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Federal Railroad Administration

Emergency Escape Breathing Apparatus

Office of Research
and Development
Washington, DC 20590

DOT/FRA/ORD-09/11

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May 2009

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13. ABSTRACT (Maximum 200 words) Through sponsorship by the Federal Railroad Administration and in cooperation with the railroad industry and railroad labor organizations. Technical Products, Inc. (TPI) has developed information and recommendations relative to the use of emergency escape breathing apparatus (EEBA) by train crews who may have exposure to hazardous materials and would pose an inhalation hazard in the event of unintentional use. The research included defining the scope of the triggering criteria—the presence on trains of hazardous material that would pose an inhalation hazard in the event of unintentional release, the state of EEBA technology, the methods by which EEBAs might be provided to crews, the incidence rate of accidents with fatalities and serious injuries attributable to the inhalation of released hazardous material, and the economic issues involved with the provision of these devices to all train crew members.			
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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

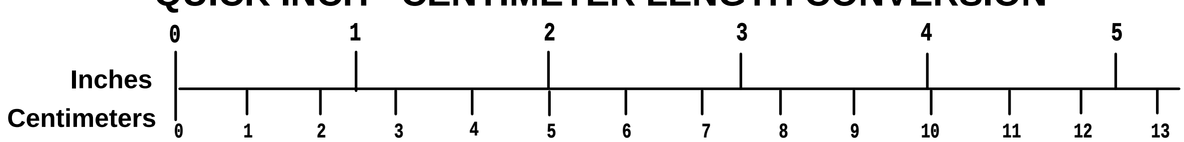
VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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EXECUTIVE SUMMARY

On January 6, 2005, a Norfolk Southern Railway Company freight train (train 192), while traveling through Graniteville, SC, encountered an improperly lined switch that diverted the train from the main line onto an industry track, where it struck an unoccupied, parked train (P22). The collision derailed both locomotives and 16 of the 42 freight cars of the train 192, as well as the locomotive and 1 of the 2 cars of train P22. Among the derailed cars from train 192 were three tank cars containing chlorine, one of which was breached, releasing chlorine gas. The train engineer and eight other people died as a result of chlorine gas inhalation. [1,2]

In its report on the Graniteville accident, the National Transportation Safety Board (NTSB) cited an accident that occurred in Macdona, TX, in June 2004, where one of the crew members of the train involved in that accident succumbed due to chlorine gas inhalation following a catastrophic release of a similar nature. These two fatalities of operating crew members in similar circumstances led to a recommendation in *Railroad Accident Report NTSB/RAR-05/04 R-05-17* that reads,

> "Determine the most effective methods of providing emergency escape breathing apparatus for all crew members on freight trains carrying hazardous materials that would pose an inhalation hazard in the event of unintentional release, and then require railroads to provide these breathing apparatus to their crew members along with appropriate training."

This recommendation led the Federal Railroad Administration (FRA) to commission this study and report.

The NTSB recommendation encompasses a wide range of issues that FRA needed assistance in evaluating. Accordingly, this report addresses the following tasks:

1. Define the scope of the triggering criteria, "freight trains carrying hazardous materials that would pose an inhalation hazard in the event of unintentional release."

Freight railroads transport a variety of hazardous materials across the country, through rural areas and populated cities alike, and it is difficult to predict in advance which hazardous materials (HazMat) will be transported, where they will be transported, when they will be transported, and what other HazMat may share the same train. This means that, in effect, almost any freight train and Train and Engine (T&E) crew could be involved in a HazMat incident if that train is involved in an accident.

On the basis of these factors, as well as analysis of HazMat accident data in the body of this report, we suggest that FRA specify as "triggering criteria" the deployment of emergency escape breathing apparatus (EEBA) on a train consist that includes one or more HazMat tank car(s) whose cargo poses an inhalation, poisonous or oxygen deficiency threat, or cars containing other bulk HazMat cargo (i.e., 50-gallon drums) totaling a quantity similar to a tank car.

2. Define the state of EEBA technology to protect crew members from "hazardous materials that would pose an inhalation hazard."

Because catastrophic railroad HazMat incidents have the potential to release concentrations that are immediately dangerous to life or health (IDLH) and/or displace oxygen, only "air-supplying" self-contained breathing apparatus (SCBA) equipment should be considered for adequate crew protection. Air-purifying respirators like filtered self-rescuers (known as FSR) or, powered air-purifying respirators (known as PAPR) must be ruled out due to the potential presence of IDLH HazMat concentrations in the area around the train following a catastrophic accident such as those that occurred in Graniteville or Macdona. The FRA EEBA should possess a capacity of not less than 30 minutes of breathing time, with a suggestion that devices with 60 minutes be considered.

3. For each device recommended, define the different methods by which the devices might be provided to employees by their railroad employers.

Different methods by which EEBAs might be provided to employees were researched. Railroads and union representatives provided input on this matter via completion of a targeted questionnaire.

Like other safety equipment, we considered the EEBA could be provided to the crews in a number of ways. Factors that influence the decision on how to deploy the device include the configuration of the selected EEBA and whether it can, or should be, hand-carried or must be mounted on the equipment. Also considered is the configuration of the EEBA and whether it is a generic one-size-fits-all or a customized-to-user type with mask size or of a type to accommodate facial hair, etc.

Regarding assignment, we defer to the responses provided from rail industry experts. Unanimously, each railroad that responded to the questionnaire preferred that in the event EEBAs were mandated, they should be assigned to each T&E employee. The railroads prefer the responsibility for care and maintenance of EEBAs be assigned to T&E employees. Railroads' opinions are largely predicated on prior experience with regulated equipment that disappears because of loss, pilfering, or damage. Additionally, their logic is that if personally assigned, EEBAs will be better cared for. Better care results in lower replacement costs if the EEBA can be deployed until its end-of-service life or when mandatory replacement is required. In contrast, union responses recommended that supply, maintenance, and inspection be accomplished by the railroad carrier.

4. Quantify the incidence rate of accidents with fatalities and serious injuries attributable to the inhalation of released hazardous material.

Research into triggering criteria revealed dramatic improvements in rail operations' safety performance. Overall accidents and casualty rates have declined significantly from the 1970s into the 1980s and again from the 1980s through the 1990s, with the past decade experiencing a leveling off of safety performance.

As shown in a May 2005 presentation by Robert Fronczak, P.E., Assistant VP, Environmental and HazMat for the Association of American Railroads (AAR), railroad incidents have been reduced significantly over the past two decades [3]. By any other industrial or business sector, the statistical improvements realized by the rail industry would be considered outstanding. Railroads have exhibited exceptional safety performance in many areas, including:

- Lower injury rates compared to other major industry groups.
- Lower injury rates compared to other transportation modes.
- Lower injury rates compared to most major European railroads.
- Declines in HazMat incident release rates (down 71 percent since 1980 and 56 percent since 1990).
- Declines in HazMat accident rates (down 90 percent since 1980 and 49 percent since 1990).
- Declines in accidents with a HazMat release (down 76 percent since 1980 and 17 percent since 1990).

Furthermore, the U.S. Department of Transportation (DOT) quoted the FRA representatives in a 2004 overview as saying that accidents declined nearly 70 percent since the late 1970s, and over the previous 3 years the Nation has had the lowest number of rail-related deaths and employee fatalities on record. Despite more than 2 million movements of HazMat cars, 2003 marked the lowest number of train accidents involving a HazMat release in the previous 5 years.

To the best of our knowledge and research, during the past 20 years, only two incidents of T&E crew members killed by inhalation of an acute toxic gas occurred, which resulted from a collision and breached tank car. These were the individuals who died as a result of the Graniteville and Macdona incidents. The NTSB lists both of these casualties as "killed by inhalation." For some perspective of the relative risk, the casualty rate for these two deaths can be expressed in three ways:

- One Fatality per 367 million train miles (Annual rate based on 10-year period average 1997- 2006 statistics found in Table 5).
- One Fatality per 5.7 million shipments of the Top 125 HazMat (1997-2006) [4].
- One Fatality per 1.1 million shipments of chlorine.

This last statistic is based on testimony by former FRA Administrator Joseph Boardman:

> "Considering just chlorine, for example, since 1965 (the earliest data available) there have been at least 2.2 million tank car shipments of chlorine–only 788 of which were involved in accidents (0.036 percent of all the shipments). Of those accidents, there were 11 instances of a catastrophic loss (i.e., a loss of all, or nearly all) of the chlorine lading 0.0005 percent of all the shipments). Of the 11 catastrophic losses, four resulted in fatalities (0.00018 percent of all the shipments)." [5]

Of those four accidents, two resulted in fatalities involving crew members, including those in Macdona in June 2004, and Graniteville in January 2005. Thus, for chlorine alone, the risk of a crew member fatality due to inhalation is one per 1.1 million shipments.

5. For the recommended devices from Task 2, define the economic issues involved in the provision of these devices to all crew members.

The economics of implementing the EEBA program across the rail industry are subject to the regulatory position taken by the FRA in terms of:

- Technology deployed (e.g., a 60-minute closed loop escape self-rescuer costs $750 whereas a 60-minute open loop SCBA costs $3,000—a 4-fold increase in cost.
- Deployment mode (e.g., issuing each T&E member their personal system versus equipping the locomotive of a HazMat consist can affect the total number of systems deployed by a factor of 2–3.
- Required recertification/training, etc. (e.g., some EEBAs may require training every month while others may require training every 6 months. This can affect cost by a factor of 2–3.

We considered the implementation costs associated with EEBAs. Regardless of the basis of issue and level of technical sophistication, the EEBA will be a very significant investment by the railroads. Also, like all technically sophisticated safety equipment, the EEBA will require significant on-going expenditures for maintenance, inspection, repair and replacement. In addition, on-going administrative costs exist for crew training and record keeping of the training, device issue and return, and device maintenance conducted. Finally, depending on the nature of the technology involved—some of the possible devices contain chemicals (i.e., catalysts, absorbents)—some disposal costs could be associated with the chemical end of life.

The numerical estimates for T&E employees and locomotives were derived from a cost/benefit analysis supplied by the AAR with adjustments made to scrap figures (i.e., shelf life) and training time based on the equipment manufacturer's recommendations. Cost estimates compared the assignment of EEBAs to the locomotive and assignment to T&E employees. For locomotive assignment, estimates were based on issuance of three EEBAs per locomotive to provide for two T&E employees plus an additional person. The cost estimated compares open loop SCBA respirators (using Grade D compressed air) to closed loop SCBA respirators (using compressed oxygen). A net present value (NPV) over 15 years was used in the equation for equipment, training, maintenance, replacement (due to damage, pilfering, or loss), and tracking (for issuance, maintenance, service life, etc.).

The resultant 15-year NPV estimates are as follows.

SCBA Type	**Open Loop**		**Closed Loop**	
Assignment	**Locomotive**	**Employee**	**Locomotive**	**Employee**
Total Capital Cost (NPV)	**$79,760,000**	**$67,200,000**	**$67,080,000**	**$83,330,000**

Summary

The technology exists to provide train crews with effective EEBA to protect themselves in the event of a catastrophic HazMat release. Implementation of a regulation to mandate EEBA on HazMat train consists has significant economic implications for the operating companies. Accident data shows this scenario to be possible, but extremely unlikely.

The responsibility to make the decision on implementing the NTSB recommendation R-05-17 to address this possibility lies with DOT/FRA.

Introduction

This report is intended to support the Federal Railroad Administration (FRA) decisionmaking in response to a National Transportation Safety Board (NTSB) recommendation for a proposed regulation requiring railroads to provide emergency escape breathing apparatus (EEBA) to railroad operating employees for use during railroad incidents involving the release of hazardous materials. The report does this by compiling factual information and performing technical, risk and economic analyses surrounding the proposed regulation.

The research used a variety of historical and public data sources covering the rail transportation of dangerous goods/HazMat, and incident rates, and casualties for both railroad and non-railroad industries. Other sources of information reviewed included safety regulations from FRA, the U.S. Department of Transportation (DOT) and the National Institute for Occupational Safety and Health (NIOSH) as well as recommendations of the National Transportation Safety Board (NTSB). Data was also retrieved from non-government entities including the American Association of Railroads (AAR), railroads, union representatives, and rail, civilian, and research organizations.

Historical data was analyzed over various periods of time, some as far back as 20 years to determine the actual frequency of rail-based HazMat incidents and, more specifically, of train crew injuries and fatalities caused by the release of HazMat into the environment (as opposed to injury from the mechanics of the crash, derailment, fire, incident). What was uncovered turned out to be an incongruous set of circumstances, whereby the two deaths attributable to HazMat incidents in the past 20 years occurred during a recent period when safety performance rates were most improved.

The other aspects of the research involved defining the economic and logistical scope of deploying EEBAs to train and engine (T&E) crews by considering the following:

1. The state of EEBA technologies currently available to protect crew members from HazMat that would pose an inhalation hazard.

2. The different methods by which the devices might be provided to T&E employees. Ascertaining the different methods by which the devices might be provided would be driven by several issues, including current industry practices regarding the placement of other types of emergency equipment on locomotives, as well as the need to ensure that *all crew members* are provided the devices.

3. The economic issues involved in the provision of these devices to all T&E crew members.

Direct feedback canvassed from rail industry professionals on the implementation of EEBAs was used in our analysis. This report is presented on a task-by-task basis as defined in the statement of work incorporated into the contract authorizing this effort. The tasks are discussed individually (although naturally some cross-referencing occurs) and then the research and analyses conducted are concluded with a summary of our findings and recommendations.

Task 1: Define the scope of the triggering criteria, “freight trains carrying hazardous materials that would pose an inhalation hazard in the event of unintentional release.”

1.1 Triggering Criteria–General

Freight railroads transport a variety of hazardous materials across the country, through rural areas and populated cities alike, and it is difficult to predict in advance which HazMat will be transported, where they will be transported, when they will be transported, and what other HazMat may share the same train. This means that, in effect, almost any freight train and T&E crew could be involved in a HazMat incident if that train is involved in an accident.

During 2000 to 2005, an average of 1.2 million tank car loads of hazardous materials were shipped. Seventy-three percent of these shipments were of the top 25 hazardous commodities shipped by rail. Of the top 25 hazardous commodities, 14 have specific known levels and types of inhalation toxicity, ranging from simple asphyxiants such as liquefied petroleum gas and carbon dioxide, to acutely toxic gases such as ammonia and chlorine. The balance of the commodities are identified by such names as FAK (Freight–All Kinds) hazardous material, elevated temperature liquid NOS (not otherwise specified), flammable liquid NOS, some of which may also pose inhalation hazards.

The question is: At what point does the transport of these materials justify the mandate to require that EEBA be provided to the train crew?

The criteria that delineate when the requirement for EEBA should be applied will include (but not be limited to) the following considerations:

- At what volume/weight does any specific cargo (e.g., LPG) pose a HazMat threat
- What effect does the configuration of the train and the relative location of HazMat-carrying cars have on the overall scenario? For example, two cars of LPG adjacent to each other may be a different hazard level than two cars of LPG separated by 10 “benign” cars.
- What is the relative hazard level under differing operating conditions of speed, traffic, likelihood of proximity to other moving trains, etc. (e.g., shunting in a freight yard versus local transit versus long haul)?

The problem is more complicated due to the varying nature of the cargo. For example, should the criteria be based on volume/weight by class of freight or be applied at the individual substance level? Does a train with (270) 50-gallon drums of a HazMat spread throughout the train represent the same risk as a single 13,500-gallon tank car?

The decision to implement a regulation requiring the provision of EEBA equipment involves significant capital and operating cost and so must be balanced against the frequency of occurrence and incident cost of HazMat release. The real crux of this decision becomes one of cost/benefit analysis with “cost” and “benefit” being defined in the broadest senses to include capital and operating costs when nothing happens, financial cost when a HazMat release occurs resulting in injury or death, employee health and safety, public health and safety, legal liability, societal cost and benefit, and more.

On the basis of these criteria and conditions, FRA wants a recommended set of criteria to be applied against the specific train consist and cargo set to generate a go/no-go decision point for the mandatory use of EEBA.

1.2 Data and Analysis

This task addresses the question of when the crew or train should carry an EEBA from a purely technical perspective. The economics of implementing a mandatory EEBA regulation is ignored in this analysis but is addressed in Task 5.

The question of when the crew/train should carry EEBA is a function of the following factors:

- The amount of HazMat being carried,
- Its toxicity (manner in which it causes harm),
- Its physical properties (solid, liquid, vapor, gas—which will determine if it will be in the atmosphere following release in sufficient quantities to cause harm)
- The likelihood of a release, and
- The potential for damage/injury/loss of public life occasioned by the HazMat release rendering an unprotected crew ineffective.

In an effort to answer these questions, data was acquired from several rail industry and government sources. This data was analyzed with regard to operating logistics of HazMat transported by rail as well as incident and casualty figures relative to HazMat tank car originations and accidents.

