile strength is still applicable although the analysis is for lead in compression

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(see reference 2). To calculate the area of lead required to withstand the four million pounds (2000 tons) force exerted by the Supercompactor, the simple equation below is used. F is the force exerted during compaction. P represents the Ultimate Strength of the material, and A is the area that will be attained at maximum deflection.

$$A = \frac{F}{P} \rightarrow \frac{4{,}000{,}000\ lb}{2610\ \frac{lb}{in^2}} = 1532in^2 = 10.6ft^2$$

This area is larger than what could be attained inside the Supercompactor mould (approximately 3.4 ft^2) therefore the lead would compress and flow to the point where it is contained by the mould. The point of this analysis is simply to show that the lead would deform under the force of compaction as opposed to preventing the compaction of an adjacent aerosol can.

<u>The Compaction of Pressurized Aerosol Cans:</u>

For the purposes of this analysis a standard aerosol can is used as described in reference 3. This can is the largest standard U.S. can at 872 mL. While multiple variations of propellants have been used throughout industry, the most common is a propane/isobutane mixture. In liquid form, at room temperature (70°F), this mixture provides a fairly constant pressure of 69 psig inside the can (ref. 3). At AMWTP altitude of approximately 5000 feet, this converts to absolute pressure as follows:

$$P_a = P_g + P_{atm} = 69psi_g + 12.2psi_{atm} = 81.2psi_a$$

This analysis presents two conditions of the aerosol cans during compaction, both of which assume 40 cans are involved in a single compaction. (Forty cans is a conservative estimate based on waste stream history at AMWTP.) Also note that the glovebox is assumed to have entirely enclosed surfaces and the gloves and glove ports are ignored.

The first condition is based on the assumption that the cans are completely expended, yet still hold a residual pressure due to the evaporation of the final traces of propellant after the product was expelled. Therefore, no liquid propellant vaporization is analyzed in this first condition.

The second condition does consider the expansion of liquid propellant and assumes that the can is unused and still contains both the propellant and product. For the purposes of this EDF, it is assumed that only the propellant will affect the glovebox pressure, and that the product (paint, adhesive, lubricant, etc.) in the can will not cause a pressure change when released during a

EDF No.: EDF-0768	Revision No.:1	FMP No. (*if any*): N/A
Title: Analysis of Compacting Lead and Aerosol Cans	Building/System No.: WMF676/410	

compaction. Typically aerosol cans have a product-to-propellant ratio of 3:1, thus containing 25% (by volume) propane/isobutane propellant. To be consistent with Reference 3 and due to the variable nature of the various products contained in aerosol cans, this analysis will conservatively assume the cans to contain 50% (by volume) propellant mixture.

Condition 1, Spent aerosol cans:

$$872mL = 0.031ft^3$$

$$P_1V_1 = P_2V_2 \rightarrow V_2 = \frac{P_1V_1}{P_2}$$

$$V_2 = \frac{40\ cans \times (81.2\ psi) \times (0.031\ ft^3)}{12.2\ psi} = 8.3\ ft^3$$

This expansion of pressurized gas into the glovebox introduces a temporary pressure transient. As the glovebox ventilation operates this transient will dissipate, but the initial change in pressure (P_{exp}) is calculated below. Per reference 4 and field measurements, the internal volume of the Supercompactor glovebox is approximately 3400 ft^3, and is designed to handle internal pressures from -4"wc to 4"wc. Assuming the initial pressure of the glovebox is 1 atm,

$$P_{exp} = \frac{1atm \times 8.3\ ft^3}{3400\ ft^3} = .0024\ atm = 0.99"wc$$

Since the normal operating range of the glovebox is approximately -1.5"w.c., the introduction of this 0.99"w.c. will temporarily cause the glovebox to lose some depression, but will not exceed the design basis pressure limits.

Condition 2, Full aerosol cans:

$$.50 \times 872mL = 436mL = 0.015ft^3 \text{ liquid propellant}$$

Based on the propellant mixture being similar to that shown in reference 3, and the liquid to gas dispersion ratios for propane and isobutane, the volume of gas released from 40 such cans is as follows:

$$V_{exp} = 40cans \times 0.015ft^3[(0.29 \times 272.3) + (0.71 \times 229.3)] = 145ft^3$$

EDF No.: EDF-0768	Revision No.:1	FMP No. (*if any*): N/A
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A calculation of the pressure as a result of this expansion similar to that done in Condition 1 above:

$$P_{exp} = \frac{1\ atm \times 145\ ft^3}{3400\ ft^3} = .043\ atm = 17.4"wc$$

In comparison to Condition 1 where the cans are expected to be expended, Condition 2 results in a substantially higher pressure being imparted to the glovebox which exceeds the maximum design pressure of 4"wc. Note that this equates to approximately 0.44"wc/can, therefore, approximately 9 full aerosol cans (or the equivalent thereof) could be compacted without exceeding the 4.0"wc pressure criteria of the glovebox. Normal operating pressure in the glovebox is approximately -1.5"wc so 3 full can equivalents could be compacted before causing the glovebox to lose depression and become pressurized.

Another comparison worth noting here are the results of an event which occurred in which a fire extinguisher was compacted. Video recorded during the event shows the fire extinguisher to be consistent in size with that of a 10lb CO_2 type. Assuming that the extinguisher was fully charged with CO_2, the resultant gas cloud and ensuing pressure transient are calculated as follows:

$$V_{liqCO2} = \frac{M_{liqCO2}}{\delta_{liqCO2}} = \frac{10\ lb}{64.4\frac{lb}{ft^3}} = 0.155ft^3$$

Liquid to gas expansion ratio for CO_2 is 845 (reference 5).

$$V_{gasCO2} = 845(0.155ft^3) = 131ft^3$$

This gas expansion that actually occurred within the glovebox is presented here simply as a qualitative reference by which the potential for damage to the glovebox can be estimated. The calculations in this document conservatively ignore the "shock absorber" effect that the rubber gloves in the glovebox would provide during an expansion event. It was noted during the expansion of the CO_2 from the extinguisher compaction that the gloves (which are normally pulled into the glovebox by depression) relaxed temporarily. This indicates that they indeed offer some cushioning effect against a pressure transient, although this is not taken into account in this paper in a quantitative sense.

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4. The equivalent of three fully charged aerosol cans can be simultaneously compacted without causing a loss of depression in the glovebox.

Attachments (*If any*):

N/A

Electrochemical Equivalent	3.858 g/A/h	3.858 g/A/h	

Mechanical Properties	Metric	English	Comments
Hardness, Brinell	4.2	4.2	Cast
Hardness, Vickers	5.00	5.00	
Tensile Strength, Ultimate	18.0 MPa	2610 psi	
Modulus of Elasticity	14.0 GPa	2030 ksi	
Poissons Ratio	0.420	0.420	
Shear Modulus	4.90 GPa	711 ksi	calculated

Electrical Properties	Metric	English	Comments
Electrical Resistivity	0.000020643 ohm-cm @Temperature 20.0 °C	0.000020643 ohm-cm @Temperature 68.0 °F	
	0.000027021 ohm-cm @Temperature 100 °C	0.000027021 ohm-cm @Temperature 212 °F	
	0.000036378 ohm-cm @Temperature 200 °C	0.000036378 ohm-cm @Temperature 392 °F	
	0.000047938 ohm-cm @Temperature 300 °C	0.000047938 ohm-cm @Temperature 572 °F	solid
	0.000097867 ohm-cm @Temperature 340 °C	0.000097867 ohm-cm @Temperature 644 °F	liquid
	0.000101418 ohm-cm @Temperature 400 °C	0.000101418 ohm-cm @Temperature 752 °F	liquid
Magnetic Susceptibility	-1.20e-7	-1.20e-7	cgs/g
Critical Magnetic Field Strength, Oersted	802 - 804	802 - 804	
Critical Superconducting Temperature	7.19 - 7.202 K	7.19 - 7.202 K	3.55 K at 16.0 GPa pressure for Pb II

Thermal Properties	Metric	English	Comments
Heat of Fusion	24.1 J/g	10.4 BTU/lb	
Heat of Vaporization	850 J/g	366 BTU/lb	
	866.313 J/g	372.688 BTU/lb	At Boiling Point
CTE, linear	29.1 µm/m-°C @Temperature 20.0 - 100 °C	16.2 µin/in-°F @Temperature 68.0 - 212 °F	
Specific Heat Capacity	0.100386 J/g-°C	0.0239929 BTU/lb-°F	Gas
	0.1287 J/g-°C @Temperature 25.0 °C	0.03076 BTU/lb-°F @Temperature 77.0 °F	
	0.132 J/g-°C @Temperature 127 °C	0.0315 BTU/lb-°F @Temperature 261 °F	
	0.1368 J/g-°C @Temperature 227 °C	0.03270 BTU/lb-°F @Temperature 441 °F	
	0.139 J/g-°C	0.0332 BTU/lb-°F	liquid

FIGURE 5-4

Tension specimen after necking. Radius of neck is R; diameter of smallest portion of neck is D.

as the radius of the neck (Fig. 5-4), and D as the smallest neck diameter, the equation is

$$\sigma_{ACT} = \frac{\sigma_C}{\left(1 + \frac{4R}{D}\right)\left[\ln\left(1 + \frac{D}{4R}\right)\right]} \tag{5-3}$$

When necking occurs, the engineering strain given by Eq. (5-1) will not be the same at all points within the gauge length. A more satisfactory relation can be obtained by using areas. Since the volume of material remains the same during the test, $A_0 l_0 = A_i l_i$. Consequently, $l_i = l_0(A_0/A_i)$. Substituting this value of l_i in Eq. (5-1) and canceling terms gives

$$\epsilon = \frac{A_0 - A_i}{A_i} \tag{5-4}$$

But see also Eq. (5-9).

Compression tests are more difficult to make, and the geometry of the test specimens differs from the geometry of those used in tension tests. The reason for this is that the specimen may buckle during testing or it may be difficult to get the stresses distributed evenly. Other difficulties occur because ductile materials will bulge after yielding. However, the results can be plotted on a stress-strain diagram, too, and the same strength definitions can be applied. For many materials the compressive strengths are about the same as the tensile strengths. When substantial differences occur, however, as is the case with the cast irons, the tensile and compressive strengths should be stated separately.

Torsional strengths are found by twisting bars and recording the torque and the twist angle. The results are then plotted as a *torque-twist diagram*. By using the equations in Chap. 2 for torsional stress, both the elastic limit and the *torsional yield strength* S_{sy} may be found. The maximum point on a torque-twist diagram, corresponding to point U on Fig. 5-2, is T_u. The equation

$$S_{su} = \frac{T_u r}{J} \tag{a}$$

where r is the radius of the bar and J is the polar second moment of area, defines the *modulus of rupture* for the torsion test. Note that the use of Eq. (*a*) implies that Hooke's law applies to this case. This is not true, because the outermost area of the bar is in a plastic state at the torque T_u. For this reason the quantity S_{su} is called the modulus of rupture. It is incorrect to call S_{su} the ultimate torsional strength.