1.2.1 HazMat Types, Originations and Routes

A document published by the Centers for Disease Control (CDC) titled, *Public Health Consequences from Hazardous Substances Acutely Released During Rail Transit* [6] released January 28, 2005, states the following:

> "Approximately 800,000 shipments of hazardous substances travel daily throughout the United States by ground, rail, air, water, and pipeline; approximately 4,300 shipments of hazardous materials travel each day by rail, including chemical and petroleum products. Although nearly all of these materials safely reach their destinations, many are explosive, flammable, toxic, and corrosive and can be extremely dangerous when improperly released. These materials frequently are transported over, through, and under areas that are densely populated or populated by schools, hospitals, or nursing homes, where the consequences of an acute release could result in environmental damage, severe injury, or death."
> …
>
> "Findings from the HSEES (Hazardous Substances Emergency Events Surveillance) system suggest that rail events constitute only 2 percent of total hazardous-substance releases. Furthermore, most rail events involved small-scale releases (75 percent of events involved $\leq$70 gallons). However, large-scale, acute releases during rail transit can occur (10 percent of events involved $\geq$2,200 gallons) and can cause substantial injury and death, as

demonstrated by case reports."

The 2004 Macdona, TX and 2005 Graniteville, SC accidents released 9,400 and 9,218 gallons of liquid chlorine, respectively [1,2]. These are the only two identified large-scale release incidents ($\geq$2,200 gallons) that resulted in T&E crew killed by inhalation of an acute toxic gas stemming from a collision and breached tank car. Of all aggregated HazMat commodity origins over the 10-year period 1997 through 2006, chlorine has ranked 12th or lower (see Table 1). According to the Acting NTSB Chairman Mark Rosenker in a 2005 NTSB Safety Recommendation [7],

> "The Macdona and Graniteville accidents, both of which have occurred since the Minot report was issued, resulted in the puncturing of two chlorine tank cars and the death of 12 people from chlorine inhalation. When a liquefied gas such as chlorine, which is poisonous by inhalation, is released, large clouds at lethal concentrations can be generated within minutes."

This statement has theoretically been proven true per a 2005 document entitled, *"Detailed Numerical Simulation of Graniteville Train Collision*." [8]

Table 1. Historical Ranking of Aggregated Hazardous Materials Commodities by Originations

All Car Types, U.S. and Canada, 1997–2001

Source: Association of American Railroads, Bureau of Explosives

Annual Reports of Hazardous Materials Transported by Rail

	RANK									
COMMODITY (DOT PROPER SHIPPING NAME)	**2006***	**2005***	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**
LIQUIFIED PETROLEUM GASES (LPG)	1	1	2	2	2	2	2	2	2	2
ALCOHOL/ALCOHOLS, N.O.S.	2	6	6	9	10	11	12	13	15	15
FAK-HAZMAT	3	2	1	1	1	1	1	1	1	1
ELEVATED TEMPERATURE LIQUID	4	3	3	3	3	3	4	4	4	4
SODIUM HYDROXIDE SOLUTION	5	4	4	4	4	4	3	3	3	3
SULFURIC ACID	6	5	5	6	5	5	6	5	5	5
DIESEL FUEL	7	8	8	5	6	8	21	18	24	25
SULFUR, MOLTEN	8	7	7	7	7	6	7	6	6	6
AMMONIA, ANHYDROUS	9	10	9	8	8	7	8	7	7	7
GASOLINE	10	11	10	10	9	9	10	10	8	13
FLAMMABLE LIQUIDS, N.O.S.	11	9	19	23	24	--	--	--	--	--
CHLORINE	12	12	11	11	11	10	9	8	9	8
FUEL OIL (HAZARD CLASS 3)	13	13	14	20	21	12	5	9	11	10
PHOSPHORIC ACID	14	14	13	13	14	16	14	12	13	14
ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.	15	16	15	14	15	13	--	--	--	--
VINYL CHLORIDE STABILIZED	16	15	12	12	12	15	11	--	12	12
METHANOL	17	17	16	15	13	14	13	11	14	11
HYDROCHLORIC ACID	18	19	18	16	18	18	15	14	20	19
CARBON DIOXIDE	19	20	20	17	19	20	19	16	17	18
ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S.	20	18	17	14	15	13	17	--	22	21
PROPANE	21	--	--	--	--	--	--	--	--	--
STYRENE MONOMER, INHIBITED	22	22	21	19	20	21	18	15	19	16
BUTANE	23	--	--	--	--	--	--	--	--	--
AMMONIUM NITRATE FERTILIZERS	24	21	22	18	17	17	16	17	16	17
PETROLEUM DISTILLATES, N.O.S.	25	24	25	--	--	--	--	--	--	--
SODIUM CHLORATE	--	25	23	21	23	22	20	19	23	22
PROPYLENE	--	23	24	22	22	23	22	--	--	--
BUTADIENES, INHIBITED	--	--	--	--	--	--	24	22	25	23

* Include U.S., Canada & Mexico

According to DOT's 2002 Commodity Flow Survey in Table 2, total HazMat shipments in tons have risen by nearly 7 percent from 1997 to 2002. However, the rate of ton–miles has declined by 8.3 percent and the average miles per shipment also declined by 17 percent over the same period of time. More recent data was not available at the time of this report.

Table 2. Hazardous Material Shipment Characteristics by Mode of Transportation For the United States: 2002 and 1997

Mode of Transportation	Tons			Ton-Miles			Average Miles Per Shipment		
	2002 (thousands)	1997 (thousands)	% Change	2002 (millions)	1997 (millions)	% Change	2002	1997	% Change
Rail	109,369	102,508	6.7	72,087	78,619	-8.3	695	837	-17

Source: United States: 2002, Hazardous Materials, 2002 Economic Census, Transportation, 2002 Commodity Flow Survey

Examination of AAR data for the 5-year period 2002 through 2006 shows 68 percent of HazMat tank car origins were of the top 25 hazardous commodities shipped by rail and 90 percent of HazMat tank car origins were of the top 125 hazardous commodities shipped by rail (see Tables 3 and 4).

Table 3. HazMat Classifications as a Percent of Total Tank Car Originations in the U.S., Canada, and Mexico*

Source: Association of American Railroads, Bureau of Explosives Annual Report of Hazardous Materials Transported by Rail

		% to Top 25 HazMat Tank Car Origins				
Hazard Class	**Hazard Title**	**2002***	**2003***	**2004***	**2005**	**2006**
2.1	Flammable Gas	23.24%	18.55%	21.03%	20.70%	19.68%
2.2	Non-Flammable Gas	8.31%	7.61%	8.51%	8.02%	7.58%
2.3	Poison Gas	4.61%	3.83%	4.42%	4.04%	3.96%
3	Flammable Liquid	19.52%	18.65%	23.32%	26.05%	29.06%
CL	Combustible Liquid	1.70%	14.80%	2.28%	2.66%	2.86%
4.1	Flammable Solid	2.92%	2.95%	2.70%	2.41%	2.39%
5.1	Oxidizing Material	0.00%	0.00%	0.00%	0.00%	0.00%
6.1	Poisonous Material	1.43%	1.23%	1.43%	1.28%	1.30%
8	Corrosive	23.65%	20.16%	22.39%	22.64%	21.84%
9	Miscellaneous	14.63%	12.22%	13.91%	12.21%	11.34%
	Totals	100.00%	100.00%	100.00%	100.00%	100.00%
% Top 25 HazMat Origins to Total HazMat Tank Car Originations:		65%	75%	66%	69%	67%

* Figures for Mexico not available for 2002–2004

Table 4. HazMat Classifications as a Percent of Total Tank Car Originations in the U.S., Canada, and Mexico*

Source: Association of American Railroads, Bureau of Explosives
Annual Report of Hazardous Materials Transported by Rail

		% to Top 125 HazMat Tank Car Origins				
Hazard Class	**Hazard Title**	**2002***	**2003***	**2004***	**2005**	**2006**
2.1	Flammable Gas	19.89%	18.86%	18.30%	18.07%	17.92%
2.2	Non-Flammable Gas	6.13%	6.42%	6.31%	6.01%	5.63%
2.3	Poison Gas	4.41%	4.22%	4.24%	3.87%	3.74%
3	Flammable Liquid	25.57%	26.53%	27.33%	28.58%	31.19%
CL	Combustible Liquid	3.64%	3.82%	4.05%	4.14%	3.97%
4.1	Flammable Solid	2.22%	2.56%	1.97%	1.77%	1.78%
5.1	Oxidizing Material	0.93%	1.08%	1.06%	1.20%	1.27%
6.1	Poisonous Material	1.57%	1.73%	1.73%	1.56%	1.50%
8	Corrosive	22.00%	21.85%	21.73%	21.98%	21.04%
9	Miscellaneous	13.63%	12.93%	13.28%	12.82%	11.95%
	Totals	100.00%	100.00%	100.00%	100.00%	100.00%
% Top 125 HazMat Origins to Total HazMat Tank Car Originations:		90%	90%	90%	93%	91%

* Figures for Mexico not available for 2002–2004

At the request of the AAR, numerical values for each hazard class in Tables 3 and 4, as well as total origins, are classified due to security concerns.

Consideration was also given to HazMat tank car originations by railroad type. Without jeopardizing the AAR's classified HazMat numbers, we can first consider that over the 5-year period 2002 through 2006, Class I railroads comprised 87 percent of all freight car originations [9]. The balance of originations was on regional and local lines. When comparing HazMat tank car origins globally to the total number of freight car origins, we find that 2.7 percent of HazMat tank cars were of the Top 25 origins and 3.4 percent of HazMat tank cars were of the Top 125 origins. When we look at these percentages for Class I railroads only, we find the 5-year average of top 25 HazMat tank car origins to be 3.10 percent of all Class I freight car origins. For the top 125 HazMat tank car origins, the average is 3.95 percent of all Class I freight car origins.

1.2.2 Accident Data

According to FRA data, rail accident rates have decreased significantly over time:

- The 10-year average from 1978 through 1988 saw the accident rate plunge by 69.9 percent, a factor of 3 from 14.8 to 4.6 accidents per million train miles.
- The 10-year average from 1987 through 1996 saw the accident rate decrease to 4.2 accidents per million train miles.
- The 10-year average from 1997 to 2006 shown in Table 5 saw the accident rate involving all railroads decrease further to 3.9 accidents per million train miles (2,911 accidents over 734,655,521 mainline miles) of which:

- 1.47 accidents per million train miles occurred on the mainline track (950 accidents over 648,218,079 mainline miles).
- 18.35 accidents per million train miles occurred on yard track (1,568 accidents over 85,437,442 mainline miles).

Of the 29,110 train accidents involving all classes of railroads, 72 percent were the result of derailments and 7 percent were due to collisions.

Table 5. 10-Year Accident/Incident Overview by Railroad

ALL RAILROADS—SUMMARY BY CALENDAR YEAR, (January–December)

Source: FRA Office of Safety Analysis Web Site, http://safetydata.fra.dot.gov/officeofsafety/

Category	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	10-yr. avg
TRAIN ACCIDENTS	2,397	2,575	2,768	2,983	3,023	2,738	3,017	3,380	3,261	2,968	2,911
Train accidents per million train miles	3.5	3.8	3.9	4.1	4.2	3.8	4.1	4.4	4.1	3.7	3.96
Train accidents on main line	867	934	858	976	1,025	886	964	1,019	1,003	963	949.5
Rate–per-million train miles 1/	1.5	1.6	1.4	1.5	1.6	1.4	1.5	1.5	1.4	1.3	1.47
Accidents on yard track	1,223	1,306	1,531	1,6197	1,569	1,478	1,667	1,921	1,808	1,555	1567.7
Rate-per-million yard switching train miles	14.4	15.6	17.5	18.2	18.3	18.2	20.4	22.9	20.5	17.5	18.35
Collisions	202	168	205	238	220	192	198	237	273	201	213.4
Derailments	1,741	1,757	1,961	2,112	2,234	1,989	2,131	2,430	2,301	2,179	2083.5
Total train miles (1,000)	676,716	682,894	712,452	722,876	711,549	728,674	743,330	770,152	788,807	809,099	734,655
Yard switching miles (1,000)	84,873	83,692	87,458	88,919	85,747	81,002	81,630	83,934	88,084	89,031	85,437

Data was further analyzed based on track type and Railroad type to determine any trends in the occurrence of HazMat incidents over the 10-year period from 1997 through 2006. The criteria used in Table 6 include collisions, derailments and highway-rail accidents that resulted in a HazMat release.

Table 6. Accidents Involving a HazMat Release *

10-year Total 1997–2006

Source: Department of Transportation

	All Railroads		Class I Railroads	
	Track Type		Track Type	
	Yard	Mainline	Yard	Mainline
No. of Accidents Involving HazMat Cars Releasing	100	198	88	162
No. of Cars Carrying HazMat	31,884	32,957	28,369	29,168
No. of HazMat Cars Damaged	4,747	3,816	4,018	3,151
No. of HazMat Cars Releasing	130	394	100	323

*Table 6 demonstrates that accidents involving a HazMat release occur nearly twice as much on mainline track versus yard track. The total number of cars carrying HazMat in those accidents is nearly equal yet the number of cars damaged is lower on mainline track accidents. Of particular note is that the total number of cars releasing HazMat is three times greater on mainline track. Lastly, Class I railroads comprise the majority (84 percent) of accidents involving a HazMat release.

AAR maintains data relative to the transportation of HazMat and sorts the data of released HazMat into several categories. One category that is heavily tracked concerns tank car non-accident releases (NARs). In consideration of this effort to analyze the need for providing emergency escape breathing apparatus for all crew members on freight trains carrying HazMat, instances of NARs have been excluded due to the relatively low release volumes stemming from sources such as plumbing fittings, valves lines, and vents. Instead, data pertaining to train accidents involving HazMat is given precedence considering the comparative and potential catastrophic effects resulting from damaged or breached tank cars.

Analyzing the 29,110 accidents between 1997 and 2006, the average number of accidents involving HazMat tank cars shown in Table 7 is as follows:

- 725 or 25 percent, of the total accidents involved a HazMat tank car.
- Of those 725 accidents involving a HazMat tank car, 359 accidents resulted in one or more tank cars being derailed or sustaining damage.
- Of the 359 accidents with derailed or damaged HazMat tank cars, an average of 33 accidents resulted in a HazMat release.
- These 33 accidents resulted in 57 tank cars releasing HazMat.

Table 7. Train Accidents, All U.S. Freight Railroads: 1997–2006

Source: FRA Office of Safety Analysis Web Site, http://safetydata.fra.dot.gov/officeofsafety/

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total	Avg.
Total Accidents (including grade crossing)	2,397	2,575	2,768	2,983	3,023	2,738	3,017	3,380	3,261	2,968	29,110	2,911
with Hazardous Material Cars in the consist:	520	598	690	725	768	714	752	843	839	796	7,245	725
in which a Hazmat Car was Damaged or Derailed:	278	305	356	374	389	385	382	388	359	378	3,594	359
in which a Hazmat Car Released Product:	31	42	42	35	32	31	27	29	36	27	332	33
Number of cars releasing Hazmat:	38	67	76	75	57	56	38	47	49	68	571	57

It is difficult to derive firm conclusions as to the efficacy of efforts to reduce HazMat incidents from the historical values observed over this 10-year period. Table 8 details the incidence rate values for each of the data categories in Table 7. The data suggests that as total train accidents rise and fall year to year, the accompanying incidence rates (e.g., the number of HazMat cars in the consist, number of HazMat cars damaged/derailed, etc.) don't always follow the same rise-and-fall trend. However, 131 million more train miles were traveled in 2006 versus in 1997, yet the rate-per-million train miles in which HazMat cars released product remained steady at a rate of 0.05. In fact, when analyzing the number of HazMat cars releasing per million train miles traveled, the data does not demonstrate any substantial difference in the rate over this 10-year period.

Comparing the rate-per-million train miles in 1997 versus 2006, the number of accidents in which HazMat cars released product decreased by 40 percent. However, the number of cars releasing HazMat was 33 percent higher, again making it difficult to derive firm conclusions as to the efficacy of efforts to reduce HazMat incidents from the historical data observed over this 10-year period.

Table 8. Train Accident Rates, All U.S. Freight Railroads: 1997–2006

Source: FRA Office of Safety Analysis Web Site, http://safetydata.fra.dot.gov

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Avg.
TOTAL TRAIN MILES (million):	676.7	682.9	712.5	722.9	711.5	728.7	743.3	770.2	788.8	809.1	734.7
Accidents per Million Train Miles											
Total Accidents (including grade crossing)	3.54	3.77	3.88	4.13	4.25	3.76	4.06	4.39	4.13	3.67	3.96
with Hazardous Material Cars in the consist:	0.77	0.88	0.97	1	1.08	0.98	1.01	1.09	1.06	0.98	0.98
in which a Hazmat Car was Damaged or Derailed:	0.41	0.45	0.5	0.52	0.55	0.53	0.51	0.5	0.46	0.47	0.49
in which a Hazmat Car Released Product:	0.05	0.06	0.06	0.05	0.04	0.04	0.04	0.04	0.05	0.03	0.05
Number of cars releasing Hazmat:	0.06	0.1	0.11	0.1	0.08	0.08	0.05	0.06	0.06	0.08	0.08

1.3 Triggering Criteria Discussion

Historical operational data clearly demonstrates that railroad safety performance has improved immensely over the past 20 years, especially with regard to the transportation of HazMat. According to an article entitled "Industrial Chemicals as Weapons: Chlorine" [10] by Benjamin H. Brodsky, "Of the approximately 12 million tons of chlorine produced annually in the United States, almost 3 million tons are shipped by rail, usually in 90-ton pressurized tank cars. Rail shipment of HazMat is very reliable; 99.997 percent of the 1.8 million annual HazMat shipments in the United States arrive without incident."

Many industry experts predict supplementary enhancements in tank car design as well as strategic placement of tank cars in train consists will further effectuate safety performance. FRA is currently overseeing several ongoing car placement programs to reduce accidents.

With this in mind and in consideration of the data offered in this section, it appears that the real likelihood of a HazMat release on a large scale would come from a train hauling a HazMat tank car. Realistically, it seems that a reasonable answer to the question, "When should the crew/train carry EEBA?" would be: "When the train includes a tank car of HazMat or an equivalent volume."

1.4 Triggering Criteria Conclusion

Although catastrophic HazMat-related rail accidents involving large volumes of explosive, flammable, toxic, and corrosive materials being released are very rare, they are most commonly associated with those in which tank cars are damaged from collisions and derailments. Derailments make up the majority of all accidents, and whereas collisions make up a minor portion of overall accidents, these possess greater potential for a catastrophic HazMat release.

In addition to car placement and car marshalling studies, several reports exist on the risk assessment of hazardous material transport via rail. One of those reports, *A National Risk Assessment for Selected Hazardous Materials Transportation* [11] concisely summarizes our assessment of its research that "the overall societal risk due to hazardous materials transportation is low. However, the potential exists for very serious accidents with many injuries and fatalities, although the probability of such events is very low."

Regarding HazMat type and volume, there is not sufficient history to label triggering criteria according to these attributes. In addition to the Macdona and Graniteville accidents, two other recent and notable "near misses" occurred including the 2002 Minot, ND accident in which five tank cars derailed and released 146,700 gal of anhydrous ammonia, and the 2003 Tamaroa, IL accident in which several derailed cars released methanol, phosphoric acid, hydrochloric acid, formaldehyde, and vinyl chloride. The Minot and Tamaroa accidents did not result in the death of any T&E crew. However, of these four cited accidents, all but one of the materials released (formaldehyde) are listed in the top 25 HazMat category for 2006.

The review of available data confirms that the scope of the triggering criteria should be any train consist that includes one or more HazMat tank cars containing volume and contents that pose a risk of injury or death by inhalation due to properties that make the material toxic by inhalation or would displace sufficient atmosphere to cause suffocation, or other bulk HazMat cargo (i.e., 50-gallon drums) totaling a similar quantity.

Task 2: Define the state of emergency escape breathing apparatus (EEBA) technology to protect crew members from "hazardous materials that would pose an inhalation hazard."

2.1 EEBA Technology—General

The optimal EEBA will be defined by how and where it will be used. By this we mean:

- How will it be employed?
  By professional HazMat personnel who undergo refresher training each month.
  By the occasional SCBA users who recertifies once annually.
  By persons who will probably only use such a device once in their lives and who, realistically, are not highly trained—such would be the case with an FRA application.
- What is it protecting against?
  Toxic chemicals (chlorine, etc.),
  Dangerous particulates (e.g., lead), and
  Lack of oxygen (as a result of a fire).

- How is it deployed?
  As a “pool” item,
  Generically configured but permanently allocated to an individual, and
  Custom fitted and permanently allocated to an individual.

We completed a technical review of the different types of EEBA necessary to address the different HazMat carried by the railroads, including their varying modes of toxicity and physical state (compressed gases: ammonia, carbon dioxide, chlorine, and vaporizing liquids: solvents, LPG).

2.2 Classes of Respirators

An EEBA falls under a broad category of “respirators.” To define EEBA technologies best suited to protect crew members from HazMat exposure, it is prudent to define the types of respirators available and how they work. Respirators fall into two categories:

Air-Purifying:	Remove specific air contaminants by passing ambient air through an air-purifying element, such as an air-purifying filter, cartridge, or canister.
Atmosphere-Supplying:	Supply breathing air from a source independent of the ambient atmosphere and includes airline supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units.

Examples of air-purifying and atmosphere-supplying respirators are shown in Figures 1–5.

Figure 1 - Filtering Face Piece with Hood

Figure 2 - Filtering Self-Rescuer with full face mask

Figure 3 - Powered Air Purifying Respirator (PAPR)

Figure 4 - Open Loop Self Contained Breathing Apparatus

Figure 5 - Closed Loop Self Contained Breathing Apparatus

Illustrations of possible Emergency Escape Breathing Apparatus range from simple mask mounted filters to sophisticated closed loop re-breather devices.

2.3 EEBA Selection for T&E Crew

NIOSH is the Federal agency within the CDC that works with government and industry partners to develop respirator standards. Respirator equipment approvals are done in accordance with the NIOSH regulations codified at Title 42 Code of Federal Regulations (CFR) Part 84 [12]. NIOSH also develops information on safe levels of exposure to toxic materials and harmful physical agents and issues recommendations for respirator use.

The Occupational Safety and Health Administration (OSHA) is the agency within the U.S. Department of Labor responsible for developing and enforcing workplace safety and health regulations. OSHA regulates the use of respiratory protection, including emergency escape devices, in the regulation codified at 29 CFR 1910.134 [13].

In considering the possible types of EEBAs that may be used by T&E crews, the requirements of both of the Federal agencies must be considered to ensure that whatever devices are recommended are consistent with them.

NIOSH has developed a comprehensive selection process for respirators. For more information, visit http://www.cdc.gov/niosh/docs/2005-100/#foreword. Two major factors that must be considered in that selection process are to determine if the respirator is intended for use in an oxygen-deficient atmosphere, i.e., less than 19.5 percent oxygen, (O_2) and to determine if the respirator intended for entry into or escape from unknown or IDLH atmospheres (e.g., an emergency situation).

Based on the findings in the 2005 report entitled, *"Detailed Numerical Simulation of Graniteville Train Collision*" [5], the concentration of the toxic chlorine cloud over derailment site area of the Graniteville incident was estimated at 2,000 parts per million (ppm). OSHA classifies chlorine as having an IDLH level of 10 ppm. Roughly estimating the distance between the final resting spot of the ninth (chlorine) tank car relative to the train crew, as well as the wind speed and size of breach, it is likely the chlorine plume traveled to the T&E crew within 2 minutes. According to the coroner's report on the eight civilian fatalities in that incident, the primary cause of death was asphyxia, or lack of oxygen. The engineer's primary cause of death was listed as lactic acidosis. The secondary cause of all deaths in the Graniteville incident was attributable to exposure to chlorine gas. In this example, both NIOSH selection criteria existed; lack of oxygen and toxic gas concentration exceeding IDLH levels.

Because catastrophic railroad HazMat incidents have the potential to release IDLH concentrations and/or displace oxygen very quickly without the crew's knowledge, the crew may need to respond to any incident (meaning collision or derailment) by donning their EEBA—even before investigating the accident. Considering the variables associated with rail transportation of HazMat and the potential hazards that exist, the NIOSH selection criteria identify an escape-type self-contained breathing apparatus (SCBA) as the device needed for this application.

2.4 Escape SCBA

Escape devices have a single function: to allow a person working in a normally safe environment sufficient time to escape from suddenly occurring respiratory hazards. Given this function, selection does not rely on assigned protection factors. Instead, these respirators are selected based on a consideration of the time needed to escape and the likelihood of IDLH or oxygen deficiency conditions.

Escape SCBA devices are commonly used with full-face pieces or hoods and, depending on the supply of air, are usually rated as 3 to 60 minute units. Available types of atmosphere-supplying SCBA are:

- Open Loop SCBA–typically classified as positive pressure, open loop systems whereby the user receives (inhales) clean air with 21 percent oxygen (O_2) from a compressed air cylinder worn with a harness on the back. The user's exhaled breath contains significant amounts (15 percent) of unused oxygen that is vented to atmosphere. Because much of the user's exhaled breath vents to atmosphere, the size of open loop systems are larger than closed loop systems. Open loop SCBA systems employ the use of full face masks, half-face masks or hoods and typically require an airtight seal against the head, face or aural/nasal area.

Rebreathers–can be positive pressure or negative pressure systems. Classified as closed loop O_2 systems, rebreathers perform as its name implies; the user re-breathes his exhaled oxygen. A scrubber removes the user's CO_2 and a small compressed 100 percent O_2 bottle makes up metabolized O_2. Because the user is re-breathing his exhaled air containing 15 percent oxygen, a rebreather has four times the efficiency compared to an open loop system, which is why they either last much longer than open loop systems (if size were comparable) or they can provide the same breathing duration as an open loop system but in a smaller package. Rebreathers use full-face masks, half-face masks, hoods or bite-down mouth pieces. Negative pressure rebreathers do not require a tight seal.

Compressed air via airline—user is tethered to compressed air source ("shop" air) and employs the use of full-face masks, half-face masks, or hoods (not appropriate for this application).

An example of a common open loop positive pressure SCBA system is that which is used by first responders (such as firefighters) for entering an emergency event. These devices are heavy and cumbersome as they incorporate a large compressed air cylinder mounted to a harness and the use of a full-face piece. Logistically and economically, the incorporation of a full-face piece is a difficult undertaking because it requires an airtight seal around the users face. An airtight seal means that each user must be personally fitted for the device. It also means that the user must be cleanly shaven, which is difficult to enforce.

A useful alternative to full-face masks are hoods as seen in Figure 1. These universal fitting devices can be used with open-loop SCBA, do not require fitting to the user, operate regardless of the facial features or hair, and also offer the significant benefit of allowing the wearer to communicate while using the SCBA.

Emergency entry devices can include additional technologies such as electronics for communications, tracking user location, alarm signals (i.e., for low air), and heads-up displays, none of which are required for escape situations.

An example of an escape closed loop system is the self-contained self rescuer devices commonly used in the mining industry and military/naval sectors. These basic rebreather devices utilize a bite-down mouth piece to avoid the problems of face seals and facial hair, and are designed as one-use escape devices. Whereas the cost for an open-loop SCBA emergency entry device is as much as $3,000, an escape SCBA typically costs less than $750.

The advantages and disadvantages of these two types of SCBA respirator are summarized below:

- Open loop escape respirators

Advantages	Disadvantages
√ Portable	√ Heavier than closed loop
√ Easy to use	√ Larger than closed loop
√ Incorporates use of a hood versus a face piece (no fitting required)	√ Shorter breathing duration than closed loop (typically offered in 5, 10 and 15 minute breathing duration)
√ Hood best for communicating	√ Compressed air cylinders need to be hydro-tested every 5 years, adding a maintenance cost
√ Uses Grade D air; more available than oxygen for recharging	

- Closed loop escape respirators

Advantages	Disadvantages
√ Portable	√ Incorporates use of a bite-down mouthpiece
√ Easy to use	√ Not ideal for communicating unless a bone conduction microphone is added to the mouthpiece for simple communication
√ Light weight	√ Disposal cost for unused CO_2 scrubber material
√ Small package	
√ Variable and longer breathing durations (commonly 15, 30, 60, 120 minutes)	
√ Low maintenance	
√ Long shelf life (10 or 15 years)	

Examples of a suitable closed loop escape rebreather EEBA is any of the 60-minute devices such as those shown in Figure 6. Manufacturer brochures for these devices are provided in Appendix A. The listed devices are approved by NIOSH with an average retail price of approximately $650:

- Ocenco EBA6.5; NIOSH certified as a 60-minute compressed oxygen rebreather. Dimensions are 8.5 in x 11.8 in x 4.5 in and weight is 8.0 lbs.
- Draeger Oxy K Plus S; NIOSH certified as a 60-minute compressed oxygen rebreather. Dimensions are 7.8 in x 10.0 in x 4.0 in and weight is 6.6 lbs.
- CSE SR-100; NIOSH certified as a 60-minute oxygen generating (KO_2) rebreather. Dimensions are 7.75 in x 4.0 in x 5.5 in and weight is 5.7 lbs.

Ocenco EBA 6.5

Drager Oxy K Plus S

CSE SR-100

Figure 6. - 60-min Closed placeLoop Air Supplying Rebreather

Other candidate respirators are those that are open loop, compressed air systems, many of which come with “smoke” hoods for a universal fit (Figure 7). Manufacturer brochures for these devices are provided in Appendix B. The following devices are approved by NIOSH and average approximately $550 retail price:

- Scott Health and Safety “ELSA”; NIOSH certified as a 15-minute compressed air rebreather. Weight is 9.5 lbs.
- Draeger QuickAIR; NIOSH certified as a 10-minute compressed air re-breather featuring a hood. Weight is 10.0 lbs.

Scott ‘ELSA’

Drager QuickAIR

Figure 7. - Open Loop Air Supplying Breathing Devices

Potential eye irritation must be considered and the requisite protection provided. Many of the HazMats of concern (e.g., chlorine) are eye irritants. This consideration is important for determining the face piece type on an EEBA. Many T&E crew wear prescription glasses so it will likely be necessary to accommodate them when selecting the specific make/model of EEBA.

Devices equipped with a full-face piece or hood should be selected rather than a device equipped with a half mask or mouthpiece with separate goggles. Another factor to consider is the presence of facial hair. If an EEBA relies on a good seal around the face to maintain its protection level, then its use by bearded or heavily mustached individuals is problematic.

Similarly, use of full-face masks requires that the wearer be correctly sized to the device. Putting an XL mask on a small face results in leaks and critically reduced protection.

2.5 EEBA Breathing Duration

Considering how quickly a HazMat plume can travel, it is vital that the crew has adequate breathing time available to allow them to move a significant distance from the site while protected from the atmosphere around them. If the incident is the result of a collision, as was the case in the Macdona and Graniteville incidents, one should also consider situations where additional time may be needed to assist/extricate fellow crewmembers who may be hurt or trapped. If it takes 10 minutes to assist a fellow crewmember and they're each wearing a 15-minute open loop respirator, they are left with just 5 minutes to egress from the plume that is already likely upon them—quite possibly not enough time. Allowing for the "Murphy's Law" effects of accidents happening at night, in tight terrain, resulting in crew injury, with a fast-moving plume, it would seem reasonable to expect that the minimum acceptable breathing capacity of the EEBA should be 30–60 min, explained by the following time-line:

- Event happens: Non-incapacitated crew immediately don EEBA,
- Event + 5 min: Crew working to release/aid injured member,
- Event + 10 min: All crew exit locomotive, assess situation and begin movement away from train,
- Event + 30 min: Crew (including injured) move 800 m away to seek help, and
- Event + 60 min: Crew maintaining protective posture until responding HazMat teams give all-clear.

2.6 EEBA Conclusions

Because catastrophic railroad HazMat incidents have the potential to release IDLH concentrations and/or displace oxygen, only air-supplying SCBA equipment should be considered for adequate crew protection. Air-purifying respirators like filtered self-rescuers (FSR), powered air-purifying respirators (PAPR) are ruled out due to the potential for rapid IDLH concentrations of HazMat around the train consist and the unknown nature of the hazard and potential for a low-oxygen environment.

The FRA EEBA should have an inherent capacity of not less than 30 minutes with a life of 60 minutes being suggested. The EEBA must incorporate eye protection from irritant gases. The EEBA must maintain an acceptable protection level regardless of user size and the presence of facial hair.

2.7 EEBA Recommendation

Based on the above discussions, the EEBA should be configured in one of two ways:

- A 30- to 60-minute open loop air-supplying SCBA device with smoke hood or face mask.
- A 30- to 60-minute closed loop air-supplying rebreather device equipped with goggles/smoke hood.

Task 3: For each device recommended, the contractor will define the different methods by which the devices might be provided to employees by their railroad employers. Include an analysis of the pros and cons for each method defined including costs and practical considerations. Ascertaining the different methods, by which the devices might be provided, would be driven by several issues including current industry practices regarding the placement of other types of emergency equipment on locomotives, as well as the need to ensure that *"all crewmembers"* are provided the devices.

3.1 Device Deployment—General

Like other safety equipment, the EEBA could be provided to the crews by the railroads in several ways, for example:

- It could be treated as a uniform item and permanently issued to the crew.
- It could be issued and recovered at the start/end of each shift as part of the clock in/out process:
    - As a dedicated personnel item permanently allocated to an individual.
    - As a pool item issued randomly.
- It could be mounted in the locomotive and other crew duty areas of each train:
- Permanently.
    - As a train containing HazMat tank cars is made up.

Four aspects of EEBA that influence the decision on how to deploy the device are:

- The configuration and form factor of the selected EEBA and if it can, or should be, hand-carried or must be mounted on the equipment.
- The configuration of the EEBA and whether it is a generic one-size-fits-all or customized to a user with mask size or type to cater to facial hair, etc.
- The capital and operational costs for inspection, maintenance, and replacement will determine whether the item is issued as personnel equipment on a permanent basis or whether it is issued from a pool only for HazMat train crews.
- Railroad's experience with other (technical or safety) regulated devices relative to theft, loss, damage, etc.

Like all safety or operational equipment, some responsibility is placed on both the railroad operating company and the crew members to ensure that the equipment is available, in place, trained on, and used correctly. Therefore, all parties involved have a real interest in deriving the optimum strategy for its employment. Considering all of the aspects above and primarily the complex and significant logistics imposed on the operating company for assigning a regulated safety device, such as a respirator, the user companies were polled as to what their preferred deployment methodology would be.