All of the stresses and strengths defined by the stress-strain diagram of Fig. 5-2 and similar diagrams are specifically known as *engineering stresses* and *strengths* or *nominal stresses* and *strengths*. These are the values normally used in all engineering de

2.2 Pressure due to Aerosol Can Contents Release

2.2.1 Introduction

In a TRUPACT-III payload of one loaded SLB2, the number of unpunctured aerosol cans must be known to ensure that a potential full release of the contents from the cans is accounted for in the MNOP determination for the package. Due to the evacuation and backfill process that renders all unsealed layers of confinement non-flammable (and, therefore, any aerosol can content release into the vented void space of the package non-flammable), the presence of aerosol cans is controlled to determine a contribution to MNOP in the package. The deflagration model presented in Section 2.1, *Pressure due to Sealed Container Deflagration*, conservatively accounts for the potential release of flammable aerosol can contents and potential subsequent deflagration inside a sealed container.

Typically, the generating and packaging procedures used at TRU waste sites do not allow unpunctured aerosol cans to be packaged with the waste. While these items have been used at the sites, their possible presence in the SLB2 would be incidental to the waste stream (i.e., not primary components of the waste stream). It is unlikely that a full aerosol can would be present in the waste. Aerosol cans that have been used for their intended purpose would likely be only partially full or empty if present in the waste. However, unpunctured aerosol cans are conservatively assumed full and accounted for in the MNOP determination as outlined below.

2.2.2 Aerosol Can Contents, Size, and Pressure

The contents of an aerosol can consist of a "product" and a "propellant". Propellants can be broadly classified as fluorocarbons ($C_wH_xF_y$, $C_wH_xCl_yF_z$, $C_wBR_xCl_yF_z$), hydrocarbons (C_wH_x), ethers (C_wH_xO, $C_wH_xF_yO$), compressed gases (CO_2, N_2O, N_2, A, etc.), and methylene chloride (CH_2Cl_2). Hydrocarbons have been the dominant propellant type used for aerosol cans since 1979.[1] Hydrocarbon propellants are typically comprised of a mixture of propane and isobutane to achieve the desired pressure of the propellant. As the product of the aerosol can is expelled, the remaining liquid propellant turns to vapor, maintaining a virtually constant interior pressure until all of the propellant gas is exhausted. The physical properties of purified hydrocarbon propellants are provided in Figure 2.2-1.[1]

Aerosol cans are produced in different sizes and with varying materials of construction. The U.S. Department of Transportation (DOT) specification for metal aerosol containers define, among other parameters, a maximum product and/or contents pressure at 130 °F of 140, 160, and 180 psig for the Specification 2N (standard), 2P, and 2Q containers, respectively.[1] Figure 2.2-2 summarizes the U.S. and European standard sizes for three-piece aerosol cans, where the U.S. standard sizes range from 1-13/16 to 3 inches in diameter and 2 to 10-½ inches tall with a full volume capacity ranging from 141 to 872 ml.[1]

[1] Johnsen, Montfort A., *Aerosol Handbook* (2nd Edition), Industry Publications, Inc. 1982.

2.2.3 Percent Contribution to MNOP

An aerosol can potentially contributes to pressure in the TRUPACT-III CV via the mechanism of liquid-to-gas volume expansion of the released propellant. The aerosol can product does not contribute significantly due to the fact that it typically remains a liquid at room temperature and/or due to limitations in the pressure capacity of aerosol cans containing compressed gas and no liquid propellants. Although ethane has the largest dispersion coefficient (i.e., liquid-to-gas volume expansion) of hydrocarbon propellants, it can be concluded from the vapor pressure data provided in Figure 2.2-1 that ethane can only be utilized as a co-propellant in small quantities since its room temperature vapor pressure is above the pressure capacity of DOT spec containers. The hydrocarbon propellants with the next highest dispersion coefficients are propane and isobutane. The mixture of propane and isobutane required to achieve a pressure of 180 psig at 130 °F (327.6 K), consistent with a DOT spec 2Q container, can be determined from the proportion of partial pressures of each liquefied gas as follows (Figure 2.2-3 and Figure 2.2-4):[2]

Propane Partial Pressure	305 psi	×	29%	=	88.4 psig @ 130 °F
Isobutane Partial Pressure	129 psi	×	71%	=	91.6 psig @ 130 °F
Propellant Mixture Pressure					180 psig @ 130 °F

At room temperature (70 °F, 294.3 K) the pressure of the propane/isobutane propellant mixture is as follows:

Propane Partial Pressure	131 psi	×	29%	=	38.0 psig @ 70 °F
Isobutane Partial Pressure	44 psi	×	71%	=	31.2 psig @ 70 °F
Propellant Mixture Pressure					69.2 psig @ 70 °F

Aerosol cans typically have a product-to-propellant volume ratio of 3:1 (i.e., 75% product and 25% propellant)[3] with a total volume limited by the full capacity of the standard size aerosol can. Due to the variable nature of the products marketed in aerosol cans, it is conservatively assumed that 50% by volume of the aerosol can is comprised of the propellant mixture. Additionally, the volume capacity of aerosol cans is assumed as the largest standard size of U.S. cans, 872 ml, given in Figure 2.2-2.

For a 211x1008 (i.e., Ø2-11/16 in. x 10-08/16 or 10-1/2 in. tall) standard aerosol can, the liquid volume of propellant is equal to 50% of 872 ml, or 436 ml. Based on the 29% propane / 71% isobutane mixture and using the liquid-to-gas volumetric dispersion ratios for each, the total released gas volume at 1 atm and 70 °F is calculated as follows:

$$V_{ac_70F} = (0.436\text{ liters})[(0.29 \times 272.3) + (0.71 \times 229.3)] = 105.4\text{ liters @ 70 °F}$$

Conservatively excluding any void volume within the SLB2, the available void volume to accommodate the aerosol can release is assumed to be equal to the void volume outside of the SLB2 and inside the TRUPACT-III CV (Section 2.1.1.4, *Percent Contribution to MNOP*), V_{cv_void} = 2,354 liters.

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[2] Air Liquide, *Gas Encyclopaedia*, New York, Elsevier Science Publishing, 1976.

[3] National Institutes of Health, *Household Products Database*, http://householdproducts.nlm.nih.gov/ingredients.htm

The 105.4 liters of released aerosol gas is heated to the bulk average void volume (gas) temperature of 145.4 °F (63.0 °C, 336.2 K) based on 80 watts as summarized in Table 2.3-1. The released aerosol gas would occupy a volume, V_{ac}, of:

$$V_{ac} = (105.4 \text{ liters})\left(\frac{336.2\,\text{K}}{294.3\,\text{K}}\right) = 120.4 \text{ liters @ } 145.4\ ^{\circ}\text{F}$$

The release of aerosol gas (adjusted for heat-up to normal conditions) from one full aerosol can into the TRUPACT-III CV void space contributes a pressure, P_{ac}, of:

$$P_{ac} = \left(\frac{120.4 \text{ liters}}{2{,}354 \text{ liters}}\right) = 0.051 \text{ atm } (0.75 \text{ psia}) \text{ @} 145.4\ ^{\circ}\text{F}$$

Therefore, the percent contribution to MNOP from aerosol can contents release into the payload is given as a function of the number of aerosol cans, N_{ac}, as follows:

$$\%_{mnop} = \left(\frac{N_{ac} \times P_{ac}}{25 \text{ psig}}\right) \times 100 = 3.0 \times N_{ac}$$

The above equation conservatively accounts for aerosol can content release in the payload by assuming all aerosol cans are full, utilizing a propellant mixture consistent with the highest pressure capacity DOT spec container, assuming a 50% by volume propellant fill of the largest standard size aerosol can, and ignoring void space available for gas expansion inside the SLB2. Table 2.2-1 summarizes the percent contribution to MNOP as a function of the number of aerosol cans in the TRUPACT-III payload.

Physical Properties of Purified Hydrocarbon Propellants

Property	Ethane*	Propane	Isobutane	N-butane	Isopentane*
Formula	C_2H_6	C_3H_8	C_4H_{10}	C_4H_{10}	C_5H_{12}
Molecular Weight	30.06	44.09	58.12	58.12	72.15
Vapor Pressure (psig at 70°F)	545	109.3	31.1	16.92	-3.5
Freezing Point (°F) (1 atm.)	-297.8	-305.9	-255.3	-216.9	-255.8
Boiling Point (°F) (1 atm.)	-127.5	-43.7	10.9	31.1	82,2
Specific Gravity (liquid) (60°F)	0.35	0.508	0.563	0.584	0.620
Specific Gravity (gas) (60°F) (Air = 1)	1.02	1.55	2.01	2.08	2.51
Critical Temperature (°F)	90.1	206.2	274.8	305.6	370.0
Critical Pressure (psig)	707.1	616.1	528.1	550.1	482.6
Critical Density (g/ml)	0.203	0.220	0.221	0.228	0.234
Flash Point (°F)	<-200	-156	-117	-101	<-60
Lower Explosive Limit (v% in air)	3.12	2.20	1.78	1.84	1.39
Upper Explosive Limit (v% in air)	15.0	9.51	8.40	8.48	7.97
Heat of Combustion (BTU/lb.)	22,190	21,620	21,298	21,318	21,102
Dispersion (Gas at 1 atm and 70°F)					
From 1 g (ml)	793	540.2	414.0	400.6	na
From 1 ml (ml)	276 est.	272.3	229.3	233.9	na
Solubility of Water in Propellent (70°F)	0.031	0.0168	0.0088	0.0075	0.0063
Solubility of Propellent in Water (70°F) (w% at 1 atm)	0.008	0.0079	0.0080	0.0080	0.0084

*Usually considered as co-propellants — present in commercial propellants.