3.2 EEBA Deployment Survey

A survey questionnaire was developed and sent to multiple Class 1 railroads and labor organizations representing crew members with the intention to have them define their preferred deployment methodology for the EEBA. Regardless of how this technology is deployed and managed, it will come with large capital and operating costs, so the operational and support mechanisms for these devices are very important. Based on this logic, the hope was that the railroads and labor would select a means of EEBA deployment that would meet their needs.

The questionnaire was sent to the following railroads:

- Union Pacific Railroad (UP)
- Norfolk Southern Railway
- CSX Transportation
- BNSF Railroad
- Canadian National Railway
- Canadian Pacific Railway

The questionnaire was also sent to the following rail labor organization:

- BLET (Brotherhood of Locomotive Engineers and Trainmen)

Detailed responses received to that survey are attached to this report as Appendix C and are summarized.

3.3 EEBA Survey Results

Unanimously, each railroad preferred that in the event EEBAs were mandated, they should be assigned to each T&E employee. One Railroad included T&E and yard employees. The railroads prefer the responsibility for care and maintenance of EEBAs be assigned to T&E employees. Union responses recommended that supply, maintenance, and inspection be carried out by the "carrier."

The railroads' opinions are largely predicated on prior experience with regulated equipment that disappears, due to loss, pilfering, or damage. Additionally, their logic is that if personally assigned, EEBAs will then be better cared for. Better care results in lower replacement costs if the EEBA can be deployed until its end-of-service life or when mandatory replacement is required.

Based on conversations with the railroad companies, EEBAs assigned to locomotives instead of individual employees would require three such devices to be within the crew cab. Three devices would cover the engineer, conductor and an additional person such as a supervisor, trainee, inspector, etc., who might be in the locomotive cab. If three EEBAs were assigned to each freight service or yard locomotive, then that number would constitute a lesser number than if assigned to each T&E employee and hence, a lower capital equipment cost. Nevertheless, each railroad respondent to the questionnaire preferred EEBA assignment to the employee, predicting overall and long-term cost savings by reducing replacement costs.

One railroad assigned an estimated dollar value to the implementation of EEBAs, and a member of the AAR provided a cost-benefit analysis based on the assumption that these devices were to be mandated. This information is discussed under Task 5.

3.4 EEBA Deployment Discussions

The previous section summarizes the position of the operating companies and labor unions on the deployment of the EEBA. Notwithstanding these positions, which are flavored by the nature of the respondents, advantages and disadvantages exist to any deployment scheme.

As stated, three methodologies exist to deploy the EEBA across the train/crew fleet. This section discusses each of these options and summarizes the advantages and disadvantages of each.

- The EEBA could be treated as a uniform item and permanently issued to the crew members.

  Pros.
  Device will be with user at all times.
  Company is relieved of most of the responsibilities for device management.
  Individual is responsible for the state of their own equipment.
  Could be a customized device.

  Cons.
  Monitoring of device status (good/damaged/leaking) is more difficult.
  Difficulty of ensuring device is with user at all times.

- The EEBA could be permanently assigned to an individual as a dedicated personnel item, and would be issued and recovered at the start/end of each shift as part of the clock in/out process.

  Pros.
  Supports centralized inspection and maintenance.
  Keeps device with user at all times.
  Could be a customized device.

  Cons.
  Increases size of EEBA fleet since all T&E personnel require stocked devices.

- The EEBA could be a pool item issued randomly and recovered at the start/end of each shift as part of the clock in/out process.

  Pros.
  Supports centralized inspection and maintenance.
  Minimizes number of devices required.
  Keeps device with user at all times.

  Cons.
  Loss of ownership (and therefore interest in long-term serviceability) of device.
  Can only be a generic one-size-fits-all device.
  Management burden increases for tracking/recovery.

- The EEBA could be permanently mounted in the locomotive cab.
  Pros.
  Ensures HazMat consists are always equipped.
  Supports centralized inspection and maintenance.

Cons.

Increases size of EEBA fleet since non-HazMat consists still carry devices.
Increases management burden for tracking/recovery.
Increases management burden for item inspection and maintenance.
Provides EEBA for worst case crewing (including possible mandatory supernumerary personnel.
Can only be a generic one-size-fits-all device.

- The EEBA could be mounted in the locomotive and other crew-duty areas of each train as a train containing HazMat tank cars is made up.

Pros.

Minimizes number of devices required.
Ensures HazMat consist is appropriately equipped.
Caters to differing crew sizes most efficiently.

Cons.

Increases management burden for initial issue to consist.
Increases management burden for tracking/recovery.
Increases management burden for item inspection and maintenance.
Can only be a generic one-size-fits-all device.

3.5 EEBA Deployment Conclusions

Railroad respondents preferred that in the event EEBAs were mandated, they should be assigned to each T&E employee. With the exception of the union responses, the railroads prefer the responsibility for care and maintenance of EEBAs be assigned to T&E employees. Union responses recommended that supply, maintenance, and inspection be carried out by the railroad carrier.

Task 4: The contractor will quantify the incidence rate of accidents with fatalities and serious injuries attributable to the inhalation of released hazardous material (HazMat).

4.1 Accident Rates – General

The FRA has done a preliminary review of accident data and related employee casualty data for the purpose of a quantitative risk assessment involving hazardous materials released by accidents. This preliminary review has identified two fatalities of this nature during the last 20 years. During this same period, the HazMat shipments cited in Task 1 were made. This preliminary review suggests a low risk of the type of incident that occurred at Macdona or Graniteville happening with any frequency.

4.2 Historical Analysis

Historical accident and incident data from up to 20 years ago was analyzed to determine the actual frequency of rail-related HazMat incidents and, more specifically, of train crew injuries and fatalities caused by the release of HazMat into the environment (as opposed to injury from the mechanics of the crash, derailment, fire, incident).

According to data published in a September 2005 presentation by Robert Fronczak, P.E., Assistant VP, Environmental and HazMat for AAR [3], railroad incidents have been reduced significantly over the past two decades. By any other industrial or business sector, the statistical improvements realized by the rail industry would be considered astounding.
Railroads have exhibited exceptional safety performance in many areas including:

- Lower injury rates compared to other major industry groups.
- Lower injury rates compared to other transportation modes.
- Lower injury rates compared to most major European railroads.
- Declines in HazMat incident release rates (down 71 percent since 1980 and 56 percent since 1990).
- Declines in HazMat accident rates (down 90 percent since 1980 and 49 percent since 1990).
- Declines in accidents with a HazMat release (down 76 percent since 1980 and 17 percent since 1990).

Furthermore, DOT stated in a 2004 Overview [14] that "accidents declined nearly 70 percent since the late 1970s, and over the previous three years the Nation has had the lowest number of rail-related deaths and employee fatalities on record. Despite more than 2 million movements of HazMat cars, 2003 marked the lowest number of train accidents involving a HazMat release in the previous five years."

Although overall accident rates have declined significantly from the 1970s into the 1980s and again from the 1980s through the 1990s the past decade has experienced a leveling off of safety performance. The accident rate, as of 2006, remains at 3.95 accidents per million train-miles.

4.3 Casualty Data

In keeping with the FRA statement of work, casualty data was examined for non-passenger train and engine personnel only.

Casualty data for on-duty T&E employees was analyzed for the 10-year period from 1997–2006. Over this period, there were of 25,941 non-passenger T&E on-duty casualties. Thirty-eight were fatalities and 25,909 were injuries. Within this data set, three specific types of casualty data were examined: those resulting from collisions, derailments, and inhalation.

Table 9. Non-Passenger T&E Employees–OnDuty (A) Casualties
Source: Federal Railroad Administration Safety Database–4.02 Casualty Data Reports

Reporting Year	Overall Casualties	Collision Casualties	Collision Fatalities	Derailment Casualties	Derailment Fatalities	Inhalation Casualties	Inhalation Fatalities
1997	2834	96	8	38	0	58	0
1998	3004	86	1	37	0	86	0
1999	3211	76	7	54	1	73	0
2000	3169	82	2	44	0	63	0
2001	2872	86	4	50	0	68	0
2002	2405	84	2	46	1	50	0
2003	2281	75	2	44	1	63	0
2004	2211	73	5	55	0	70	1
2005	2102	84	0	27	0	69	1
2006	1852	60	1	28	0	64	0
10 year Avg	2594.1	80.2	3.2	42.3	0.3	66.4	0.2

Table 9 is intended to demonstrate the difference between total T&E casualties (an average of 2,594 over 10 years) to those T&E casualties resulting from collisions, derailments, and inhalation. The balance of injuries is attributable to other causes (e.g., slip and fall, etc). Injury type "inhalation" was chosen as a data point because these casualties represent the only two T&E deaths resulting from a HazMat release. Injury types "derails" and "collisions" were chosen as a data point because these casualties represent the most likely events leading to a HazMat release with T&E personnel present. These events also have the most potential for damage/injury/loss of public life occasioned by a HazMat release rendering an unprotected crew ineffective.

The 10-year average of 193 T&E casualties (injured and killed) due to inhalation, collision, and derailment represents 7.4 percent of the average number of 2,594 T&E on-duty casualties during the same period.

Table 9 suggests that collisions prove to be the most life threatening, whereby 84 percent (32 out of 38) of T&E casualties involved in a collision resulted in death compared to 7 percent (3 out of 38) involved in a derailment. Only 5 percent (2 out 38) of T&E casualties died from inhalation, those being in the 2004 Macdona and 2005 Graniteville accidents.

The two on-duty T&E deaths resulting from a collision and subsequent inhalation of HazMat compared to average annual train miles in the period 1997–2006 of 734.6 million can be expressed as a rate of one death per 367 million train miles.

Note that Table 9 has been modified to show two total deaths from inhalation whereas the reports from the FRA Safety Database lists only one fatality over this 10-year span—the death from Graniteville. The Macdona death in 2004 was listed as being killed by collision when in fact the cause of death was inhalation (see Table 10). Once a record is entered into the FRA database it is not changed so as to guard the integrity of the data. This sometimes results in the cause of death to ultimately be recorded incorrectly.

Table 10. 4.05 - Casualties by State, Railroad, or Type

Selections:

Railroad	All Railroads
State	All States County - All Counties
Region	All Regions
	All Job Types / On or Near Track / Fatalities Only
Type of Person	RR Emp on duty

Report Sort Sequence - Date

RR	Year	Month	Day	TA	Incident Number	Type Person	Condition	Event	St	County	Age
UP	2004	June	28	1	0604SA011	RR Emp on duty	Fatality	Collision - between on track equipment	TX	BEXAR	23
NS	2005	January	6	1	19414	RR Emp on duty	Fatality	Exposure to fumes - inhalation	SC	AIKEN	28

TA=Type Accident/Incident: 1 = Train Accident (form 54), 2 = Highway-rail (from 57), 3 = Other (form 55a)

4.4 HazMat Incidents

Incident data relative to trains carrying HazMat materials are covered in Task 1 for triggering criteria. It is worthy to restate the findings from the Hazardous Substances Emergency Events Surveillance (HSEES) System, which reports that rail events constitute only 2 percent of total hazardous-substance releases. Furthermore, most rail events involved small-scale releases (75 percent of events involved $\leq$70 gallons). However, large-scale, acute releases during rail transit can occur (10 percent of events involved $\geq$2,200 gallons) and cause substantial injury and death, as demonstrated by case reports. The Macdona and Graniteville accidents released 9,400 and 9,218 gallons of liquid chlorine respectively.

4.5 Accident Data Conclusions

In the period from 1997 to 2006, total T&E on-duty casualty rates have declined steadily, particularly from its high point in 2000 when 3,893 casualties were reported. In 2006, significant improvement to casualty statistics was demonstrated with 2,473 reported casualties (Appendix D). However, when referencing those casualties attributed to inhalation, collision, and derailment, the data does not illustrate an appreciable reduction over time in casualty performance. Although 2006 alone demonstrated improvement, the balance of the period showed variation in casualty performance.

Of all the historical data reviewed only two fatalities among on-duty T&E crew could be identified that were related to the release of a hazardous material associated with a railroad accident. These were the individual T&E crew member fatalities involved in Macdona in 2004 and Graniteville in 2005, both of which were from acute inhalation of chlorine from a breached tank car that occurred as a result of a collision. The casualty rate for these two deaths can be expressed according to 2006 statistics as follows:

- One death per 367 million train miles (1997-2006).
- One death per 5.7 million shipments of the top 125 HazMat (1997-2006).

Because no other casualties of similar circumstances could be identified, at least for the past 20 years, drawing conclusions is impractical from the aforementioned rates that indicate positive or negative trends for this kind of fatality.

Task 5: **For the recommended devices from Task 2, the contractor will define the economic issues involved in the provision of these devices to all crew members**

5.1 EEBA Economics–General

Any regulation mandating the use of EEBAs will require significant initial and on-going costs for the railroads. Similar to all technical, and specifically safety equipment, the EEBA will require significant ongoing expenditure in terms of maintenance, inspection, crew training, repair, and replacement. As a safety item it will also impose a significant administrative burden to track its issue, use and maintenance, and the users will need to have their initial and refresher training logged. Finally, depending on the nature of the technology involved and the chemicals it contains (catalysts, absorbents, etc.) some disposal costs could exist associated with its end of life.

5.2 Life Cycle Costs

We considered attributes associated with some respirator models that could affect the cost model to the railroads, such as if the units require periodic refurbishment or recharge and whether that action can only be completed at the manufacturers plant, as opposed to a rail depot in which case ongoing maintenance costs could be significantly different to other in-house maintained options.

The volume estimates for T&E employees and locomotives were derived from the AAR's Cost/Benefit Analysis (Appendix E). Exceptions to scrap figures (i.e., shelf life) and training time noted in the AAR report are adjusted based on the equipment manufacturer's recommendations.

In general, respondents to the questionnaire led this author to the conclusion that their understanding of available respirator technologies was somewhat lacking, at least as it pertains to the type of HazMat threat in question. Therefore, the respondents' recommendations for the same were in large part not considered. The responses relative to the type of device, how long it should protect the user and the cost of the device were quite varied. The only respondent that could lend any credence in these matters was from UP. This respondent had a level of practical respirator knowledge due to the ongoing Respiratory Protective Equipment program for T&E crew operating in Colorado's Moffat Tunnel.

In consideration of the economics involved in the deployment of an EEBA program for the railroad, the cost schedule in Table 11 captures the following elements:

- Net Present Value (NPV) over 15 years for equipment, training, maintenance, replacement (due to damage, pilfering or loss), and tracking (for issuance, maintenance, service life, etc.).
- Compares open loop SCBA (using Grade D compressed air) to closed loop SCBA (using compressed oxygen)
- Compares Assignment to Locomotive and assignment to T&E employees. Pooling devices at yards were not considered due to respondents' desire to have the EEBAs personally assigned and the associated concern about logistics, pilfering, and loss.
- For locomotive assignment, estimates are based on issuance of three EEBAs per locomotive to cover two T&E employees plus an additional person (e.g., supervisor, trainer, other personnel).
- Assumes the Railroads would be granted approximately five years to fully outfit their labor force with the devices
- Maintenance cost for open loop devices includes labor plus $25 per unit for 5-year hydro testing on cylinders.
- Scrap levels (replacement age) were not considered for open loop devices because they possess an indefinite shelf life.
- Scrap levels (replacement age) for closed loop devices reflect a common shelf life of 10 years.

Table 11. Estimated Cost for Deploying EEBA in Various Modes

SCBA Type	Open Loop		Closed Loop	
Assignment	Locomotive	Employee	Locomotive	Employee
No. Units	45,000	68,307	45,000	68,307
Cost per Unit	$550	$550	$650	$650
Capital Cost (NPV)	$60,890,000	$46,300,000	$52,440,000	$66,340,000
Training and Maintenance (NPV)	$18,870,000	$20,900,000	$14,640,000	$16,990,000
Total Capital Cost (NPV)	**$79,760,000**	**$67,200,000**	**$67,080,000**	**$83,330,000**
Replacement Age	N/A	N/A	10 Years	10 Years

The following cost schedules are provided in Appendix F as supporting documentation to the cost estimates:

- Cost Schedule–Positive Pressure, Open Loop SCBA with Hood, Grade D Pressurized Air Supply, Assigned to Employee.
- Cost Schedule–Positive Pressure, Open Loop SCBA with Hood, Grade D Pressurized Air Supply, Assigned to Locomotive.
- Cost Schedule–For Positive Pressure, Closed Loop SCBA with Mouthpiece, Oxygen Pressurized Air Supply, Assigned to Employee.
- Cost Schedule–For Positive Pressure, Closed Loop SCBA with Mouthpiece, Oxygen Pressurized Air Supply, Assigned to Locomotive.

The difference between the values for an open loop device assigned to a locomotive versus employee is largely predicated on the assumption that there would be a 20 percent pilfering/damage loss as compared to just 5 percent loss if assigned to the employee. The assumption is that if the EEBA is assigned to the employee, then it will be better taken care of and less susceptible to loss, pilfering, or damage. Estimates for open loop devices also include a maintenance fee that accounts for periodic hydrostatic testing of the compressed air cylinder.

Closed loop devices assume the same percentages for pilfering/damage loss as open loop devices (i.e., 20 percent if locomotive assigned vs. 5 percent employee assigned). Although there is no maintenance cost associated with closed loop devices, there is a shelf life of 10 years. The difference between the values for a closed loop device assigned to a locomotive versus employee is largely predicated on the raw difference between the number of units assigned to locomotives versus employees (approximately 23,000 units).