Figure 2.2-1 – Physical Properties of Purified Hydrocarbon Propellants

Standard Sizes For Three-Piece Aerosols

U.S.A. Nominal Dimensions	European I.S.O.* Dimensions	European Commercial Description	Area Where Used	Brimful Capacity Fl. Oz.	Brimful Capacity ml
113 × 313	45 × 97	140.045	U.S.A. & Europe	4.77	141
113 × 411	45 × 119	175.045	U.S.A. & Europe	5.95	176
113 × 509	45 × 140	210	U.S.A. & Europe	7.10	210
202 × 200	52 × 50	100.052	U.S.A.	3.5	102
202 × 213	52 × 72	140.052	Europe**	4.9	142
202 × 214	52 × 73	145.052	U.S.A.	5.0	147
202 × 307.5	52 × 88	175.052	Europe**	6.0	177
202 × 314	52 × 98	190.052	U.S.A.	6.8	192
202 × 402.5	52 × 105	210.052	Europe	7.2	212
202 × 405 ni	52 × 109 ni	210.052 ni	Europe	7.2	212
202 × 406	52 × 111	225.052	U.S.A.	7.6	226
202 × 413	52 × 122	245.052	U.S.A.	8.3	246
202 × 503.5	52 × 132	270.052	Europe	9.2	272
202 × 506 ni	52 × 136 ni	270.052 ni	Europe	9.2	272
202 × 509	52 × 141	290.052	U.S.A.	9.8	290
202 × 514 dni	52 × 149 dni	300.052 dni	U.S.A.	10.2	301
202 × 605.5	52 × 161	335.052	Europe	11.4	337
337 × 608 ni	52 × 165 ni	335.052 ni	Europe	11.4	337
202 × 700	52 × 177	365.052	U.S.A.	12.4	367
202 × 708	52 × 190	390.052	U.S.A.	13.4	391
202 × 711	52 × 195	405.052	Europe	13.8	407
202 × 804	52 × 209	450.052	Europe	15.2	450
205 × 409.5 ni	57 × 117 ni	270.057 ni	Europe	9.2	272
205 × 508 ni	57 × 140 ni	335.057 ni	Europe	11.4	337
205 × 607.5 ni	57 × 164 ni	405.057 ni	Europe	13.8	407
205 × 802.5 ni	57 × 207 ni	520.057 ni	Europe	17.7	522
205 × 1020 ni	57 × 257 ni	650.057 ni	Europe	22.1	652
207.5 × 413	60 × 122	330.060	U.S.A.	11.3	332
207.5 × 509	60 × 141	390.060	U.S.A.	13.2	389
207.5 × 512	60 × 146	405.060	Europe**	13.7	407
207.5 × 605	60 × 160	450.060	U.S.A. & Europe	15.3	452
207.5 × 701	60 × 179	500.060	U.S.A. & Europe	16.8	498
207.5 × 705.5	60 × 186	520.060	Europe	17.7	522
207.5 × 708	60 × 190	525.060	U.S.A.	17.9	527
207.5 × 713	60 × 198	540.060	U.S.A.	18.4	541
207.5 × 903	60 × 232	650.060	Europe	22.1	652
211 × 407.5	65 × 113	375.065	U.S.A.	12.6	373
211 × 410.5	65 × 118	395.065	Europe	13.4	397
211 × 413	65 × 122	405.065	U.S.A. & Europe	13.7	404
211 × 510	65 × 142	470.065	U.S.A.	16.0	472
211 × 604	65 × 157	520.065	U.S.A. & Europe	17.8	522
211 × 612	65 × 171	565.065	U.S.A.	19.2	567
211 × 612 dni	65 × 171 dni	560.065 dni	U.S.A. - Exptl.	18.9	559
211 × 702	65 × 181	600.065	Europe	20.4	602
211 × 711	65 × 195	650.065	Europe	22.1	652
211 × 713	65 × 198	655.065	U.S.A.	22.3	657
211 × 808	65 × 215	720.065	U.S.A.	24.3	720
211 × 908	65 × 238	795.065	U.S.A.	26.9	796.
211 × 909	65 × 240	800.065	Europe	27.2	802
211 × 1008	65 × 266	870.065	U.S.A.	29.5	872
211 × 1114	65 × 300	1000.000	Europe	33.9	1002
300 × 709	76 × 192	795.076	U.S.A.	26.9	796
300 × 709 ni	76 × 192 ni	780.076	U.S.A. - Exptl.	26.4	781

Figure 2.2-2 – Standard Sizes for Three-Piece Aerosols

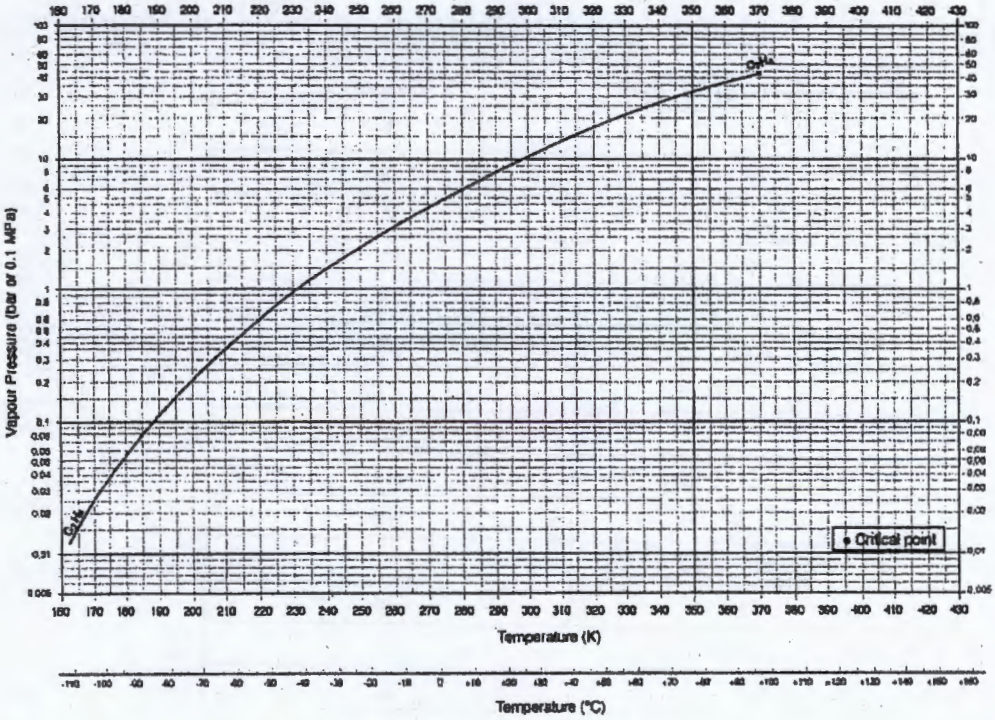


Figure 2.2-3 – Propane Vapor Pressure as a Function of Temperature

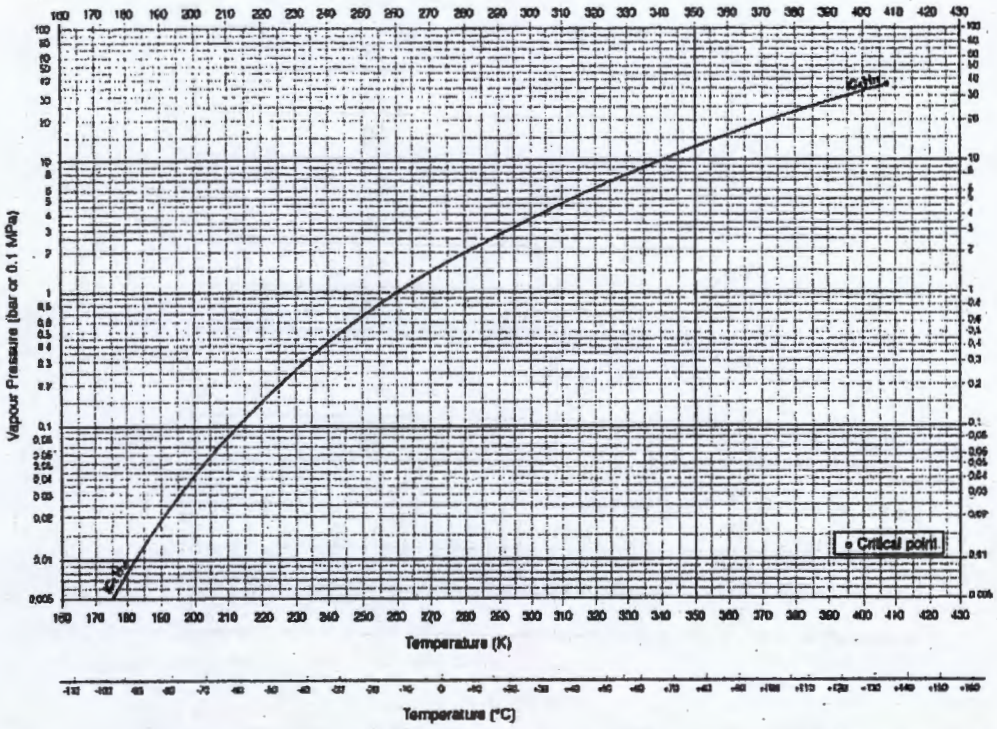


Figure 2.2-4 – Isobutane Vapor Pressure as a Function of Temperature

Table 2.2-1 – Percent Contribution to MNOP from Aerosol Can Release

No. of Aerosol Cans	$\%_{mnop}$
1	3
2	6
3	9
4	12
5	15
6	18
7	21
8	24
9	27
10	30
11	33
12	36
13	39
14	42
15	45
16	48
17	51
18	54
19	57
20	60
21	63
22	66
23	69
24	72
25	75
26	78
27	81
28	84
29	87
30	90
33	99

BNFL Inc.

Mechanical Data Sheet

Project:	AMWTP	Site:	Idaho Falls	Data Sheet No.:	DZ410283
Project No.:	K0105C	Area:	Supercompactor Cell	No. Installed:	1
PI No.:	Z-410-283	Category:	UBC PC 2	% Duty:	On Demand
Description:	Supercompactor Glovebox	System No.:	410		

Function: To provide a Zone 3 containment to prevent release of radioactivity and toxic substances whilst the process is carried out.

SUMMARY DATA	UNITS	
Maximum Duty	hp	N/A
Design Life	year	15
Failure on Demand	-	N/A
Minimum Design Pressure	in. wg	-4 (Glovebox test depression)
Maximum Design Pressure	in. wg	+4 (Test pressure)
Minimum Design Temperature	°F	50
Maximum Design Temperature	°F	104
Length	ft & in.	9'- 7" Approx. 115
Width	ft & in.	6'- 8" Approx. 80 500 ft³
Height	ft & in.	9'- 10" Approx. 7-10" 94
Estimated Weight	lb	5170
Materials and Construction	Stainless Steel	
Maintenance	Maintainable components shall be of modular design/construction and allow rapid access for maintenance and removal/replacement if necessary. Maintenance of components will be done through glove ports.	

Description:
The supercompactor glovebox joins the top and bottom flanges of the press to form containment. The trolley passes over the bottom flange interface. The top edge to have a stainless steel bellows fitted to allow press expansion.

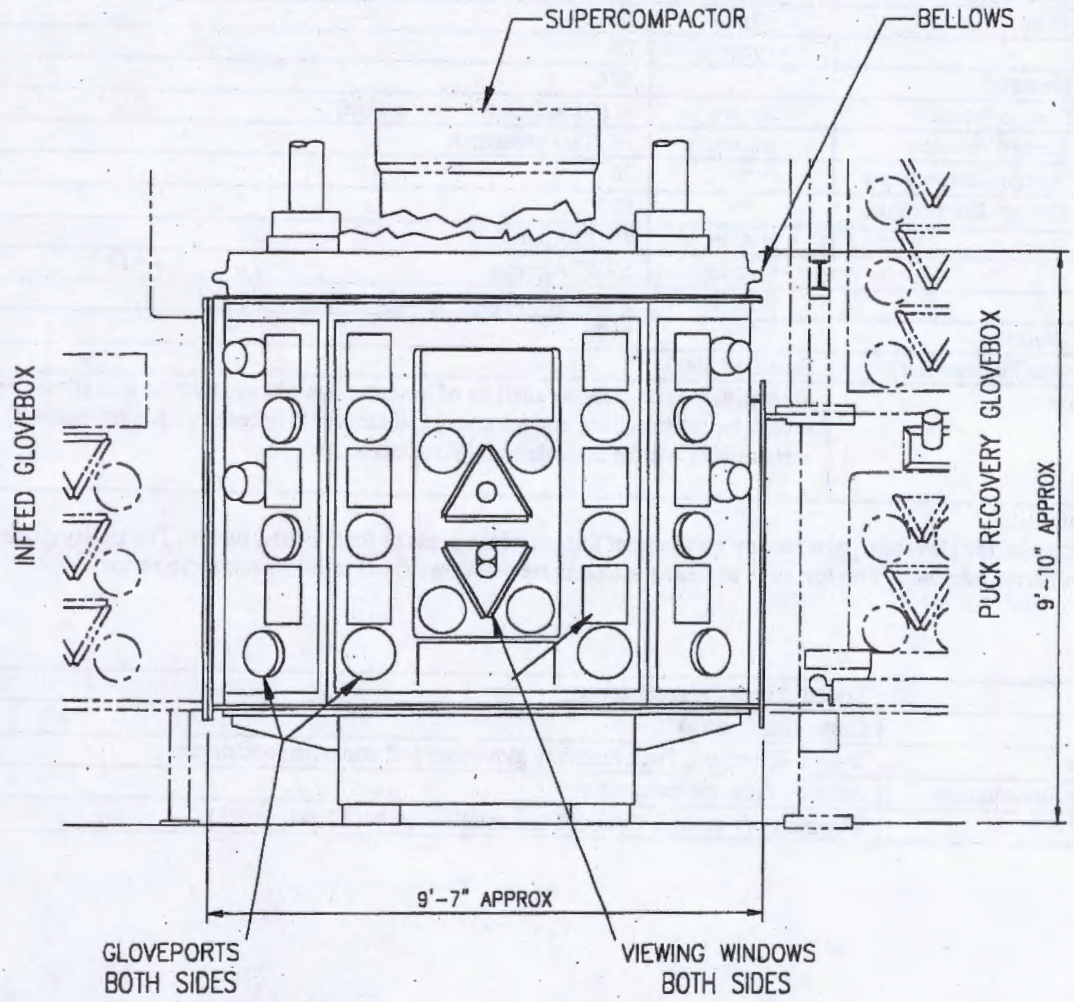
Inputs:	lidded drums for compaction
Outputs:	Compacts (pucks)
Interfaces:	Infeed Glovebox, Puck recovery glovebox, and supercompactor press
Operating Environment:	Zone 3, alpha contaminated
Services:	Electricity (Power & Control), pneumatic supply (80 psig ± 5%)

Date	Issue	By	Checked	Approved	Purpose of Issue
04/23/07	02	J. Godak	[signature]	[signature]	For permit
01/12/01	01	M. Green	E. Calvert	D. Yew	For permit
11/22/00	00	S. Mason	E. Calvert	D. Yew	For permit

BNFL Inc.

Mechanical Data Sheet

Description:	Supercompactor Glovebox	Site:	Idaho Falls	Data Sheet No.:	DZ410283



FRONT ELEVATION (LOOKING NORTH)

BNFL Inc.

Mechanical Data Sheet

Project:	AMWTP	Site:	Idaho Falls	Data Sheet No.:	DZ410211
Project No.:	K0105C	Area:	Supercompaction Cell	No. Installed:	1
PI No.:	Z-410-211	Category: UBC PC 2		% Duty:	On Demand
Description:	Supercompactor Infeed Glovebox	System No.:	410		

Function: To provide a Zone 3 containment to prevent the release of radioactivity and toxic substances whilst the process is carried out.

SUMMARY DATA	UNITS	
Maximum Duty	hp	N/A
Design Life	year	15
Failure on Demand	-	N/A
Design Capacity	drums per 24 hour	160 (max)
Minimum Design Pressure	in. wg	-4 (Glovebox test depression)
Maximum Design Pressure	in. wg	+4 (Test pressure)
Minimum Design Temperature	°F	50
Maximum Design Temperature	°F	104
Infeed Glovebox Dimensions	ft & in.	See sheet 2 670 ft3
Estimated Weight	lb	21000
Materials and Construction	Stainless Steel	
Maintenance	Maintainable components shall be of modular design/construction and allow rapid access for maintenance and removal/replacement if necessary. Maintenance of components will be done through glove ports.	

Description:
High integrity sealed glovebox, which will contain infeed conveyor, infeed turntable, drum elevator door, drum handler, compaction trolley, drum piercing station.

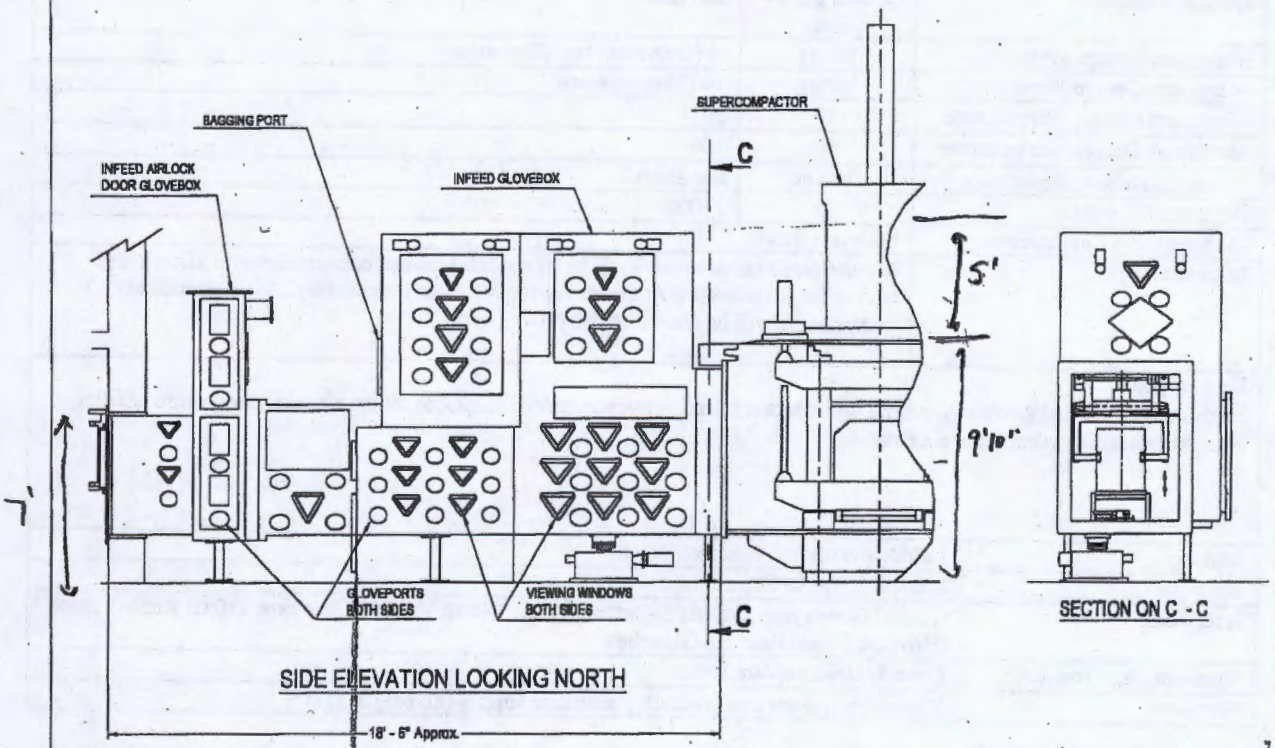
Inputs:	Lidded drums to Supercompactor
Outputs:	Lidded drums to Supercompactor
Interfaces:	Central Conveying System, Supercompactor, North Venturi Glovebox, Infeed Airlock Door Glovbox, Drum Piercing Glovebox
Operating Environment:	Zone 3, alpha contaminated
Services:	Electricity (power and control), pneumatic supply (80 psig ± 5%)

Date	Issue	By	Checked	Approved	Purpose of Issue
5/17/04	05	T. Kelly	[signature]	[signature]	For CCR
10/27/03	04	S. Schulthies	Richard Beck	Phil Leatherbarrow	Issue for permit - CCR
06/01/01	03	M. Ogden	K. Shaw	D. Yew	For permit
02/08/01	02	L Markiewka	K. Shaw	D. Yew	For permit
01/12/01	01	M. Green	E. Calvert	D. Yew	For permit
11/22/00	00	S. Mason	E. Calvert	D. Yew	For permit

BNFL Inc.

Mechanical Data Sheet

Description:	Supercompactor Infeed Glovebox	Site:	Idaho Falls	Data Sheet No.:	DZ410211



6'2" 12'4"

INFEED GLOVEBOX

7'10" + 5' = 12'10" = 154"
12'4" 148"
3'4" 40"
527 ft³

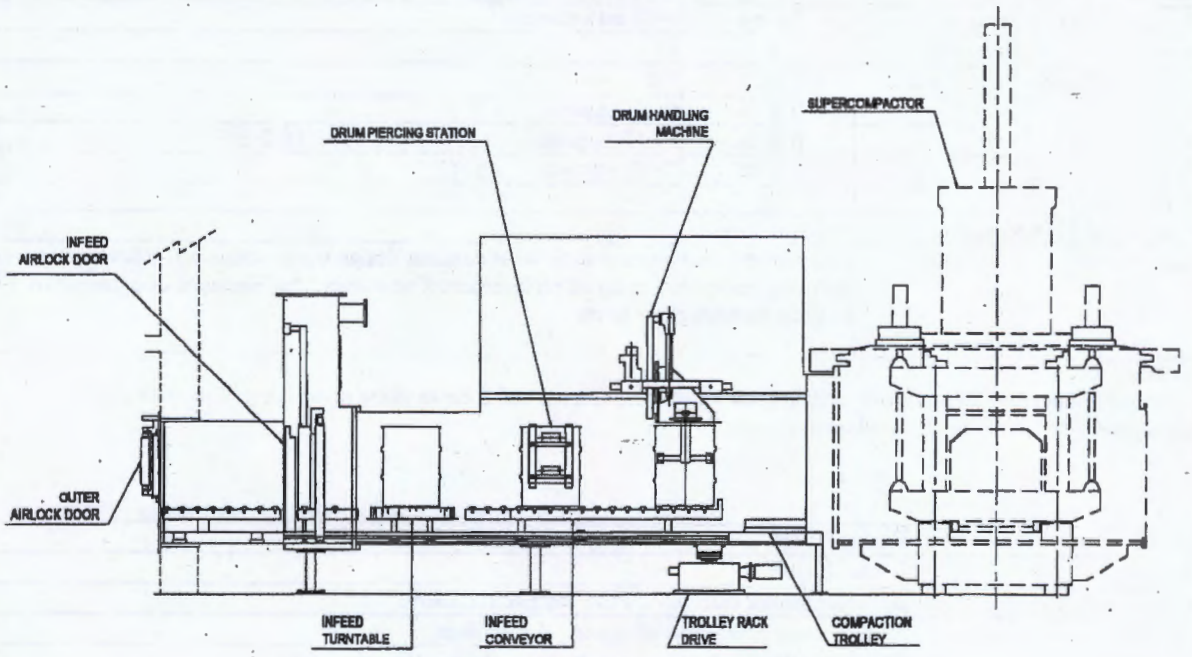
7' = 84"
6'2" = 72"
3'4" = 40"
140 ft³

670 ft³

BNFL Inc.

Mechanical Data Sheet

Description:	Supercompactor Infeed Glovebox	Site:	Idaho Falls	Data Sheet No.:	DZ410211



CROSS SECTION THROUGH INFEED GLOVEBOX

BNFL Inc.