5.3 Stakeholder's Positions

While all respondents to the questionnaire agree that training in the use of EEBAs should be managed by the Railroad, the responses relative to inspection and maintenance vary. Some believe the responsibility for inspection and maintenance belongs with the employee where some believe it is the responsibility of the railroad. Most railroads believe the responsibility for inspection and maintenance falls on the employee whereas one railroad would accept that responsibility and farm those services out to contract engineering firms. That same company expressed concern about the manpower availability of such firms to handle the magnitude of an EEBA program, further suggesting a high tech, expensive transponder system would needed to facilitate the check-in/check-out process of bar coded EEBAs.

5.4 Economics Conclusions

The implementation of EEBAs would pose a significant financial burden on the railroads regardless of the method of assignment (i.e., locomotive or employee) or the type of EEBA (i.e., closed or open loop escape rebreather).

Based on the raw financial figures, the least expensive option suggests closed loop devices assigned to the locomotive are the best choice. However, the railroads' desire to have EEBAs personally assigned to the employee suggests open loop devices are the best choice.

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Appendix A

- Ocenco EBA6.5; NIOSH certified as a 60-minute compressed oxygen rebreather. Dimensions are 8.5” x 11.8” x 4.5” and weight is 8.0 lbs.

ocenco
INCORPORATED

SEARCHING FOR ESCAPE BREATHING APPARATUS?

THE OCENCO EBA 6.5 IS THE U. S. STANDARD

Since introducing the EBA 6.5, Ocenco Inc. has sold more emergency escape breathing apparatus to the U. S. mining industry than all other manufacturers combined.

The EBA 6.5 can be donned in 15 seconds or less.

Why? Because the EBA's oxygen supply is long-lasting. The EBA 6.5 supplies the wearer more than 90 minutes of oxygen during a typical mine escape — up to 8 eight hours of oxygen at rest — a performance that exceeds all MSHA and NIOSH standards. (Oxygen delivery ranges from 1.5 l/min constant flow up to 100 l/min demand flow.)

The EBA 6.5 uses compressed oxygen as a source rather than generating oxygen from chemicals. The oxygen content indicated on the gauge is always visible for inspection through the clear, tamper-proof sealed case.

The apparatus can be refurbished for a service life of up to 15 years and provides a lower cost per year of service than any comparable unit.

The EBA 6.5 is a highly reliable breathing apparatus tested in life-threatening situations throughout the world. Thousands are currently in service in mines in Australia, Canada, Chile and South Africa as well as in the United States.

THE EBA 6.5 IS:

Quick to don – can be put on and be fully operational in 15 seconds or less.

Easy to operate – turning the valve on activates the system; turning off permits conservation of oxygen.

Long-lasting – over 90 minutes oxygen in demand mode; up to eight hours in conservation mode.

Light-weight – donned weight 8.0 lbs (4.17 kg). With composite cylinder only 7.0 lbs (3.17 kg).

Compact – at 8.5" x 11.8" x 4.5" (21.6 cm x 30 cm x 11.4 cm), it stores easily and is easy to retrieve.

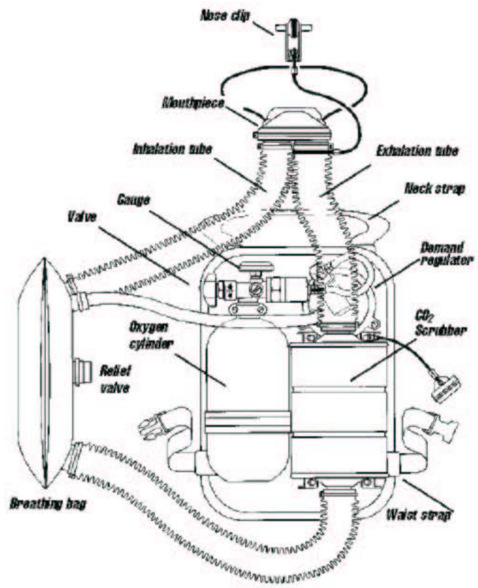
Easy to inspect – simple visual inspection confirms that unit is ready to use.

The EBA 6.5, in its clear, polycarbonate case, is durable and easy to inspect.

EBA 6.5 PHYSICAL CHARACTERISTICS AND PERFORMANCE DATA

Approvals	Approval Numbers	Approval Duration
MSHA/NIOSH	TC-13F-104	60 minutes
Republic of South Africa	GME 14/6/14/3	90 minutes
Australia Queensland New South Wales	 QMDA-6693 1899 MDA BA 2742	 60 minutes 100 minutes 100 minutes
Performance duration	110 minutes	
Rest duration	8 hours	
Time to don/activate	15 seconds, or less	
Total weight	9.2 lbs (4.17 kg) Aluminum cylinder 8.2 lbs (3.72 kg) Composite cylinder	
Donned weight	8.0 lbs (3.63 kg) Aluminum cylinder 7.0 lbs (3.17 kg) Composite cylinder	
Dimensions	8.5" x 11.8" x 4.5" (21.6 cm x 30 cm x 11.4 cm)	
Storage temperature range	10° F to 140° F (-12° C to 60° C)	
Liters of oxygen available	157	
Repair/refurbish after use	Yes	
NIOSH service life	15 Years	
Oxygen delivery system	Compressed oxygen On/off valve Constant flow/demand regulated	
Cylinder pressure	3000 psi (207 Bars)	
CO_2 Scrubbing material	Lithium hydroxide	
Inspection	Visual	

EBA 6.5 SELF-CONTAINED SELF RESCUER



THE EBA 6.5 CIRCUIT

Oxygen from the breathing bag is inhaled through the inhalation tube and the mouthpiece. Breath is exhaled through the mouthpiece into the CO_2 scrubber. Scrubbed breath enters the breathing bag and is mixed with oxygen from the oxygen cylinder via the demand regulator.

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DESIGNING SAFE SOLUTIONS FOR HAZARDOUS ENVIRONMENTS

- Draeger Oxy K Plus S; NIOSH certified as a 60-minute compressed oxygen rebreather. Dimensions are 7.8” x 10.0” x 4.0“ and weight is 6.6 lbs.

DETECTION PERSONAL PROTECTION DIVING TECHNOLOGY SYSTEM TECHNOLOGY SERVICES

Dräger Oxy K plus S 60-minute SCSR

(Self-Contained Self-Rescuer)

The Oxy K plus S is a belt wearable SCSR

The Oxy K plus S

- Delivers oxygen to the user from KO_2 and provides air escape time of 60 minutes.
- Has a color indicator which is located on top so the user always knows that the Oxy K plus S is safe to use.
- Has an easy opening "Quick Latch" for quick and easy opening .
- Automatically starts when the unit is opened and put on (donned)
- Is belt mounted with standard belt clip or optional carry pouch.

Features and Benefits:

- New Quick-Flip opener
- Lowest breathing resistance of any SCSR
- Starter oxygen activates automatically
- Operational time of 60 minutes
- Ergonomic shape
- Can be stored or carried
- Up to 10 year service life
- Easy to see indicator
- Training unit available

Oxy K plus S

Oxy K plus S

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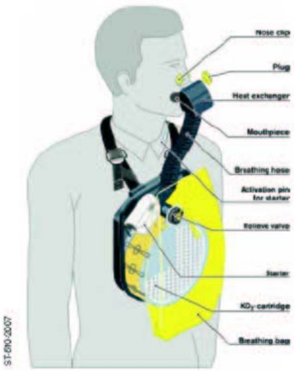
TECHNICAL DATA



Training mouth piece

Heat Simulator

ENVIRONMENTAL CONDITIONS

Storage and Transportation Temperature	-4º F (-16º C) to 122º F (50º C) Ambient conditions
Short Term Storage Exposure	58º F (70º C) for maximum of 24 hours
Minimum Usage Temperature	23º F (-5º C)
Storage Temperature prior to use	23 F (-5º C) to 122º F (50º C)
Humidity	Up to 100% r.h.
Atmosheric Pressure	700 to 1300 hPa
According to CEN 50014 T4	Maximum Surface Temperature: 275º F (135º C)

USAGE PERIOD IN MINUTES

Volume 10 L/Min.	180 minutes
Volume 30 L/Min.	60 minutes
Volume of breathing bag	> 6 Liters

INHALATION/EXHALATION RESISTANCE

With 30 L/minute beginning of usage	4 mbar	
With 30 L/minute end of usage	maximum 6 mbar	
Dimensions W x H x D	7.8" x 10" x 4 " (20 x 25 x 10 cm)	
Weight Storage/in-use	6.6 lbs./5.28 lbs. (2.7/2.4 kg)	
Approvals	NIOSH/MSHA	TC-13F-289

ORDER INFORMATION

Oxy K plus S	6302000
Heat Simulator for Oxy K plus	6404699
Oxy K Training Unit	6302001
Training mouth piece	6303646
Oxy K plus S Carry Pouch	4056699

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USA
Tel 1-412-787-8383
Fax 1-412-787-2207
www.draeger.com

CUSTOMER SERVICE
Tel 1-800-615-5503
Fax 1-800-922-5519

TECHNICAL SERVICES
Tel 1-800-794-3806
Fax 1-800-794-3807

DRAEGER CANADA LTD.
7555 Danbro Crescent
Mississauga, Ontario L5N 6P9
CANADA
Tel 1-905-821-8988
Fax 1-905-821-2565
www.draeger.com

CUSTOMER SERVICE
Tel 1-877-372-4371
Fax 1-800-Fax-Tube

DRAEGER SAFETY S.A. DE C.V.
Av. Penuelas No. 5
Bodega No. 37
Fraccionamiento Industrial
San Pedrito
Querétaro, Qro
MEXICO

Tel 52-442-246-1113
Fax 52-442-246-1114
www.draeger.com

- CSE SR-100; NIOSH certified as a 60-minute oxygen generating (KO2) rebreather. Dimensions are 7.75″ x 4.0″ x 5.5″ and weight is 5.7 lbs.

CSE CORPORATION

SR-100

60 Minute ESCBA

Since 1969, CSE Corporation has been providing quality, portable gas detection and breathing apparatus for mining applications all over the world. Thousands of miners depend on CSE equipment to alert and protect them against the hazards that could exist during a normal ten-hour work shift.

Today, CSE has a full range of products for mining and industrial applications. Our products meet strict OSHA, NIOSH and MSHA compliance standards and are built to endure the challenging conditions that are found in many confined spaces. CSE has a proven track record and has maintained the same commitment to quality, service and performance that has been demanded by our customers for the past 30 years.

The SR-100

The SR-100 self-contained oxygen breathing apparatus was designed with the cooperation of MSHA for the protection of workers in confined spaces against the dangers of toxic gases, oxygen deficiency and smoke inhalation. The unit uses a bi-directional rebreathing system in which exhaled gas makes two passes through a CO2 absorption/oxygen generation canister before the gas returns to the user. Specific amounts of KO2 (potassium superoxide) and LiOH (lithium hydroxide) are used to produce O2 and scrub CO2 respectively, resulting in the production of a minimum of 100 liters of oxygen. The unit is certified by NIOSH/MSHA for a minimum of one hour of operation, however, the duration is dependent on the user's physical work rate.

Applications

Portable ESCBA's such as the SR-100 have successfully been used in mining and aboard submarines for emergency escape. They are now being used widely throughout the industrial sectors in areas such as these:

- Manholes
- Tunnels
- Sewers
- Silos
- Vaults
- Mines
- Tanks, vessels
- Wet wells, waste water
- Clean rooms, semiconductor labs

The SR-100 is approved by NIOSH/MSHA under CFR 30, part 75-1714, and OSHA CFR 29 1910.146 Appendix E. The approval is for escape only with a duration of one hour. Each unit is supplied complete with starter oxygen cylinder, goggles, case and approved pouch. Optional reflective belts are available in various sizes to accommodate most any user. Each SR-100 has a ten-year shelf life. There is no scheduled maintenance other than simple user inspection of the unit.

The 3+3 Donning Procedure

The SR-100 is easily donned by following the 3+3 procedure described below. Weighing less than 6 lbs., the SR-100 is designed to be worn on the belt, or kept within arm's reach of workers exposed to dangerous hazards.

In emergencies, the user should position themselves kneeling on the ground removing the unit from the belt. Open the unit by lifting the latch on top, removing both top and bottom covers. Loop the neck strap over the head and begin the 3+3 donning procedure.

1. **Pull orange actuator tag down to activate oxygen.**
2. **Remove plug and insert mouthpiece.**
3. **Pull apart nose pads and affix to nose so that both nostrils are completely closed.**
4. **Put on safety goggles.**
5. **Adjust neck strap so that the SR-100 unit rests on chest. Fasten waist strap around waist.**
6. **Replace hard hat if removed and move out.**

By following these steps written by MSHA/ NIOSH, the SR-100 can be donned in less than 20 seconds when worn on the worker's belt. Keeping the SR-100 within arm's reach ensures minimal donning time, and maximizes worker protection in emergency situations.

Technical Specifications – SR-100

Unit Description

SR-100:
1-hour Self-Contained SCBA

Weight Carried:
5.7 lbs/2.6 kg

Weight in use:
4.9 lbs/2.2 kg

Dimensions:
7-3/4" x 4" x 5-1/2"

Deliverable 02:
3.5 ft³/100 liters

Rated Duration:
60 minutes (minimum)

Storage Temperature:
32-130F/0-54 C

Approvals:
MSHA/NIOSH – TC-13F-239

Method of Operation:
Chemical based rebreather -KO2/LiOH

Designed to meet:
CFR 30, Part 75.1714
CFR 29, 1910.146 App. E

Ordering Information

Part #	Description
Q152000006	SR-100
Q152090006	Training Unit
Q152090026	SR-100 Pouch
X151590398	Video Tape
X151590058	Suspenders
X151590108	Belt- Small 27"–33"
X151590118	Belt- Medium 33"–39"
X151590128	Belt- Large 39"–45"
X151590138	Belt- XL 45"–51"
X151590148	Belt- XXL 51"–57"
X151590158	Belt- XXXL 57"–63"
X151590298	Battery Pouch
Q152090046	4 Unit Storage Box
Q152090086	8 Unit Storage Box
Q152090066	10 Unit Storage Box
Q152090076	12 Unit Storage Box

Storage Life:
10 Years

Warranty:
1 Year

Readiness: The SR-100 can be checked instantly by visually inspecting the moisture indicators in the top and bottom covers. The indicators are blue as long as seals are intact. If the seal has been broken, and moisture has contaminated the unit, the moisture indicators will turn pink or white. The unit must then be taken out of service.

Made in the U.S.A.

PERMISSIBLE ONE HOUR SELF-CONTAINED OXYGEN-GENERATED BREATHING APPARATUS FOR ESCAPE ONLY
MSHA
NIOSH
APPROVAL NO. TC-13F-239
MINE SAFETY AND HEALTH ADMINISTRATION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ISSUED TO CSE CORPORATION-2/23/89

CSE CORPORATION

CSE Corporation
600 Seco Road
Monroeville, PA 15146
1.800.245.2224
Fax: 412.856.9203

Distributed By:

Appendix B

- Scott Health and Safety "ELSA"; NIOSH certified as a 15-minute compressed air rebreather. Weight is 9.5 lbs.

- Draeger QuickAIR; NIOSH certified as a 10-minute compressed air rebreather featuring a hood. Weight is 10.0 lbs.

Draeger Safety | Dräger

QuickAir

The QuickAir Emergency Escape Breathing Apparatus (EEBA) is NIOSH approved for escape from atmospheres that have become immediately dangerous to life or health. The QuickAir provide a constant supply of air at 40 liters per minute for 5 or 10 minutes of escape. The QuickAir can be donned quickly with minimal training, even in the dark. Pictograms showing how to don the unit serve as convenient reminders on the carrying bag. The QuickAir EEBA is user friendly for both left and right handed personnel and can be worn over either shoulder or around the neck.

The transparent, self-extinguishing hood will not fog and provides unlimited vision range. It will accommodate long hair, beards and eyeglass wearers.

The QuickAir is a rugged, durable unit designed for long shelf life in extreme conditions. The visible orange carrying bag is made of flexible PVC that resists flame, chemicals, mildew and ultraviolet rays.

The QuickAir is available with a 10-minute 3000 psi cylinder, with a 5-minute 3000 psi cylinder or with a 5-minute 2216 psi cylinder. A hard plastic storage case is available for each unit. An optional wall hanging kit to attach the case to the wall is also available.