Mechanical Data Sheet

Project:	AMWTP	Site:	Idaho Falls	Data Sheet No.:	DZ410284
Project No.:	K0105C	Area:	Supercompaction Cell	No. Installed:	1
PI No.:	Z-410-284	Category: UBC PC 2		% Duty:	On Demand
Description:	Puck Recovery Glovebox	System No.:	410		
Function:	Connects the upper puck handler area glovebox and the press glovebox and allows a separate area for puck recovery.				

SUMMARY DATA	UNITS	
Maximum Duty	hp	N/A
Design Life	year	15
Failure on Demand	-	N/A
Minimum Design Pressure	in. wg	-4 (Glovebox test depression)
Maximum Design Pressure	in. wg	+4 (Test pressure)
Minimum Design Temperature	°F	50
Maximum Design Temperature	°F	104
Length	ft & in.	4'-6" Approx. 9'
Width	ft & in.	3'- 4" Approx. 3.33') 165 ft3
Height	ft & in.	7'- 0" Approx. 5.5'
Estimated Weight	lb	12,000
Materials and Construction	Stainless Steel	
Maintenance	Maintainable components shall be of modular design/construction and allow rapid access for maintenance and removal/replacement if necessary. Maintenance of components will be done through glove ports.	

Description:
The Puck Recovery Glovebox will contain puck transfer equipment and tools to allow re-working of puck to enable subsequent satisfactory puck handling operation.

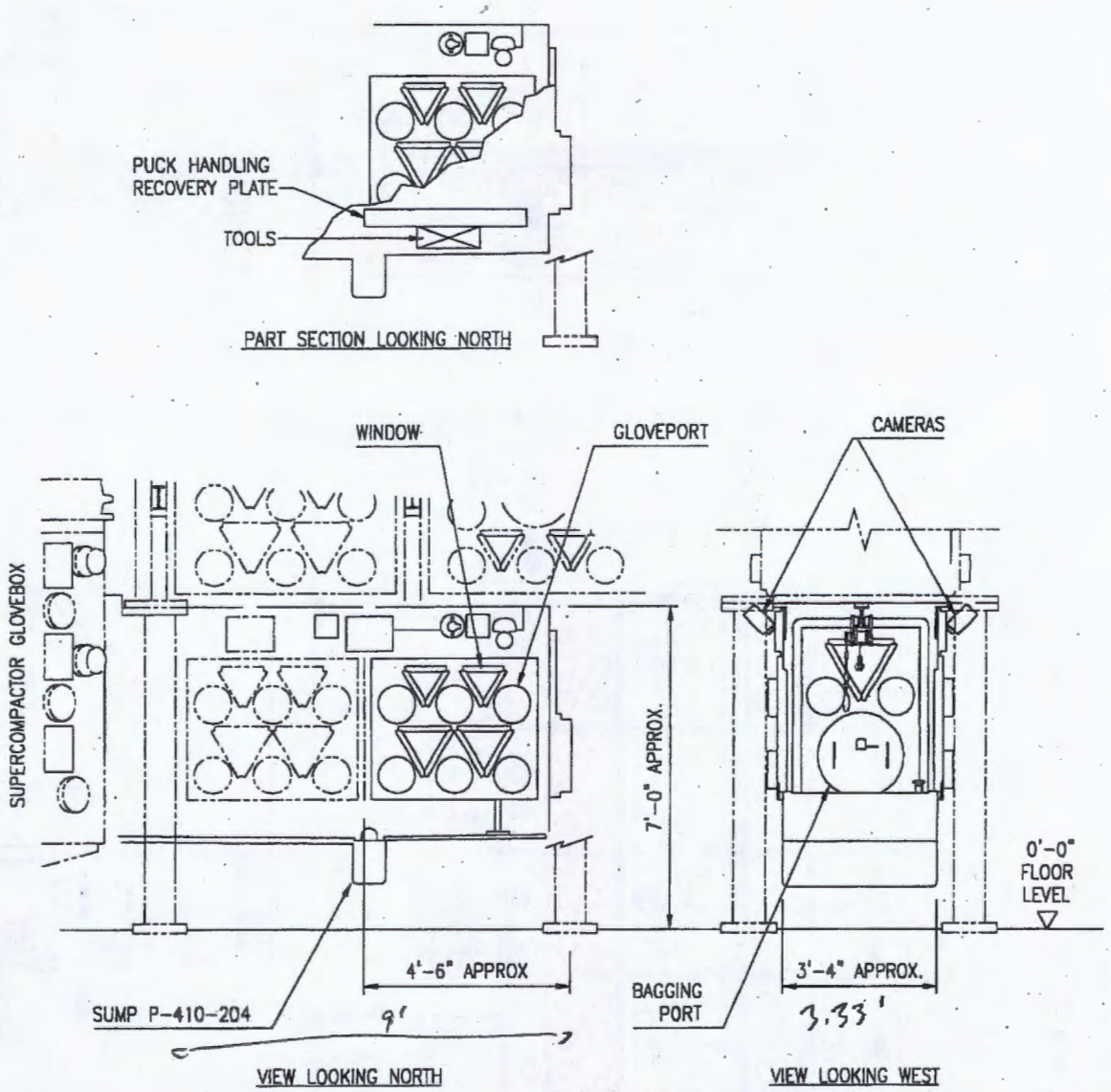
Inputs:	Pucks, Liquid
Outputs:	Pucks, Liquid
Interfaces:	Supercompactor Glovebox, Post Compaction Glovebox
Operating Environment:	Zone 3, alpha contaminated, some puck spillage
Services:	Electricity (Power & Control), pneumatic supply (80 psig ± 5%)

Date	Issue	By	Checked	Approved	Purpose of Issue
5/17/04	03	T. Kelly	[signature]	[signature]	For CCR
10/27/03	02	S. Schulthies	Richard Beck	P. Leatherbarrow	Issue for permit - CCR
01/12/01	01	M. Green	E. Calvert	D. Yew	For permit
11/15/00	00	S. Mason	E. Calvert	D. Yew	For permit

BNFL Inc.

Mechanical Data Sheet

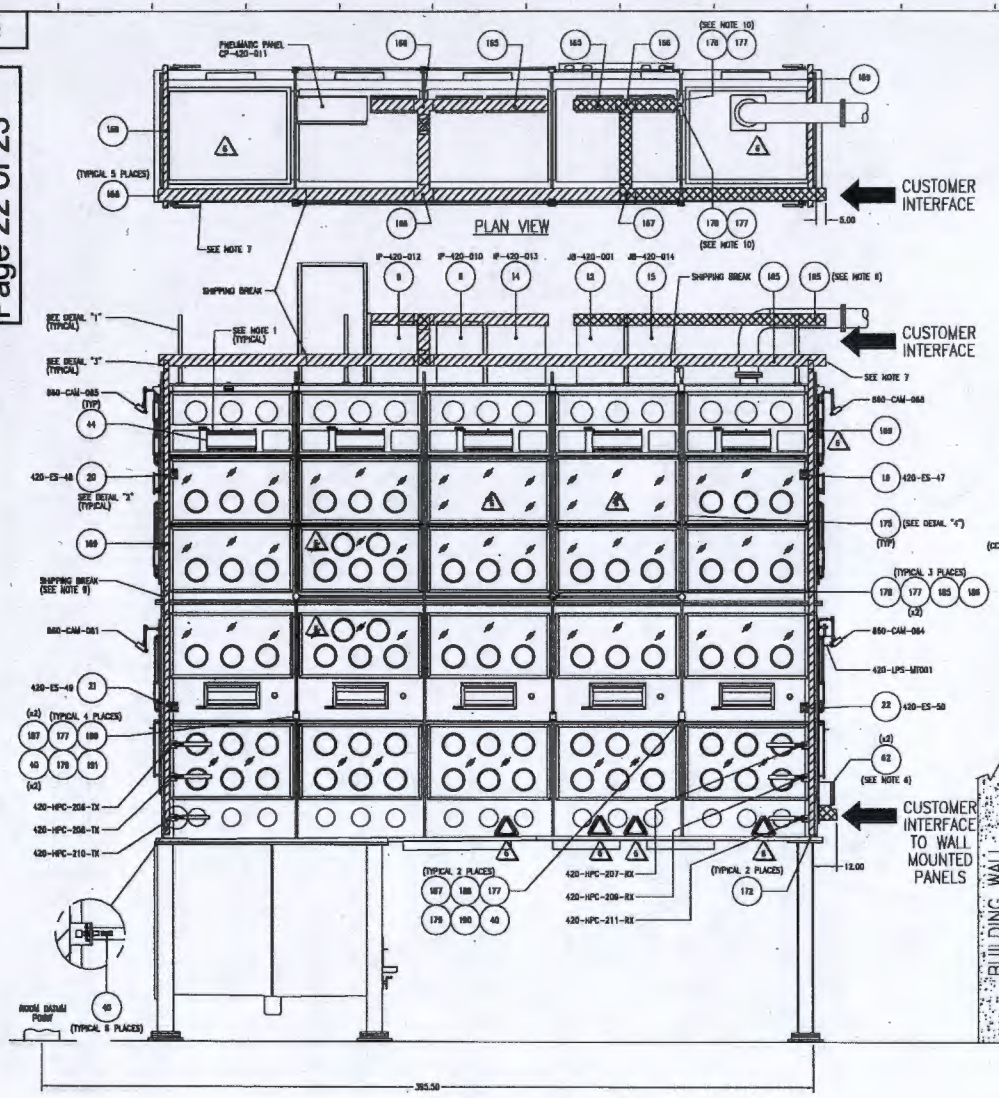
Description:	Puck Recovery Glovebox	Site:	Idaho Falls	Data Sheet No:	DZ410284

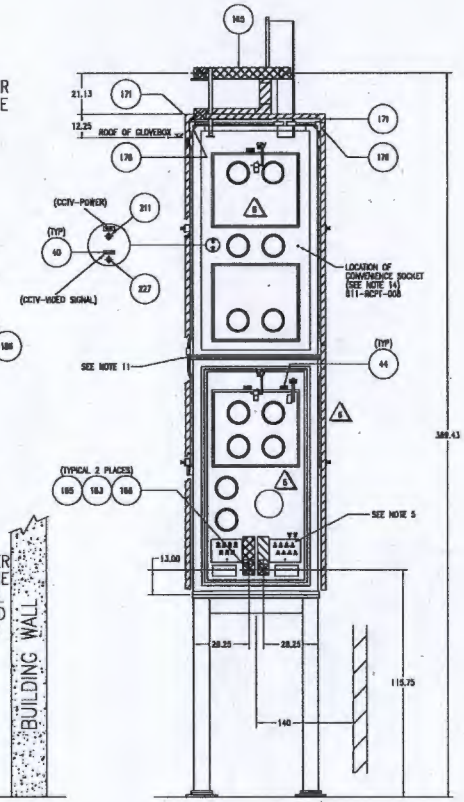


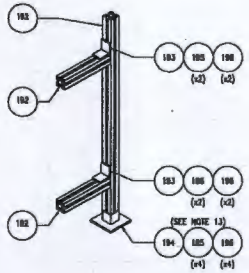
PUCK RECOVERY GLOVEBOX

E0100310002

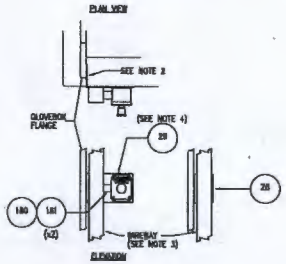
NOTE :
ALL CUSTOMER INTERFACES ARE WIREMOLD C1600 6" x 6" WIREWAYS