Technical Data

Hood Material:	Flame retardant PVC		
Harness Material:	Nylon webbing		
Carrying Bag:	Laminated reinforced PVC		
Cylinder Type:	Aluminum Cylinder with CGA 346 Valve		
Cylinder DOT#	DOT-3AL		
Flow Rate:	40 liters per minute		
Air Capacity:	5-Minute 3000 psi	250 liters	
	5-Minute 2216 psi	227 liters	
	10-Minute 3000 psi	430 liters	
Unit Weight:	5-Minute 3000	7.8 pounds	(3.53 kg)
	5-Minute 2216	7.0 pounds	(3.2 kg)
	10-Minute 3000	10.0 pounds	(4.53 kg)
Shipping Weight:	5-Minute Unit	9.6 pounds	(4.35 kg)
	5-Minute 2216	8.8 pounds	(4.0 kg)
	10-Minute Unit	11.8 pounds	(5.35 kg)
NIOSH Approvals:	5-Minute 3000	TC-13F-347	
	5-Minute 2216	TC-13F-395	
	10-Minute 3000	TC-13F-348	

Order Information	Part Number
QuickAir 5-Minute (3000 psi cylinder)	4054953
QuickAir 5-Minute (2216 psi cylinder)	4055438
QuickAir 10-Minute (3000 psi cylinder)	4054954
Sturdy Carrying Case for 5-Minute Units	4055042
Sturdy Carrying Case for 10-Minute Unit	4055041
Wall Mount Kit (to Attach Carrying Case to Wall)	4055000

Draeger Safety Inc.
Distributed By: AFC International, Inc.
PO Box 894
DeMotte, IN 43610
Tel: 219.987.6825
Fax 219.987.6826
Customer Service:
Tel: 800.952.3293
www.afcintl.com

DraegerService
DraegerService offers regular inspection and training. We do everything to ensure your equipment will be repaired and back in operation as quickly as possible.

Draeger Expertise
Since 1889, Draeger continues its outstanding reputation in technology for human breathing. Draeg has always been at the forefront in particular hazard protection and the saving of lives in medical and industrial emergencies. Many of the company's 850(employees are active in research and innovation to ensure that the latest techniques and scientific advances are fully tested before their inclusion in ne equipment.

Draeger Worldwide
The Draeger sales and service organization is spread throughout the world. It comprises more than 25 subsidiaries and associated companies to ensure that Draeger is always within easy reach of its clients and in close contact with all important markets. Draeger's ever increasing market share demonstrates the company's international competitiveness and strength.

Draeger has subsidiaries in the following countries: Australia, Austria, Belgium, Bulgaria, Canada, Czech Republic, China, Denmark, France, Great Britain, Hunga Indonesia, Italy, Japan, Croatia, Netherlands, Norway, Romania, Singapore, South Korea, Slovenia, Slowakia, Africa, Spain, Sweden, Switzerland, Yugoslavia, USA. Additionally, Draeger is widely represented in Central a South America, Africa, the Middle East, Asia Pacific anc Eastern Europe.

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Appendix C

EEBA Deployment Survey

Template Questionnaire regarding Emergency Escape Breathing Devices (EEBD) and their possible use in the Railroad Community

1. Emergency Protocol

1.1. If you don't believe EEBD's are a necessary safety device for train crews, please explain the protocols a train crew should undertake (if any) when there is an unintentional release of hazardous and/or toxic material on their consist.

2. Equipment

2.1. If EEBD's were mandated, what type of device would you recommend for your train crew? Choose those that apply:

- **Air Purifying –** These contain an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These do not supply oxygen and must only be used when there is sufficient oxygen to sustain life and the air contaminant level is below the concentration limits of the device. Common choices are as follows:
    - **Particulate respirators** use a mechanical filter to remove particulate matter such as dusts.
    - **Gas and vapor respirators** (or chemical cartridge respirators) use chemicals such as activated charcoal to remove specific gases and vapors from the air. These are effective for concentrations of no more than ten times the TLV of the contaminant, if the contaminant has warning properties (odor or irritation) below the TLV.
    - **Combination respirators** have filters for both particulates and vapors.
    - **Powered air-purifying respirators (PAPR)** use a blower to force the ambient air through air-purifying elements to the inlet covering.
- **Compressed Air-Supplying 'Self-Contained Breathing Apparatus' (SCBA)** – This is much like the apparatus a SCUBA diver or fire fighter might use. Air (or oxygen) is supplied from a compressed cylinder, usually through a full-face mask, which is worn on the back. This gives greater movement than an air-line respirator, but the air supply is limited. Two common choices are as follows:
    - **Open loop system –** unused exhaled O_2 is lost to atmosphere, hence larger cylinders to provide adequate breathing time. Typical breathing duration is 30 minutes.
    - **Closed loop system –** captures and reuses exhaled O_2. Scrubber removes CO_2 and small makeup O_2 bottle provides additional O_2. Typical breathing duration is a minimum of 1 hour.
- **Filtering Face piece (dust mask) –** the filter is an integral part of the face piece
- **Bite Valve with Nose Clamp –** breathing through bite valve with nostrils pinched off
- **Half Mask –** respirator covering the mouth and nose. Requires optimum fit. Facial hair is not recommended.
- **Full Face piece –** respirator designed to seal around the entire face. Must be sized and fitted per user, particularly with a closed loop system.
- **Negative Pressure Respirator** – wearer draws air through filter or cartridge by breathing

2.2. If you believe EEBD's should be air-supplying versus air-purifying, should the supplied gas be compressed 'clean' air (ie: grade D) or compressed oxygen? (Note: open loop compressed air systems typically have sizeable cylinders to provide adequate breathing duration whereas closed loop compressed O2 systems have much smaller cylinders, yet provide substantially longer breathing duration).

2.3. If EEBD's were mandated, how much breathing time should the device provide? Please provide reasoning, taking into consideration the time it may take for the train crew to extricate themselves from their immediate surroundings which may be encompassed with a toxic cloud.

2.4. If EEBD's were mandated, what do you think would constitute a reasonable shelf life of the device before mandatory replacement?

3. Assignment

3.1. If EEBD's were mandated, should the devices be assigned to the locomotive or should they be assigned to each appropriate employee?

3.2. If EEBD's were mandated and assigned to employees, which employees would receive the devices (ie: T&E, other)?

3.3. How many employees would that constitute?

3.4. How many locomotives are in your fleet:

- Freight service =
- Yard/switchers =

3.5. If EEBD's were mandated, would they need to accompany personnel on every type of locomotive?

4. Economics

4.1. If EEBD's were mandated, what do you believe is a practical price to pay per device?

4.2. If EEBD's were mandated, there is certainly going to exist a need for training, maintenance, inspection and tracking. Based on the type of device you recommend, how would you handle each of these (ie: internally or externally), how often, and what do you estimate are the associated costs for the same?

- Training: (address if training might be one-on-one or in a group, and how often training should take place)
- Maintenance: (address who would be responsible for maintenance and how often it should take place, ie: preventative maint.)
- Inspection; (address who would be responsible for inspection and how often it should take place)
- Tracking: (address who would be responsible for tracking and how often it should take place. Please compare a tracking program for EEBD's to other similar devices that need to be present on the consist, such as fire extinguishers. How are those tracked?)

5. Professional Opinion

5.1. What is your professional opinion about the need or use of these devices for train crews? Please elaborate on your answer.

5.2. Do you believe the number of incidents in the form of collisions, derailments or near misses with consists carrying Hazmat freight, compared to the number of deaths and injuries resulting from the same, warrants the need for EEBD's for train crews?

Questionnaire regarding Emergency Escape Breathing Devices (EEBD) and their possible use in the Railroad Community

B. Blissett (BLET) Response

1. **Emergency Protocol**
   1.1. Do you believe EEBD's are a necessary safety device for train crews? If not, please explain the protocols a train crew should undertake (if any) when there is an unintentional release of hazardous and/or toxic material on their consist.

   YES

2. **Equipment**
   2.1. If EEBD's were mandated, what type of device would you recommend for the train crew? Choose those that apply:
   - **Air Purifying –** These contain an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These do not supply oxygen and must only be used when there is sufficient oxygen to sustain life and the air contaminant level is below the concentration limits of the device. Common choices are as follows:
     - **Particulate respirators** use a mechanical filter to remove particulate matter such as dusts.
     - **Gas and vapor respirators** (or chemical cartridge respirators) use chemicals such as activated charcoal to remove specific gases and vapors from the air. These are effective for concentrations of no more than ten times the TLV of the contaminant, if the contaminant has warning properties (odor or irritation) below the TLV.
     - **Combination respirators** have filters for both particulates and vapors.
     - **Powered air-purifying respirators (PAPR)** use a blower to force the ambient air through air-purifying elements to the inlet covering.
   - **Compressed Air-Supplying 'Self-Contained Breathing Apparatus' (SCBA)** – This is much like the apparatus a SCUBA diver or fire fighter might use. Air (or oxygen) is supplied from a compressed cylinder, usually through a full-face mask, which is worn on the back. This gives greater movement than an air-line respirator, but the air supply is limited. Two common choices are as follows:
     - **Open loop system –** unused exhaled O_2 is lost to atmosphere, hence larger cylinders to provide adequate breathing time. Typical breathing duration is 30 minutes.
     - **Closed loop system –** captures and reuses exhaled O_2. Scrubber removes CO_2 and small makeup O_2 bottle provides additional O_2. Typical breathing duration is a minimum of 1 hour.
   - **Filtering Face piece (dust mask) –** the filter is an integral part of the face piece
   - **Bite Valve with Nose Clamp –** breathing through bite valve with nostrils pinched off
   - **Half Mask –** respirator covering the mouth and nose. Requires optimum fit. Facial hair is not recommended.
   - **Full Face piece –** respirator designed to seal around the entire face. Must be sized and fitted per user, particularly with a closed loop system.

   - **Negative Pressure Respirator** – wearer draws air through filter or cartridge by breathing

   2.2. If you believe EEBD's should be air-supplying versus air-purifying, should the supplied gas be compressed 'clean' air (ie: grade D) or compressed oxygen? (Note: open loop compressed air systems typically have sizeable cylinders to provide adequate breathing duration whereas closed loop compressed O2 systems have much smaller cylinders, yet provide substantially longer breathing duration).

2.3. If EEBD's were mandated, how much breathing time should the device provide? Please provide reasoning, taking into consideration the time it may take for the train crew to extricate themselves from their immediate surroundings which may be encompassed with a toxic cloud.

2.4. If EEBD's were mandated, what do you think would constitute a reasonable shelf life of the device before mandatory replacement?

3. Assignment

3.1. If EEBD's were mandated, should the devices be assigned to the locomotive or should they be assigned to each appropriate employee?

Locomotives and yard offices where crews report and take their lunch time. Crews already carry a lot of gear both company mandated and personal supplies, because of the extended stays away from home.

3.2. If EEBD's were mandated and assigned to employees, which employees would receive the devices (ie: T&E, other)?

Engineers, Conductors and Brakeman is assigned to the crew.

3.3. If EEBD's were mandated, would they need to accompany personnel on every type of locomotive?

YES

4. Economics

4.1. If EEBD's were mandated, what do you believe is a practical price to pay per device and who should pay for that device?

I have no idea how much they would cost. I should think about $250.00 and they should be supplied and maintained by the Carrier.

4.2. If EEBD's were mandated, there is certainly going to exist a need for training, maintenance, inspection and tracking. Based on the type of device you recommend, how would you expect the operating company to handle each of these (ie: internally or externally), how often, and what do you estimate are the associated costs for the same?

- Training: (address if training might be one-on-one or in a group, and how often training should take place)

Training could take place in a group and could be peer based.

- Maintenance: (address who would be responsible for maintenance and how often it should take place, ie: preventative maintenance program.)

The carrier should be responsible for all maintenance and it should take place per manufactures recommendations.

- Inspection; (address who would be responsible for inspection and how often it should take place)

The carrier should be responsible for inspection and it should take place per manufactures recommendations.

- Tracking: (address who would be responsible for tracking and how often it should take place. Please compare a tracking program for EEBD's to other similar devices that need to be present on the consist, such as fire extinguishers. How are those tracked?)

  I believe that they should have a life of at least 90 days as all locomotives have to be inspected on this time line.

4.3. Has your organization performed any cost/benefit analysis on this matter? If so, please describe and/or supply the analysis.

NO

5. Professional Opinion

5.1. What is your professional opinion about the need or use of these devices for train crews? Please elaborate on your answer.

Railroads are carrying more and more hazardous shipments. There have been a significant number of accidents and hazardous material releases. There have been large haz mat spills of Anhydrous Ammonia and Chlorine and with shipments on the rise there are bound to be more. The only way a train crew can survive a haz mat release is to have a EBB.

5.2. Do you believe the number of incidents in the form of collisions, derailments or near misses with consists carrying Hazmat freight, compared to the number of deaths and injuries resulting from the same, warrants the need for EEBD's for train crews?

YES

5.3. Can you personally cite instances in the past several years where having an EEBD available would have proved beneficial to the train crew?

There was a Anhydrous Ammonia release in Minot, ND on January 18, 2002 and a Chlorine release in Graniteville, SC on January 6, 2005.

Questionnaire regarding Emergency Escape Breathing Devices (EEBD) and their possible use in the Railroad Community

BNSF Response

1. **Emergency Protocol**

    1.1. If you don't believe EEBD's are a necessary safety device for train crews, please explain the protocols a train crew should undertake (if any) when there is an unintentional release of hazardous and/or toxic material on their consist.

2. **Equipment**

    2.1. If EEBD's were mandated, what type of device would you recommend for your train crew? Choose those that apply:

    - **Air Purifying –** These contain an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These do not supply oxygen and must only be used when there is sufficient oxygen to sustain life and the air contaminant level is below the concentration limits of the device. Common choices are as follows:
        - **Particulate respirators** use a mechanical filter to remove particulate matter such as dusts.
        - **Gas and vapor respirators** (or chemical cartridge respirators) use chemicals such as activated charcoal to remove specific gases and vapors from the air. These are effective for concentrations of no more than ten times the TLV of the contaminant, if the contaminant has warning properties (odor or irritation) below the TLV.
        - **Combination respirators** have filters for both particulates and vapors.
        - **Powered air-purifying respirators (PAPR)** use a blower to force the ambient air through air-purifying elements to the inlet covering.
    - **Compressed Air-Supplying 'Self-Contained Breathing Apparatus' (SCBA)** – This is much like the apparatus a SCUBA diver or fire fighter might use. Air (or oxygen) is supplied from a compressed cylinder, usually through a full-face mask, which is worn on the back. This gives greater movement than an air-line respirator, but the air supply is limited. Two common choices are as follows:
        - **Open loop system –** unused exhaled O2 is lost to atmosphere, hence larger cylinders to provide adequate breathing time. Typical breathing duration is 30 minutes.
        - **Closed loop system –** captures and reuses exhaled O2. Scrubber removes CO2 and small makeup O2 bottle provides additional O2. Typical breathing duration is a minimum of 1 hour.
    - **Filtering Face piece (dust mask) –** the filter is an integral part of the face piece
    - **Bite Valve with Nose Clamp –** breathing through bite valve with nostrils pinched off
    - **Half Mask –** respirator covering the mouth and nose. Requires optimum fit. Facial hair is not recommended.
    - **Full Face piece –** respirator designed to seal around the entire face. Must be sized and fitted per user, particularly with a closed loop system.

    - **Negative Pressure Respirator** – wearer draws air through filter or cartridge by breathing

    2.2. If you believe EEBD's should be air-supplying versus air-purifying, should the supplied gas be compressed 'clean' air (ie: grade D) or compressed oxygen? (Note: open loop compressed air systems are typically have sizeable cylinders to provide adequate breathing duration whereas closed loop compressed O2 systems have much smaller cylinders, yet provide substantially longer breathing duration).

2.3. If EEBD's were mandated, how much breathing time should the device provide? Please provide reasoning, taking into consideration the time it may take for the train crew to extricate themselves from their immediate surroundings which may be encompassed with a toxic cloud.

2.4. If EEBD's were mandated, what do you think would constitute a reasonable shelf life of the device before mandatory replacement?

3. Assignment

3.1. If EEBD's were mandated, should the devices be assigned to the locomotive or should they be assigned to each appropriate employee?

3.2. If EEBD's were mandated and assigned to employees, which employees would receive the devices (ie: T&E, other)?

3.3. How many employees would that constitute?

3.4. How many locomotives are in your fleet:

- Freight service =
- Yard/switchers =

3.5. If EEBD's were mandated, would they need to accompany personnel on every type of locomotive?

4. Economics

4.1. If EEBD's were mandated, what do you believe is a practical price to pay per device?

4.2. If EEBD's were mandated, there is certainly going to exist a need for training, maintenance, inspection and tracking. Based on the type of device you recommend, how would you handle each of these (ie: internally or externally), how often, and what do you estimate are the associated costs for the same?

- Training: (address if training might be one-on-one or in a group, and how often training should take place)
- Maintenance: (address who would be responsible for maintenance and how often it should take place, ie: preventative maint.)
- Inspection; (address who would be responsible for inspection and how often it should take place)
- Tracking: (address who would be responsible for tracking and how often it should take place. Please compare a tracking program for EEBD's to other similar devices that need to be present on the consist, such as fire extinguishers. How are those tracked?)

5. Professional Opinion

5.1. What is your professional opinion about the need or use of these devices for train crews? Please elaborate on your answer.

Do you believe the number of incidents in the form of collisions, derailments or near misses with consists carrying Hazmat freight, compared to the number of deaths and injuries resulting from the same, warrants the need for EEBD's for train crews?

Questionnaire regarding Emergency Escape Breathing Devices (EEBD) and their possible use in the Railroad Community
Response by Gregory Oblom, CSX RR

1. **Emergency Protocol**
   1.1. If you don't believe EEBD's are a necessary safety device for train crews, please explain the protocols a train crew should undertake (if any) when there is an unintentional release of hazardous and/or toxic material on their consist.

   I don't believe EEBD's are necessary. If the train crew were to use simple logic or common sense in the event of an unintentional release of hazardous material, they should either decide to shelter in place or evacuate the area as quickly as possible.

2. **Equipment**
   2.1. If EEBD's were mandated, what type of device would you recommend for your train crew? Choose those that apply: A device similar to Draeger's QuickAir system.
   - **Air Purifying –** These contain an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These do not supply oxygen and must only be used when there is sufficient oxygen to sustain life and the air contaminant level is below the concentration limits of the device. Common choices are as follows:
     - **Particulate respirators** use a mechanical filter to remove particulate matter such as dusts.
     - **Gas and vapor respirators** (or chemical cartridge respirators) use chemicals such as activated charcoal to remove specific gases and vapors from the air. These are effective for concentrations of no more than ten times the TLV of the contaminant, if the contaminant has warning properties (odor or irritation) below the TLV.
     - **Combination respirators** have filters for both particulates and vapors.
     - **Powered air-purifying respirators (PAPR)** use a blower to force the ambient air through air-purifying elements to the inlet covering.
   - **Compressed Air-Supplying 'Self-Contained Breathing Apparatus' (SCBA)** – This is much like the apparatus a SCUBA diver or fire fighter might use. Air (or oxygen) is supplied from a compressed cylinder, usually through a full-face mask, which is worn on the back. This gives greater movement than an air-line respirator, but the air supply is limited. Two common choices are as follows:
     - **Open loop system –** unused exhaled O2 is lost to atmosphere, hence larger cylinders to provide adequate breathing time. Typical breathing duration is 30 minutes.
     - **Closed loop system –** captures and reuses exhaled O2. Scrubber removes CO2 and small makeup O2 bottle provides additional O2. Typical breathing duration is a minimum of 1 hour.
   - **Filtering Face piece (dust mask) –** the filter is an integral part of the face piece
   - **Bite Valve with Nose Clamp –** breathing through bite valve with nostrils pinched off
   - **Half Mask –** respirator covering the mouth and nose. Requires optimum fit. Facial hair is not recommended.
   - **Full Face piece –** respirator designed to seal around the entire face. Must be sized and fitted per user, particularly with a closed loop system.
   - **Hood –** covers entire head
   - **Negative Pressure Respirator** – wearer draws air through filter or cartridge by breathing

   2.2. If you believe EEBD's should be air-supplying versus air-purifying, should the supplied gas be compressed 'clean' air (ie: grade D) or compressed oxygen? (Note: open loop compressed air systems typically have sizeable cylinders to provide adequate breathing duration whereas closed loop compressed O2 systems have much smaller cylinders, yet provide substantially longer breathing duration).

Compressed clean air.

2.3. If EEBD's were mandated, how much breathing time should the device provide? Please provide reasoning, taking into consideration the time it may take for the train crew to extricate themselves from their immediate surroundings which may be encompassed with a toxic cloud.

10 minutes

2.4. If EEBD's were mandated, what do you think would constitute a reasonable shelf life of the device before mandatory replacement?

3. Assignment

3.1. If EEBD's were mandated, should the devices be assigned to the locomotive or should they be assigned to each appropriate employee?

Our experience with on-board accountability of anything that isn't bolted down is that they tend to disappear or be tampered with. Our experience has lead us to a system whereby each employee is typically issued the "device" and held accountable for it care and safekeeping.

Case in point, when it was required that we provide train crew members with emergency response information (the DOT emergency response guidebook) we initially placed them in holders in the locomotive cab. After about a year of constant replacing -- and crews refusing to depart because there was no book -- we found it easier and more cost effective to issue to each T&E employee and state via the rules that they must have a copy in their possession while on duty.

3.2. If EEBD's were mandated and assigned to employees, which employees would receive the devices (ie: T&E, other)? T&E only
3.3. How many employees would that constitute? 16,000
3.4. How many locomotives are in your fleet:
- Total = 3,800
- Freight service =
- Yard/switchers =

3.5. If EEBD's were mandated, would they need to accompany personnel on every type of locomotive?

4. Economics

4.1. If EEBD's were mandated, what do you believe is a practical price to pay per device? $435.00 (ref. Draeger QuickAir device)
4.2. If EEBD's were mandated, there is certainly going to exist a need for training, maintenance, inspection and tracking. Based on the type of device you recommend, how would you handle each of these (ie: internally or externally), how often, and what do you estimate are the associated costs for the same?
- Training: (address if training might be one-on-one or in a group, and how often training should take place)

- Maintenance: (address who would be responsible for maintenance and how often it should take place, ie: preventative maint.)
- Inspection; (address who would be responsible for inspection and how often it should take place)
- Tracking: (address who would be responsible for tracking and how often it should take place. Please compare a tracking program for EEBD's to other similar devices that need to be present on the consist, such as fire extinguishers. How are those tracked?)

5. Professional Opinion

5.1. What is your professional opinion about the need or use of these devices for train crews? Please elaborate on your answer.

Largely unnecessary. If the train crew were to use simple logic or common sense in the event of an unintentional release of hazardous material, they should either decide to shelter in place or evacuate the area as quickly as possible.

Do you believe the number of incidents in the form of collisions, derailments or near misses with consists carrying Hazmat freight, compared to the number of deaths and injuries resulting from the same, warrants the need for EEBD's for train crews?

Questionnaire regarding Emergency Escape Breathing Devices (EEBD) and their possible use in the Railroad Community
Response by Lyndle Burton, Canadian National RR

1. **Emergency Protocol**
   1.1. If you don't believe EEBD's are a necessary safety device for train crews, please explain the protocols a train crew should undertake (if any) when there is an unintentional release of hazardous and/or toxic material on their consist.

   Train crew needs to either disconnect engine or walk/run upwind of the gas cloud.

2. **Equipment**
   2.1. If EEBD's were mandated, what type of device would you recommend for your train crew? Choose those that apply:
   - **Air Purifying –** These contain an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These do not supply oxygen and must only be used when there is sufficient oxygen to sustain life and the air contaminant level is below the concentration limits of the device. Common choices are as follows:
     - **Particulate respirators** use a mechanical filter to remove particulate matter such as dusts.
     - **Gas and vapor respirators** (or chemical cartridge respirators) use chemicals such as activated charcoal to remove specific gases and vapors from the air. These are effective for concentrations of no more than ten times the TLV of the contaminant, if the contaminant has warning properties (odor or irritation) below the TLV.
     - **Combination respirators** have filters for both particulates and vapors.
     - **Powered air-purifying respirators (PAPR)** use a blower to force the ambient air through air-purifying elements to the inlet covering.
   - **Compressed Air-Supplying 'Self-Contained Breathing Apparatus' (SCBA)** – This is much like the apparatus a SCUBA diver or fire fighter might use. Air (or oxygen) is supplied from a compressed cylinder, usually through a full-face mask, which is worn on the back. This gives greater movement than an air-line respirator, but the air supply is limited. Two common choices are as follows:
     - **Open loop system –** unused exhaled O2 is lost to atmosphere, hence larger cylinders to provide adequate breathing time. Typical breathing duration is 30 minutes.
     - **Closed loop system –** captures and reuses exhaled O2. Scrubber removes CO2 and small makeup O2 bottle provides additional O2. Typical breathing duration is a minimum of 1 hour.
   - **Filtering Face piece (dust mask) –** the filter is an integral part of the face piece
   - **Bite Valve with Nose Clamp –** breathing through bite valve with nostrils pinched off
   - **Half Mask –** respirator covering the mouth and nose. Requires optimum fit. Facial hair is not recommended.
   - **Full Face piece –** respirator designed to seal around the entire face. Must be sized and fitted per user, particularly with a closed loop system.
   - **Hood –** covers entire head
   - **Negative Pressure Respirator** – wearer draws air through filter or cartridge by breathing

   2.2. If you believe EEBD's should be air-supplying versus air-purifying, should the supplied gas be compressed 'clean' air (ie: grade D) or compressed oxygen? (Note: open loop compressed air systems typically have sizeable cylinders to provide adequate breathing duration whereas closed loop compressed O2 systems have much smaller cylinders, yet provide substantially longer breathing duration). Supplied compressed 'clean' air because it's logistically easier to fill with air (ie: finding a local dive shop to do refills)

2.3. If EEBD's were mandated, how much breathing time should the device provide? Please provide reasoning, taking into consideration the time it may take for the train crew to extricate themselves from their immediate surroundings which may be encompassed with a toxic cloud. 30 minutes

2.4. If EEBD's were mandated, what do you think would constitute a reasonable shelf life of the device before mandatory replacement?

3. Assignment

3.1. If EEBD's were mandated, should the devices be assigned to the locomotive or should they be assigned to each appropriate employee? Employee assigned

3.2. If EEBD's were mandated and assigned to employees, which employees would receive the devices (ie: T&E, other)? T&E

3.3. How many employees would that constitute? 3,800

3.4. How many locomotives are in your fleet:

- Total =
- Freight service =
- Yard/switchers =

3.5. If EEBD's were mandated, would they need to accompany personnel on every type of locomotive?

4. Economics

4.1. If EEBD's were mandated, what do you believe is a practical price to pay per device? $1,500.00 USD

4.2. If EEBD's were mandated, there is certainly going to exist a need for training, maintenance, inspection and tracking. Based on the type of device you recommend, how would you handle each of these (ie: internally or externally), how often, and what do you estimate are the associated costs for the same?

- Training: (address if training might be one-on-one or in a group, and how often training should take place) Assume 1 hour face-to-face training per employee (direct time/wages not included) plus the expense of the trainer.
- Maintenance: (address who would be responsible for maintenance and how often it should take place, ie: preventative maint.)
- Inspection; (address who would be responsible for inspection and how often it should take place) Each employee would check their device at the beginning and end of each run. The FRA will also spot inspect.
- Tracking: (address who would be responsible for tracking and how often it should take place. Please compare a tracking program for EEBD's to other similar devices that need to be present on the consist, such as fire extinguishers. How are those tracked?) It's likely that Dangerous Goods Reps from our Hazmat Dept, not IH Dept would track the devices. Generally speaking, this would be an extremely demanding logistical problem for CN.

5. Professional Opinion

5.1. What is your professional opinion about the need or use of these devices for train crews? Please elaborate on your answer. EEBD's are routinely used in mines. But mines are a captured entity whereas our RR has over 7K miles of track, so tracking & maintenance would be difficult, if not impossible and expensive to the company.

Do you believe the number of incidents in the form of collisions, derailments or near misses with consists carrying Hazmat freight, compared to the number of deaths and injuries resulting from the same, warrants the need for EEBD's for train crews?

Union Pacific Railroad (UPRR) Response 11-16-07
Questionnaire regarding Emergency Escape Breathing Devices (EEBD) and their possible use in the Railroad Community

1. **Emergency Protocol**
   1.1. If you don't believe EEBD's are a necessary safety device for train crews, please explain the protocols a train crew should undertake (if any) when there is an unintentional release of hazardous and/or toxic material on their consist.

UPRR Response to Question 1: The UPRR Industrial Hygiene and Safety Engineering (IH&SE) staff has carefully reviewed the National Transportation Safety Board (NTSB) recommendations. A comprehensive risk assessment and feasibility study related to train crews, associated with an unintentional release of hazardous material, should be performed by a qualified, disinterested professional, before it is determined whether an Emergency Escape Breathing Apparatus (EEBA) or other escape device is necessary. This risk assessment should include quantification of exposure risk, a feasibility study, and a comparison of similar industries transporting hazardous chemicals. The UPRR IH staff has serious concerns regarding TPI, Inc. performing this risk assessment, since TPI supplies escape apparatus and naturally has a commercial interest in the outcome of this process.

Current UPRR Policy, per Instructions for Handling Hazardous Materials in Form 8620, is that crew members will not be involved in hazardous material spill recovery, and should get out of harms way as quickly as possible. Our train crews receive regular training related to handling hazardous material shipments.

2. **Equipment**
   2.1. If EEBD's were mandated, what type of device would you recommend for your train crew? Choose those that apply:
   - **Air Purifying –** These contain an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element. These do not supply oxygen and must only be used when there is sufficient oxygen to sustain life and the air contaminant level is below the concentration limits of the device. Common choices are as follows:
     - **Particulate respirators** use a mechanical filter to remove particulate matter such as dusts.
     - **Gas and vapor respirators** (or chemical cartridge respirators) use chemicals such as activated charcoal to remove specific gases and vapors from the air. These are effective for concentrations of no more than ten times the TLV of the contaminant, if the contaminant has warning properties (odor or irritation) below the TLV.
     - **Combination respirators** have filters for both particulates and vapors.
     - **Powered air-purifying respirators (PAPR)** use a blower to force the ambient air through air-purifying elements to the inlet covering.
   - **Compressed Air-Supplying 'Self-Contained Breathing Apparatus' (SCBA)** – This is much like the apparatus a SCUBA diver or fire fighter might use. Air (or oxygen) is supplied from a compressed cylinder, usually through a full-face mask, which is worn on the back.

This gives greater movement than an air-line respirator, but the air supply is limited. Two common choices are as follows:

  - **Open loop system –** unused exhaled O2 is lost to atmosphere, hence larger cylinders to provide adequate breathing time. Typical breathing duration is 30 minutes.
  - **Closed loop system –** captures and reuses exhaled O2. Scrubber removes CO2 and small makeup O2 bottle provides additional O2. Typical breathing duration is a minimum of 1 hour.

- **Filtering Face piece (dust mask) –** the filter is an integral part of the face piece
- **Bite Valve with Nose Clamp –** breathing through bite valve with nostrils pinched off
- **Half Mask –** respirator covering the mouth and nose. Requires optimum fit. Facial hair is not recommended.
- **Full Face piece –** respirator designed to seal around the entire face. Must be sized and fitted per user, particularly with a closed loop system.
- **Negative Pressure Respirator** – wearer draws air through filter or cartridge by breathing

<u>UPRR Response to Question 2.1</u>: To the best of my knowledge, the term "emergency escape breathing device" is not one recognized or used by the National Institute for Occupational Safety and Health. The term used by NIOSH when talking about such equipment is Self-Contained Breathing Apparatus (SCBA) – Escape Only, and it applies to a limited number of schedule 13F- respirators, all of which are designed for the express purpose of allowing employees to escape hazardous environments, including those that are immediately dangerous to life and health (IDLH). This is the list of 39 NIOSH-certified escape respirators with loose-fitting hoods that could potentially be appropriate for use by train engine and yard employees.

Certified Equipment List Search

Selection Criteria

Schedule(s)
13F - Self Contained Breathing Apparatus (SCBA)
Face Piece Type(s)
Hood
SCBA Use = Escape Only
Do NOT Include Obsolete Respirators

Schedule	Approval #	Manufacturer		
13F	0111	International Safety Instruments, Inc.	ELSA 5	Hood
13F	0172	North Safety Products	845	Hood
13F	0178	Respiratory Systems, Inc.	Lifeair 10 Minute EEBA	Hood
13F	0182	Dräger Safety, Inc.	MAX	Hood
13F	0195	North Safety Products	850	Hood

13F	0200	Dräger Safety, Inc.	ERMA	Hood
13F	0205	Airolife Safety, Inc.	550HF-7	Hood
13F	0217	Mine Safety Appliances Company	Custom Air V	Hood
13F	0232	Survivair, Inc.	EBA-10	Hood
13F	0254	Mine Safety Appliances Company	Custom Air V	Hood
13F	0291	International Safety Instruments, Inc.	ELSA 6XF	Hood
13F	0348	Dräger Safety, Inc.	Quick Air-10	Hood
13F	0395	Dräger Safety, Inc.	QuickAir 5	Hood
13F	0438	Respiratory Systems, Inc.	Lifeair 15	Hood
13F	0446	Mine Safety Appliances Company	Transair 10	Hood
13F	0471	International Safety Instruments, Inc.	10 minute EEBA	Hood
13F	0485	Interspiro USA, Inc.	Spiroscape HP 15 minute	Hood
13F	0487	Scott Health & Safety Ltd	Sabre ELSA 10	Hood
13F	0524	International Safety Instruments, Inc.	CEEBA, 5 MINUTE	Hood
13F	0530	Scott Health & Safety Ltd	ELSA 15	Hood

Total records found: 39
Records shown: 1 to 39

Last Updated 10/12/2007 8:41:27 AM

2.2. If you believe EEBD's should be air-supplying versus air-purifying, should the supplied gas be compressed 'clean' air (ie: grade D) or compressed oxygen? (Note: open loop compressed air systems typically have sizeable cylinders to provide adequate breathing duration whereas closed loop compressed O2 systems have much smaller cylinders, yet provide substantially longer breathing duration).

<u>Response to Question 2.2</u>: UPRR is limited to those devices certified by NIOSH per OSHA 29CFR1910.134. To the best of my knowledge, a closed loop compressed oxygen system is not presently certified by NIOSH for industry use.

2.3. If EEBD's were mandated, how much breathing time should the device provide? Please provide reasoning, taking into consideration the time it may take for the train crew to extricate themselves from their immediate surroundings which may be encompassed with a toxic cloud.

<u>Response to Question 2.3</u>: To answer this question more scientifically, a disinterested, third-party professional should review the history of hazardous material accidents requiring crew evacuation to determine whether such devices would be, on balance, beneficial or harmful and, if beneficial, the appropriate requirement.