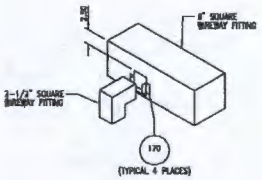




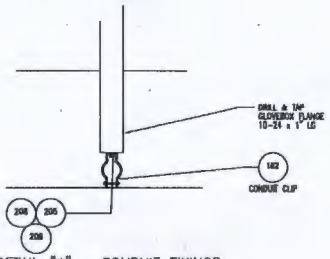
DETAIL "1" – WIREWAY SUPPORT
(SCALE 1/8" : 1")
(TYPICAL 4 PLACES)



DETAIL "2" – WIREWAY & PUSHBUTTON MOUNTING PLATES
(SCALE 1/8" : 1")



DETAIL "3" – WIREWAY PANEL FLANGE & CUT-OUT DETAIL
(SCALE 1/8" : 1")



DETAIL "4" – CONDUIT FIXINGS
(SCALE 1:2)
(SEE NOTE 12)

6	06/18/02	[illegible]	[illegible]	[illegible]	[illegible]
5	05/30/02	[illegible]	[illegible]	[illegible]	[illegible]
4	05/09/02	[illegible]	[illegible]	[illegible]	[illegible]
3	04/15/02	[illegible]	[illegible]	[illegible]	[illegible]
2	03/28/02	[illegible]	[illegible]	[illegible]	[illegible]
1	03/04/02	[illegible]	[illegible]	[illegible]	[illegible]
0	02/12/02	[illegible]	[illegible]	[illegible]	[illegible]

NOTES

1. FOR DETAILS OF FLOURESCANT LIGHT FITTING ASSEMBLY, REFER TO DRAWING A047600.
2. DRILL & TAP GLOVEBOX FLANGE 1/4"-20, AND FIX MOUNTING PLATES (ITEMS 28 & 29) USING ITEMS 198, 200, 201 & 202 AS REQUIRED.
3. FIX WIREWAY TO GLOVEBOX FLANGE AT TOP & BOTTOM OF RUN VIA MOUNTING PLATE ITEM 28.
   FIX WIREWAY TO GLOVEBOX FLANGE AT PUSHBUTTON LOCATIONS VIA MOUNTING PLATE ITEM 29.
   FIX WIREWAY TO MOUNTING PLATES (ITEMS 28 & 29) USING ITEMS 203, 204, 201 & 202 AS REQUIRED.
4. FIX PUSHBUTTON TO MOUNTING PLATE (ITEM 29) USING ITEMS 204, 205, 206 & 207 AS REQUIRED.
5. FOR DETAILS OF GLOVEBOX PENETRATIONS SEE SHEET 3.
6. FOR DETAILS OF COVER BOX CUT-OUTS SEE SHEET 3.
7. SECTIONS OF 24VDC CONTROL TRUNKING INDICATED, TO BE REMOVABLE FOR SHIPPING PURPOSES.
8. SECTION OF 120/480VAC POWER TRUNKING INDICATED, TO BE REMOVED DURING SHIPPING.
9. VERTICAL SECTIONS OF TRUNKING JOINING TOP & BOTTOM SECTIONS OF GLOVEBOX TO HAVE 12" REMOVABLE FOR SHIPPING PURPOSES.
   ALL CABLES CONNECTED TO INSTRUMENTS LOCATED ON BOTTOM SECTION OF GLOVEBOX, TO BE DISCONNECTED & COILED UP ON TOP SECTION, READY FOR RE-CONNECTION ON FINAL ASSEMBLY.
10. CONDUIT FITTINGS ON TOP OF GLOVEBOX TO BE REMOVABLE FOR SHIPPING PURPOSES.
11. CONDUIT TO BE DISCONNECTED BETWEEN TOP & BOTTOM GLOVEBOX SECTIONS FOR SHIPPING PURPOSES.
    ALL CABLES/CORES CONNECTED TO INSTRUMENTS LOCATED ON BOTTOM SECTION OF GLOVEBOX, TO BE DISCONNECTED & COILED UP ON TOP SECTION, READY FOR RE-CONNECTION ON FINAL ASSEMBLY.
12. FIX CONDUIT TO GLOVEBOX FLANGE AS PER DETAIL "4" AS REQUIRED.
    SOCKET OUTLETS / CONDUIT OUTLET BOXES ARE NOT FIXED DIRECT TO GLOVEBOX FLANGES, BUT ARE SUPPORTED BY THE RIGID CONDUIT THAT CONNECTS INTO THEM.
13. FLOOR MOUNT BASEPLATES (ITEM 184) TO BE FIXED TO GLOVEBOX ROOF USING ITEMS 260 & 261 AS REQ'D. 3/8"-16 x 3/4" LG STUD BOLTS TO BE FIXED TO GLOVEBOX ROOF ON ASSEMBLY AS REQUIRED.
14. CONVENIENCE SOCKET TO BE INSTALLED AS PER DRG A047201, VIA 1/2" NPT COUPLING IN LOCATION INDICATED.

KEY

- 120VAC / 480VAC POWER CABLES
- 24VDC CONTROL / CCTV / SAFETY CABLES
- IS CONTROL CABLES

REFERENCE DRAWINGS

DRAWING NO	DRAWING TITLE
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

ADVANCED MIXED WASTE TREATMENT PROJECT
INEEL – DOE/ID

POST COMPACTION GLOVEBOX
C,E&I SYSTEM 420 LAYOUT
(SHEET 1 OF 7)

RTS WRIGHT
NUCLEAR SYSTEMS GROUP
1520 ELM HILL PIKE
NASHVILLE, TN 37216
(615)241-4411

RTS WRIGHT DRAWING No. E0100310002 REV 6

SCALE: 1/64	06/18/02	
DRAWN: A. ALLEN	06/18/02	
DESIGNED: A.BAILEY	06/18/02	
CHECKED: A.BAILEY	06/18/02	
VERIFIED: N/A	N/A	
APPROVED: N/A	N/A	

Gas Properties CO_2

Molecular Weight

Molecular weight : 44.01 g/mol

Solid phase

Latent heat of fusion (1,013 bar, at triple point) : 84.3 Btu/lb
Solid density : 97.512 lb/ft^3

Liquid phase

Liquid density (at -20 °C (or -4 °F) and 19.7 bar) : 64.425 lb/ft^3
Liquid/gas equivalent (1.013 bar and 15 °C (per kg of solid)) : [redacted]
Boiling point (Sublimation) : -109.3 °F
Latent heat of vaporization (1.013 bar at boiling point) : 245.52 Btu/lb
Vapor pressure (at 20 °C or 68 °F) : 848.47082 psi

Air Liquide, Gas Encyclopedia

EDF No.: EDF-0783	**Revision No.:**0	**FMP No. (*if any*):** NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

Summary:

The conclusion from the first calculation determined that if the entire contents of 3 aerosol cans were to be released into the glovebox, develop a stoichiometric mixture, and ignite, the resulting overpressure (due to the entire 3 full can vapor cloud deflagration) would potentially develop an overpressure of 298.29 in wg, which is more than 50 times the design pressure. This ideal pressure deflagration event could likely cause severe structural damage to the supercompactor glove box. The damage could be severe enough that any radiological containment associated with the glovebox would likely be compromised (lost).

The conclusion from the second calculation is that one can (retaining approximately 5.7% (49 ml) liquid), if compacted and (under ideal stoichiometric conditions) resulting in a deflagration, would not exceed the given structural design of the supercompactor glovebox, when ventilation is operating at -1.5 in wg. Loss of radiological containment is not likely to occur.

Effective mitigation of a collocated fuel/air mixture and ignition source is achieved through monitoring and automatic shutdown of the supercompactor.

Additionally, there is not expected to be an ideal combustible fuel/air mixture migration to communicating areas that contain unrated electrical components.

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

References:

1. Zalosh, R.G., "Explosion Protection," *The SFPE Handbook of Fire Protection Engineering, Chapter 16,* Society of Fire Protection Engineers, Bethesda, MD, 2002
2. Beyler, C., "Flammability Limits of Premixed and Diffusion Flames," *The SFPE Handbook of Fire Protection Engineering, Chapter 7,* Society of Fire Protection Engineers, Bethesda, MD, 2002
3. Mitu, M., Brinzea, V., Musuc, A., Razus, D., Oancea, D., "Deflagration Parameters of Propane-air Mixtures in a Closed Cylindrical Vessel," *UPB Science Bulletin, Series B, Volume 73, Issue 3,* 2011
4. Diversified CPC International, *Liquefied Gas Propellant Handbook,* Channahon, IL
5. Godak, J., "Analysis of Compacting Lead and Aerosol Cans," *EDF-0768, Rev. 1,* 2012
6. Waste Isolation Pilot Plant, *TRUPACT-III PREx, Rev. 0,* June 2007
7. Air Liquide, *Gas Encyclopaedia* (online)
8. Zgliczynski, M., Sansalvadore, P., *Contribution to Safety Aspect Discussion on Isobutane Compressors for Domestic Refrigeration,* Purdue University, 1994

Originator: David K. Young, P.E.	Signature	14 Nov 2012 Date:
Technical Review: Bruce G. Campbell	Signature	11/14/12 Date:

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

Additional Reviewers: (by title)

Mechanical Engineer. Quin Blackburn	[signature]	11/19/2012
Print Title	Signature	Date
Waste Programs Manager	[signature] ACTING FOR D. HAAR	11/19/12
Print Title	Signature	Date
Print Title	Signature	Date

Distribution List:

Carol Anderson, John Godak, Quin Blackburn, Dave Haar, Catherine Madore, Christian Maupin, Roger Raymond, Ron Warnecke

Approval:

Printed Name: Mark Wescoat

Printed Title: ES&H Director

Mark J Wescoat	11-20-12
Signature	Date

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

Scope:

AMWTP is evaluating the process of compacting waste drums containing unvented aerosol cans in the Supercompactor located in WMF-676. These cans may contain flammable propellant that, during the supercompaction process, is expected to be released into the supercompactor glovebox. Should the released propellant, in a flammable fuel/air mixture, find an ignition source, a vapor cloud deflagration within the glovebox would likely be the result. The temperatures generated during the supercompaction process are such that the minimum autoignition temperature of the propellant, which is between 450°C (842°F) and 460°C (860°F) (ref. 2, SFPE Handbook, Chapter 7, Table 2-7.1), is likely not reached. However, during the supercompaction process, there is likely to be ferrous metal on metal friction, which will create sparks. Sparks occurring during compacting is a significant and plausible ignition mechanism for a propellant/air mixture. This evaluation will analyze the overpressure effects, due to a vapor cloud explosion associated with the contents of 3 full aerosol cans, on the glovebox.

The maximum volume of propellant (if ignited), that will not challenge the structural integrity of the glovebox is also determined.

Analysis:

Assumptions:

- No explosion venting exists in the supercompactor glovebox (e.g. not taking credit for the venting effects of the ventilation ductwork),
- The liquid within the aerosol can consists of 50% product and 50% propellant, (ref. 6),
- The propellant within aerosol cans is flammable and is 29% propane/71% isobutane (ref. 6),
- Vapor cloud, which develops inside the glovebox, is a stoichiometric mixture of propellant and air,
- During compaction operations, the glovebox is at -1.5 in wg (-0.004 barg) (ref. 5),
- Initial pressure (P_o) = 101 x 10^3 Pa,
- Initial temperature (T_o) = 298 K,
- Aerosol can volume = 872 ml (can volume chosen to be consistent with EDF-0768) (ref. 5, 6).

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	Building/System No.: WMF676/410	

Given:

- Supercompactor maximum design pressure = 0.01 barg (4 in wg) (ref. 5),
- The release of three (3) full aerosol cans (provided there is no combustion) will result in loss of vacuum within the glovebox (ref. 5),
- Stoichiometric concentration of propane ($\chi_{propane}$) = 4.02% volume (ref. 3),
- Stoichiometric concentration of isobutane ($\chi_{isobutane}$) = 3.5% volume (ref. 8),
- Stoichiometric concentration of propellant ($\chi_{propellant}$) = 3.65% volume (ref. 8) (calculated: (4.02%)(0.29)+(3.5%)(0.71)),
- Molecular weight of propane ($M_{propane}$) = 44.1 kg/kmol (ref. 7),
- Molecular weight of isobutane ($M_{isobutan}$) = 58.1 kg/kmol (ref. 7),
- Molecular weight of propellant ($M_{propellant}$) = 54.0 kg/kmol (calculated: (44.1 kg/kmol)(0.29)+(58.1 kg/kmol)(0.71)),
- Volume of supercompactor glovebox (V) = 96.3m^3 (3400 ft^3),
- Molecular weight of air (M_{air}) = 28.8 g/mol,
- Gas constant (R) = 8,314 kg m^2/(s^2 kmol K)=8,314 Pa m^3/(kmol K),
- $\rho_{propane}$ = 0.493 g/ml (ref. 7),
- $\rho_{isobutane}$ = 0.593 g/ml, (ref. 7),
- $\rho_{propellant}$ = 0.564 g/ml (calculated: (0.493 g/ml)(0.29)+(0.593 g/ml)(0.71)),
- $P_{max\text{-}propane}$ = 7.90 barg (ref. 1),
- $P_{max\text{-}isobutane}$ = 7.75 barg (ref. 8),
- $P_{propellant}$ = 7.79 barg (calculated: (7.9 barg)(0.29)+(7.75 barg)(0.71)).
- Liquid to gas dispersion; propane = 272.3 (ref. 5)
- Liquid to gas dispersion; isobutane = 229.3 (ref. 5)

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

Calculation one of this analysis will determine the maximum pressure developed within the supercompactor glovebox, given a stoichiometric propellant/air mixture, vapor cloud deflagration due to the involvement of three (3) , 872 ml cans at 100% capacity, of which 50% is propellant. 3 cans is used in the calculation because the result of the analysis from EDF-0768, Rev. 1, "Analysis of Compacting Lead and Aerosol Cans," indicates that 3 aerosol cans can potentially be compacted (assuming ventilation within the glovebox is operational and there is no combustion of propellant) without affecting the structural integrity of the supercompactor glovebox. It is necessary to determine the effect on the glovebox due to a vapor cloud deflagration resulting from the release of 3 full aerosol cans.

First, we need to find the molecular weight of the stoichiometric mixture of propellant in air:

- $M_{mix} = (\chi_{propellant})(M_{propellant}) + (1 - \chi_{propellant})(M_{air})$

  = (0.0365)(54.0 kg/kmol) + (1-0.0365)(28.8 kg/kmol)

  = <u>29.72 kg/kmol</u>

The stoichiometric mixture density is calculated from the ideal gas law:

- $\rho_{mix} = \frac{M_{mix} P_o}{R T_o}$

  = (29.72 kg/kmol)(101x10^3 Pa)/((8314 Pa m^3/kmol•K)(298 K))

  = <u>1.21 kg/m^3</u>

Propellant mass required to fill the glovebox at stoichiometric concentration:

- $m_o = \left[\frac{\chi_{propellant} M_{propellant}}{M_{mix}}\right] \rho_{mix} V$

  = [(0.0365)(54.0 kg/kmol)/(29.72 kg/kmol)]•1.21 kg/m^3•96.3m^3

  = <u>7.73 kg</u>

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	Building/System No.: WMF676/410	

Total mass of propellant contained in 3 aerosol cans:

- $m_{propellant}$ = (3 cans)(872 ml)(0.5)(0.564 g/ml)(1 kg/1000 g)

  = 0.738 kg

Ratio of mass of propellant to mass required to fill glovebox at stoichiometric concentration:

- $m_{propellant}/m_o$ = (0.738 kg)/(7.73 kg)

  = 0.0954

Max pressure within the glovebox due to deflagration from the release of 3 full aerosol cans:

(using the calculated value for $P_{max} - P_o$ for propellant of 7.79 barg)

- P_{max}-P_o = (7.79 barg)(0.0954)

  = 0.743 barg = 298.29 in wg

This exceeds the 0.014 barg (5.5 in. wg) maximum pressure increase.

Calculation 2 of this analysis will determine the maximum amount of propellant that could be released into the glovebox, develop a stoichiometric mixture, and ignite that would not cause damage (i.e., be within the maximum supercompactor glovebox design pressure) to the glovebox.

Set P_{max}-P_o = 5.5 in wg (0.014 barg)

Determine new mass of propellant to mass fraction of propellant that will not exceed glovebox design parameters:

- P_{max}-P_o = (0.014 barg) = (7.79 barg)(x)

  Solving for x:

  x = 0.0018

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	Building/System No.: WMF676/410	

Total mass of propellant that will not exceed glovebox design parameters:

- $m_{propellant} = (m_o)(0.0018)$

  $= (7.73\ kg)(0.0018) = 0.0139\ kg = \underline{13.9\ g}$

Total volume of propellant that will not exceed glovebox design parameters:

- $V_{propellant} = (m_{propellant})/(\rho_{propellant})$

  $= (13.9\ g)/(0.564\ g/ml) = \underline{24.65\ ml}$

Total amount of propellant initially in one aerosol can

$V_{propellant} = 872\ ml*0.5 = 436\ ml$

Portion of 1 can that will not exceed glovebox maximum overpressure design pressure (if deflagration of stoichiometric propellant/air mixture occurs):

= <u>24.65 ml/436 ml = 5.7% of initial propellant charge of one can</u>

This relates to approximately 49 ml (aggregate) observable liquid.

The only concern is a deflagration outside the compactor collar. According to AMWTP Engineering, the inside volume of the mold when compaction starts is between approximately 69 and 72 gallons, depending on the height of the drum. Subtracting out 55 gallons for the drum gives 14 – 17 gallons of surrounding air space. The air within the drum itself is neglected, under the assumption that most of it will be evacuated prior to building enough internal pressure to breach the aerosol cans. This volume (14 – 17 gallons) is sufficiently small so that the pressure created by a deflagration, due to the ignition of a stoichiometric fuel/air mixture, is well below that necessary to challenge the glovebox design. Also, qualitatively, the collar will act to suppress any pressure rise within the collar.

Because the primary mode of ignition is sparking developed in the waste matrix during supercompaction, administrative and/or engineering controls may be implemented that would decrease the probability of an ignition. These controls may allow the volume of observable liquid to be increased, given the overall risk is

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

accepted by ITG management and the maximum possible fire loss, as determined by RPT-ESH-012, WMF-676 Fire Hazards Analysis and Fire Safety Assessment, does not exceed limits outlined in DOE STD-1066, Fire Protection.

The control that is evaluated in this EDF is that of lower explosive limit (LEL) detection with automatic shutdown of the supercompaction process. This method was chosen as it is meant to eliminate the ignition source (i.e., sparking during the compaction process) at the time a combustible fuel/air mixture is present within the glovebox.

The gas detector chosen for this control is the MSA, Ultima XIR Gas Monitor (this may change based on feedback from MSA). It can provide an output signal so that automatic shut-down of the compaction process can be achieved (i.e., without human interface). This detector model provides a readout directly on the monitor in addition to the ability of the monitor to transmit the percent LEL to a remote location. The environment within the glove box is normally inaccessible for maintenance and calibration activities. Routine calibration for the MSA detector does not require cal-gas and the zero adjustment meets the requirement for full calibration. However, it is recommended that calibration gas be used, as part of the system operability test, for the initial monitor calibration. The detector is immune to poisoning and the detector life is not reduced from gas exposure. The detector automatically compensates for humidity and temperature changes and is capable of operating in high gas and low oxygen environments.

Field-selectable algorithms can be set, for this detector, so that a variety of hydrocarbon-based gases can be detected. This is critical as the actual propellants within the aerosol cans are not known. The most common hydrocarbon based aerosol propellants include:

- isobutane (flammable limits 1.8% - 8.44%)
- n-butane (flammable limits 1.86% - 8.41%)
- propane (flammable limits 2.1 % - 10.1%)
- methyl ethyl ether (flammable limits 2.0% - 10.1%)
- dimethyl ether (flammable limits 3.4% - 27%)

The alarm calibration is based on the IR absorbing properties of the gas, as well as the concentration. For the propellants listed above the calibration should be based on butane, which has very similar properties to

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	Building/System No.: WMF676/410	

isobutane and has the same flammable limits.

Once the detector goes into "alarm" (i.e., flammable gas is detected greater than some fraction of the LEL) and the compaction process is automatically stopped and criteria for restart will be established. This, at a minimum, should be that the detector has cleared and is no longer in "alarm."

For proper detection of flammable gases, and to minimize nuisance alarms, the detector will be located, within the glovebox, based on consultation with Engineering. The philosophy for placement of the detector and the alarm set point is that prior to detector activation (given the development of a fuel/air mixture that may challenge the design parameters of the glovebox), the mixture inside the collar (where the potential ignition sources are) is not within the explosible range of the fuel. The compaction is shut down (thus eliminating ignition sources) well before an explosible fuel/air mixture develops within the collar.

Because there are electrical components that are not rated for hazardous locations, in spaces that communicate with the supercompactor glovebox, this analysis will determine if a fuel/air mixture will develop in the presence of these components.

Based on a propellant mixture of 29% propane and 71% isobutane, the volume of the propellant gas is as follows:

- V_{liquid} *(per can)* = 0.50 x 872 ml = 436ml = 0.015ft^3
- V_{gas} *(total)* = (3 cans)(0.015 ft^3)[(0.29)(272.3) + (0.71)(229.3)]

  = <u>10.88 ft^3</u>
- $V_{stoichiometric}$ = 10.88 ft^3/0.035 = <u>298.1 ft^3</u>
- V_{LEL} = 10.88 ft^3/0.018 = <u>604.4ft^3</u>

EDF No.: EDF-0783	Revision No.:0	FMP No. (*if any*): NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

If we look at the V_{LEL} as a sphere, centered at the top of the collar (where propellant will be discharged), the radius due to this propellant "cloud" would extend 5.25 ft. radially. All non-rated electrical components are outside this distance.

Summary:

The conclusion from the first calculation determined that if the entire contents of 3 aerosol cans were to be released into the glovebox, develop a stoichiometric mixture, and ignite, the resulting overpressure (due to the entire 3 full can vapor cloud deflagration) would potentially develop an overpressure of 298.29 in wg, which is more than 50 times the design pressure. This ideal pressure deflagration event could likely cause severe structural damage to the supercompactor glove box. The damage could be severe enough that any radiological containment associated with the glovebox would likely be compromised (lost).

The conclusion from the second calculation is that one can (retaining approximately 5.7% (49 ml) liquid), if compacted and (under ideal stoichiometric conditions) resulting in a deflagration, would not exceed the given structural design of the supercompactor glovebox, when ventilation is operating at -1.5 in wg. Loss of radiological containment is not likely to occur.

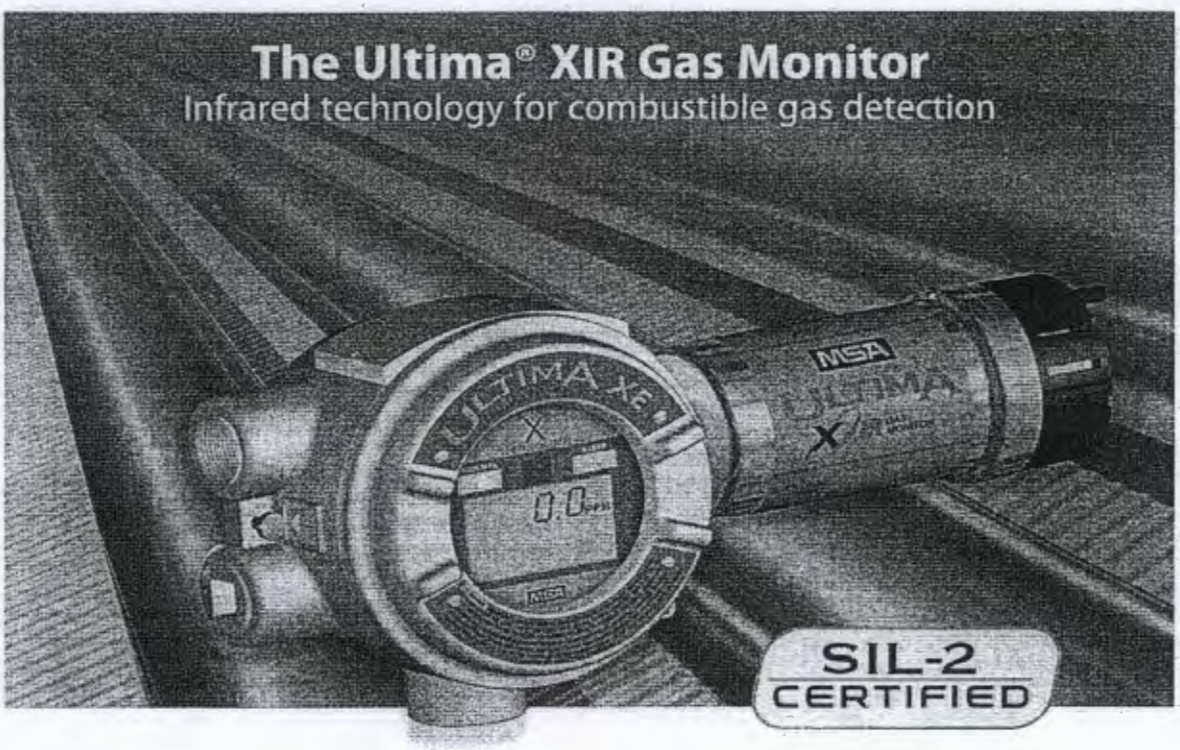
Effective mitigation of a collocated fuel/air mixture and ignition source is achieved through monitoring and automatic shutdown of the supercompactor.

Additionally, there is not expected to be an ideal combustible fuel/air mixture migration to communicating areas that contain unrated electrical components.

EDF No.: EDF-0783	**Revision No.:**0	**FMP No. (*if any*):** NA
Title: Deflagration Analysis of Aerosol Can Propellant in the Supercompactor Glovebox	**Building/System No.:** WMF676/410	

Attachments (*If any*):

MSA Ultima XIR Gas Monitor data sheet.



Features

- DuraSource Technology offers improved IR sensor life
- Field-selectable algorithms for a variety of hydrocarbon-based gases
- LCD display with scrolling messages and LEDs
- Single-board design for ultimate reliability and easy, no-tool servicing
- 4-20mA, HART, and Modbus (X³™ Technology) output
- Optional quick-check LEDs for increased product visibility
- *Fail-to-safety* operation

Benefits

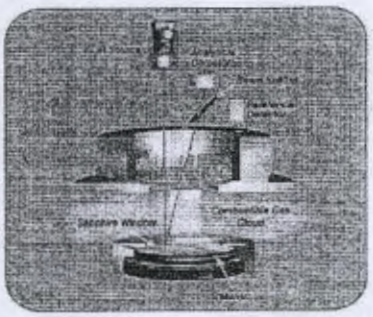
- No-gas calibration; zero adjustment meets requirement for full calibration
- Extremely fast response speed (t90 < 2 sec)
- Designed without sintered disk for optimum performance in harsh, offshore environments
- Operates over extended temperature ranges
- Immune to poisoning
- No sensor life reduction from gas exposure
- Automatic compensation for humidity and temperature changes
- Operates in high gas and low oxygen environments

DURA™ SOURCE TECHNOLOGY 10-YEAR WARRANTY

MSA
The Safety Company

The Ultima XIR Gas Monitor is a microprocessor-based, infrared point gas detector for continuous monitoring of combustible gases and vapors. Designed around a rugged, 316 stainless steel enclosure, the Ultima XIR Monitor has multiple entries for maximum flexibility.

Ultima XIR Monitor operation is based upon dual-wavelength, heated-optics technology, providing definitive compensation for temperature, humidity, and aging effects. IR technology offers excellent long-term stability, eliminates the need for frequent calibrations, and reduces overall cost of ownership.



Principles of IR Technology

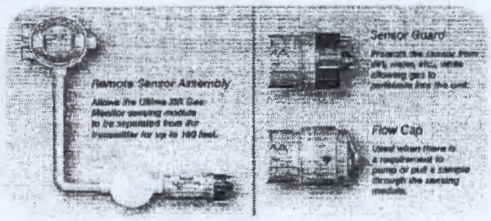
The Ultima XI Gas Monitor uses an electronically modulated infrared energy source and two detectors that convert infrared energy into electrical signals. Each detector is sensitive to a different range of wavelengths in the spectrum's infrared portion.

The source emission is directed through a main enclosure window into an open volume. A mirror at the end of this volume, protected by a second window, directs energy back through the main enclosure window and onto the detectors.

Combustible gas presence in the open volume will reduce the source emission intensity reaching the analytical detector but not the source emission intensity reaching the reference detector. The microprocessor monitors the ratio of these two signals and correlates this ratio to a %LEL combustible reading.

Ordering Information

All Ultima X Series Gas Monitors are manufactured using MSA's Assemble-To-Order (ATO) process. For further information on the Ultima X Series Gas Monitors, see bulletins 07-2051-MC and 07-2054-MC.



Ultima XIR Accessories

Specifications

Gas Types and Ranges	Combustible gases & vapors; 0-100% LEL CO_2 0-5% and 0-2% by volume, 0-5000 ppm
Temperature Range	-40°C to +60°C (-40°F to +140°F)
Stability	± 2% full scale/year
Repeatability	± 1% full scale
Accuracy	± 3% full scale (< 50% LEL) ± 5% full scale (> 50% LEL)
Response Times (without sensor guard) t90	< 2 sec.
Humidity	0%-95% RH, non-condensing
Sensor Warranty	10 years for IR source
Power Input	8-30 VDC, 5 watts
Current Draw	290mA maximum @ 24 VDC
Wiring Requirements	3-wire
Signal Output	4-20mA 3-wire current source
Conduit Entries	One entry, 3/4" NPT (19.05 mm) with optional conduit
Physical Weight Dimensions	316 stainless steel 6 lbs. (2.7 kg) 2.5" dia. x 8" long (64 x 203 mm)
Approval Ratings	$_CFM_{US}$ $_CUL_{US}$ CSA Class I, Div. 1 and 2, Groups A, B, C, & D Class II, Div. 1, Groups E, F, & G Class III ANSI/ISA 12.13.01 CSA C22.2 No. 152 Combustible Gas Performance; Class I, Div. 1 and Groups B, C, & D CE EMC Directive: 89/336/EEC CE ATEX Directive: 94/9/EC II 2G EEx d IIc T5 (Tamb -40°C to +60°C) TYPE 4X; IP 66 SIL 2 assessed to IEC 61508

Note: This Bulletin contains only a general description of the products shown. While uses and performance capabilities are described, in no circumstances shall the products be used for unqualified individuals and not in the product instructions including any warnings or cautions, provided have been thoroughly read and understood. Only they contain the complete and detailed information concerning proper use and care of these products.

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Offices and representatives worldwide
See home page for details

The Safety Company

MSA The Safety Company — Ultima® XIR Gas Monitor Quick Start-Up Guide

⚠ WARNING

This Guide is not a substitute for the manual contained in the Product Literature CD. The Ultima X Series Gas Monitor Manual must be carefully read by all individuals who have or will have the responsibility for using or servicing the product. Failure to follow this warning can result in serious personal injury or loss of life.

1. Remove the lid and the electronics from the enclosure (FIGURE 1).
2. Mount the enclosure in the desired location and run wiring to the enclosure per instructions on the enclosed Installation Outline Drawing. The XIR sensor should be mounted horizontally as shown in FIGURE 1.
3. Connect 8 to 30 VDC power lead to J8-1 (FIGURE 2).
4. Connect the signal ground wire to J8-3.
5. Connect J8-2 to the 4 - 20 mA input on remote system.
6. Connect the sensor module to J-1 on the main pc board.
7. Wire for optional acknowledge push-button (J10) and/or optional relays (FIGURE 3).
8. Connect the optional HART barrier to J9 (FIGURE 3).
9. Assemble the electronics assembly and the lid on the enclosure.
10. Apply power and observe the LCD as all segments light, software version displays, and a 30-second (self-check) countdown occurs.
11. After 30-second countdown, observe that the gas type and gas concentration alternately display. (For units with LEDs, green LED is ON and red LED is OFF).
12. Perform a gas check to ensure proper operation.

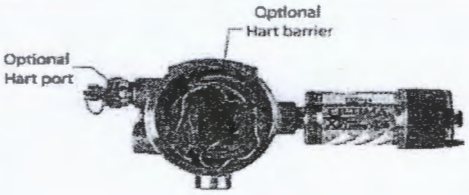

Figure 1

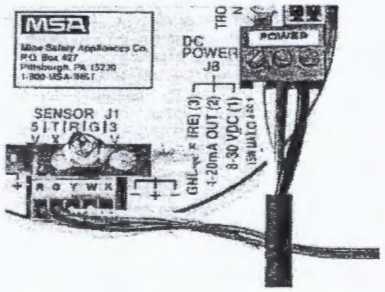

Figure 2

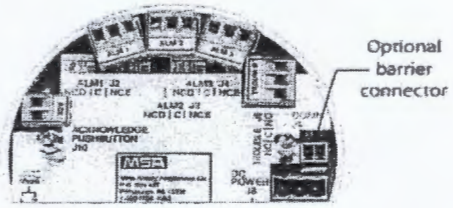

Figure 3