2.4. If EEBD's were mandated, what do you think would constitute a reasonable shelf life of the device before mandatory replacement?

<u>Response to Question 2.3</u>: Shelf life should be consistent with the present requirements of OSHA 29CFR1910.134(g)(3), (h) and (i).

3. Assignment

3.1. If EEBD's were mandated, should the devices be assigned to the locomotive or should they be assigned to each appropriate employee?

<u>Response to Question 3.1</u>: There are advantages and disadvantages to either choice. There are many parameters that need to be considered, such as EEBA size and weight, before a system design could be appropriately developed. Another option may be to contract an engineering firm to maintain, inspect and issue the equipment including employee training. The equipment would be checked-in and checked-out each work day by employees performing specific train operation duties. Again, a comprehensive risk assessment would be used to develop an appropriate system design.

3.2. If EEBD's were mandated and assigned to employees, which employees would receive the devices (ie: T&E, other)?

<u>Response to Question 3.2</u>: All train, engine and yard (TE&Y) employees and other occupants whose duties require riding in locomotive cabs.

3.3. How many employees would that constitute?

<u>Response to Question 3.3</u>: This is difficult to estimate; however, there are approximately 24,000 TE&Y employees.

3.4. How many locomotives are in your fleet:

- Freight service = **Approximately 6500**
- Yard/switchers = **Approximately 2100**

3.5. If EEBD's were mandated, would they need to accompany personnel on every type of locomotive?

<u>Response to Question 3.5</u>: We do not understand this question.

4. Economics

4.1. If EEBD's were mandated, what do you believe is a practical price to pay per device?

<u>Response to Question 4.1</u>: Current information is approximately $400 per 10-15 minute EEBA unit.

4.2. If EEBD's were mandated, there is certainly going to exist a need for training, maintenance, inspection and tracking. Based on the type of device you recommend, how would you handle each of these (ie: internally or externally), how often, and what do you estimate are the associated costs for the same?

- Training: (address if training might be one-on-one or in a group, and how often training should take place)
- Maintenance: (address who would be responsible for maintenance and how often it should take place, ie: preventative maint.)
- Inspection; (address who would be responsible for inspection and how often it should take place)
- Tracking: (address who would be responsible for tracking and how often it should take place. Please compare a tracking program for EEBD's to other similar devices that need to be present on the consist, such as fire extinguishers. How are those tracked?)

<u>Response to Question 4.1</u>:

Training, maintenance, inspection, and tracking will certainly cause logistical challenges for approximately 24,000 UPRR TE&Y employees. Assuming EEBAs would be carried in each train crew grip, estimated costs would include the following:

- $10,000,000 for EEBA purchase
- $11,000,000 for transponder EEBA tracking systems *
- $15,000,000 for maintenance, inspection, and tracking

* This cost estimate includes a transponder based check-in/check-out system, which may be necessary to automate distribution at 430 crew change locations for a relatively heavy (greater than 4 pounds) "SCBA-escape only" system distribution.

Training: Annual training including "hands-on" practice. Training should include a short lecture using Powerpoint or something similar in small groups of 5 to 10 employees maximum. Re-cert training after initial training recommended.
Maintenance: UPRR IH&SE have successfully used consulting engineering firms for small pools of several hundred TE&Y traveling through tunnels, but the magnitude of this task would

max out the available manpower pool for one consultant firm very quickly. Numerous consulting firms would need to be involved, all with the same scope of work, equipment and following the same Federally required maintenance procedures. More than likely, multiple manufacturing firms would need to supply the EEBAs with the same specifications. Each manufacturer should be required to provide spare parts for a minimum of seven years after the last respirator of a given year group comes off their assembly line.
Inspection: A consulting engineering firm.
Tracking: Each EEBA should have an embedded bar-code or transponder assigned to the entire unit – hood, regulator, hose lines, tanks and cases. Replacement of any component would require the manufacturer to manage the replacement and update the bar-code/transponder for the entire unit. A very large number of EEBAs would be involved; as a result, automation technology would be necessary for proper EEBA tracking and maintenance.

5. Professional Opinion

5.1. What is your professional opinion about the need or use of these devices for train crews? Please elaborate on your answer.

5.2. Do you believe the number of incidents in the form of collisions, derailments or near misses with consists carrying Hazmat freight, compared to the number of deaths and injuries resulting from the same, warrants the need for EEBD's for train crews?

Response to Question 5.1 and 5.2:

We researched our records and identified one TE&Y conductor fatality related to a hazardous material release. Our major concern is that EEBAs may be counter productive for emergency escape, causing our TE&Y employees to spend extra time in a potentially hazardous area. In addition, the feasibility of complying with federal standards related to pressurized air tank maintenance and hands-on training for 24,000 employees 24/7 also raises concerns. EEBAs have limited usefulness when considering the multitude of chemical release scenarios.

The railroad industry would be best served by a scientific approach. Specifically, the UPRR IH&SE staff recommend a disinterested, third party professional risk analysis, before discussing EEBA system design.

5.3. Regarding the use of EEBD's in the Moffat Tunnel:

- How successful has the program been?
- What lessons have been learned?
- What would you do differently?
- Can you incorporate any lessons learned from that program that would help in a system-wide EEBD approach?

Response to Question 5.3:

- How successful has the program been?

The Moffat Tunnel program includes 30-minute Self-Contained-Breathing-Apparatus (SCBA) systems specifically designed for tunnel emergencies. This system has been very successful during train stalls involving potentially high diesel emission exposure, not hazardous material release.

- What would you do differently?

We would do nothing differently.

- Can you incorporate any lessons learned from that program that would help in a system-wide EEBD approach?

Employee training, SCBA maintenance, and SCBA tracking is critical for a successful program. Training, including hands-on training, must be available at all times for efficient railroad operations.

Appendix D

Non-Passenger T&E Employees - on duty (A) casualties

Source: Federal Railroad Administration Safety Database - 4.02 Casualty Data Reports

Reporting Year	Overall Casualties	Collision Casualties	Collision Fatalities	Derailment Casualties	Derailment Fatalities	Inhalation Casualties	Inhalation Fatalities
1997	2834	96	8	38	0	58	0
1998	3004	86	1	37	0	86	0
1999	3211	76	7	54	1	73	0
2000	3169	82	2	44	0	63	0
2001	2872	86	4	50	0	68	0
2002	2405	84	2	46	1	50	0
2003	2281	75	2	44	1	63	0
2004	2211	73	5	55	0	70	1
2005	2102	84	0	27	0	69	1
2006	1852	60	1	28	0	64	0
10 year Avg	2594.1	80.2	3.2	42.3	0.3	66.4	0.2

Appendix E

AAR's Cost/Benefit Analysis – Equipping T&E Employees

Breathing Apparatus BCA.xls				% Lost:	Scrap Age	Road Locomotives:				
	Inputs:		4 Years	5%	5	15,000	20%	1		$15
Year	Year	Available Units at Beginning of Year	Units Installed	Units Pilfered or Lost	Units Scrapped	Total T&E Employees	T&E Employees Retired, Left	T&E Employees Hired	T&E Employees Trained	T&E Employees Retrained
	NPV									
0	2008	0	20,000	500	0	68,307	6,120	6,120	68,307	0
1	2009	19,500	20,500	1,488	0	68,307	6,212	6,212	6,212	62,095
2	2010	38,513	21,488	2,463	0	68,307	6,212	6,212	6,212	62,095
3	2011	57,537	12,463	3,188	0	68,307	6,181	6,181	6,181	62,126
4	2012	66,812	3,188	3,420	0	68,307	6,068	6,068	6,068	62,239
5	2013	66,580	18,896	3,414	15,476	68,307	5,902	5,902	5,902	62,405
6	2014	66,586	18,890	3,405	15,863	68,307	5,696	5,696	5,696	62,611
7	2015	66,208	19,267	3,376	16,627	68,307	5,434	5,434	5,434	62,873
8	2016	65,473	20,003	3,533	9,643	68,307	5,123	5,123	5,123	63,184
9	2017	72,300	13,176	3,883	2,467	68,307	4,790	4,790	4,790	63,517
10	2018	79,126	6,350	3,750	14,621	68,307	4,459	4,459	4,459	63,848
11	2019	67,105	18,371	3,449	14,617	68,307	4,132	4,132	4,132	64,175
12	2020	67,410	18,066	3,449	14,909	68,307	3,824	3,824	3,824	64,483
13	2021	67,117	18,358	3,428	15,478	68,307	3,566	3,566	3,566	64,741
14	2022	66,570	18,906	3,546	10,195	68,307	3,358	3,358	3,358	64,949
15	2023	71,734	13,742	3,807	4,913	68,307	3,225	3,225	3,225	65,082

	Initial Cost:	$34,153,500									
Cost/Unit:	Training		Maint	Probability Available:		90%					
$500	$70 per hour		$80	Probability of Use:		90%	$3.00	$0.20	$0.025		53.8
Discount Ra	1.0 hours train		0.5								-0.0186
7%	0.25 hours retrain			0.08	0.4	1.0					
					Safety Benefits: Number of Casualties Avoided			Casualty Costs Avoided ($Millions)			Pre-Tax Benefits Minus Costs
	Costs (in Millions of $)										
Capital	Training	Maintenance	Total	Fatalities	Major Injuries	Minor Injuries	Fatalities	Major Injuries	Minor Injuries	Total	
$78.18	$16.99	$20.26	**$115.43** #			#	$1.49	$0.50	$0.16	**$2.14** #	($113.29)
$10.00	$4.78	$0.00	$14.78	0.01	0.05	0.12	$0.03	$0.01	$0.00	$0.04	-$14.74
$10.25	$1.52	$0.78	$12.55	0.03	0.14	0.34	$0.08	$0.03	$0.01	$0.12	-$12.43
$10.74	$1.52	$1.54	$13.81	0.05	0.23	0.57	$0.14	$0.05	$0.01	$0.20	-$13.61
$6.23	$1.52	$2.30	$10.05	0.06	0.29	0.74	$0.18	$0.06	$0.02	$0.25	-$9.80
$1.59	$1.51	$2.67	$5.78	0.06	0.32	0.79	$0.19	$0.06	$0.02	$0.27	-$5.51
$9.45	$1.51	$2.66	$13.62	0.06	0.32	0.79	$0.19	$0.06	$0.02	$0.27	-$13.34
$9.45	$1.49	$2.66	$13.60	0.06	0.31	0.79	$0.19	$0.06	$0.02	$0.27	-$13.33
$9.63	$1.48	$2.65	$13.76	0.06	0.31	0.78	$0.19	$0.06	$0.02	$0.27	-$13.49
$10.00	$1.46	$2.62	$14.08	0.07	0.33	0.82	$0.20	$0.07	$0.02	$0.28	-$13.80
$6.59	$1.45	$2.89	$10.93	0.07	0.36	0.90	$0.22	$0.07	$0.02	$0.31	-$10.62
$3.17	$1.43	$3.17	$7.77	0.07	0.35	0.87	$0.21	$0.07	$0.02	$0.30	-$7.47
$9.19	$1.41	$2.68	$13.28	0.06	0.32	0.80	$0.19	$0.06	$0.02	$0.28	-$13.01
$9.03	$1.40	$2.70	$13.13	0.06	0.32	0.80	$0.19	$0.06	$0.02	$0.28	-$12.85
$9.18	$1.38	$2.68	$13.25	0.06	0.32	0.79	$0.19	$0.06	$0.02	$0.27	-$12.97
$9.45	$1.37	$2.66	$13.49	0.07	0.33	0.82	$0.20	$0.07	$0.02	$0.28	-$13.20
$6.87	$1.36	$2.87	$11.10	0.03	0.17	0.43	$0.10	$0.03	$0.01	$0.15	-$10.96

AAR's Cost/Benefit Analysis – Equipping T&E Locomotives

Breathing Apparatus BCA.xls				% Lost:	Scrap Age	Road Locomotives:				
	Inputs:		4 Years	20%	5	15,000	20%	1		$15
Year	Year	Available Units at Beginning of Year	Units Installed	Units Pilfered or Lost	Units Scrapped	Total T&E Employees	T&E Employees Retired, Left	T&E Employees Hired	T&E Employees Trained	T&E Employees Retrained
	NPV									
0	2008	0	10,000	1,000	0	68,307	6,120	6,120	68,307	0
1	2009	9,000	11,000	2,900	0	68,307	6,212	6,212	6,212	62,095
2	2010	17,100	12,900	4,710	0	68,307	6,212	6,212	6,212	62,095
3	2011	25,290	11,710	6,229	0	68,307	6,181	6,181	6,181	62,126
4	2012	30,771	6,229	6,777	0	68,307	6,068	6,068	6,068	62,239
5	2013	30,223	10,054	6,722	3,277	68,307	5,902	5,902	5,902	62,405
6	2014	30,278	9,999	6,695	3,604	68,307	5,696	5,696	5,696	62,611
7	2015	29,977	10,299	6,603	4,227	68,307	5,434	5,434	5,434	62,873
8	2016	29,447	10,830	6,589	3,837	68,307	5,123	5,123	5,123	63,184
9	2017	29,851	10,426	6,809	2,041	68,307	4,790	4,790	4,790	63,517
10	2018	31,427	8,850	6,841	3,294	68,307	4,459	4,459	4,459	63,848
11	2019	30,141	10,135	6,714	3,277	68,307	4,132	4,132	4,132	64,175
12	2020	30,286	9,991	6,719	3,375	68,307	3,824	3,824	3,824	64,483
13	2021	30,183	10,094	6,691	3,549	68,307	3,566	3,566	3,566	64,741
14	2022	30,037	10,240	6,690	3,416	68,307	3,358	3,358	3,358	64,949
15	2023	30,171	10,106	6,755	2,900	68,307	3,225	3,225	3,225	65,082

Breathing Appara			Initial Cost: $15,000,000										
		Cost/Unit:	Training		Maint	Probability Available:		90%					
	Inputs:	$500	$70 per hour		$80	Probability of Use:		90%	$3.00	$0.20	$0.025		33.7
		Discount Ra	1.0 hours train		0.5								-0.0297
		7%	0.25 hours retrain			0.08	0.4	1.0					
			Costs (in Millions of $)				Safety Benefits: Number of Casualties Avoided			Casualty Costs Avoided ($Millions)			Pre-Tax Benefits Minus Costs
Year	Year	Capital	Training	Maintenance	Total	Fatalities	Major Injuries	Minor Injuries	Fatalities	Major Injuries	Minor Injuries	Total	
	NPV	$48.43	$16.99	$8.98	**$74.40** #			#	$1.54	$0.51	$0.16	**$2.21** #	($72.19)
0	2008	$5.00	$4.78	$0.00	$9.78	0.01	0.05	0.12	$0.03	$0.01	$0.00	$0.04	-$9.74
1	2009	$5.50	$1.52	$0.36	$7.38	0.03	0.14	0.35	$0.08	$0.03	$0.01	$0.12	-$7.26
2	2010	$6.45	$1.52	$0.68	$8.66	0.05	0.23	0.57	$0.14	$0.05	$0.01	$0.20	-$8.46
3	2011	$5.86	$1.52	$1.01	$8.39	0.06	0.30	0.76	$0.18	$0.06	$0.02	$0.26	-$8.13
4	2012	$3.11	$1.51	$1.23	$5.86	0.07	0.33	0.82	$0.20	$0.07	$0.02	$0.28	-$5.58
5	2013	$5.03	$1.51	$1.21	$7.74	0.07	0.33	0.82	$0.20	$0.07	$0.02	$0.28	-$7.46
6	2014	$5.00	$1.49	$1.21	$7.71	0.07	0.33	0.81	$0.20	$0.07	$0.02	$0.28	-$7.42
7	2015	$5.15	$1.48	$1.20	$7.83	0.06	0.32	0.80	$0.19	$0.06	$0.02	$0.28	-$7.55
8	2016	$5.41	$1.46	$1.18	$8.06	0.06	0.32	0.80	$0.19	$0.06	$0.02	$0.28	-$7.78
9	2017	$5.21	$1.45	$1.19	$7.85	0.07	0.33	0.83	$0.20	$0.07	$0.02	$0.29	-$7.57
10	2018	$4.42	$1.43	$1.26	$7.11	0.07	0.33	0.83	$0.20	$0.07	$0.02	$0.29	-$6.82
11	2019	$5.07	$1.41	$1.21	$7.69	0.07	0.33	0.82	$0.20	$0.07	$0.02	$0.28	-$7.40
12	2020	$5.00	$1.40	$1.21	$7.60	0.07	0.33	0.82	$0.20	$0.07	$0.02	$0.28	-$7.32
13	2021	$5.05	$1.38	$1.21	$7.64	0.07	0.33	0.81	$0.20	$0.07	$0.02	$0.28	-$7.36
14	2022	$5.12	$1.37	$1.20	$7.69	0.07	0.33	0.81	$0.20	$0.07	$0.02	$0.28	-$7.41
15	2023	$5.05	$1.36	$1.21	$7.62	0.07	0.33	0.81	$0.20	$0.07	$0.02	$0.28	-$7.34

Appendix F

Cost Schedule - Positive Pressure, Open Loop SCBA with Hood, Grade D Pressurized Air Supply, Assigned to Employee

Open Loop Breathing Apparatus

Cost Estimate if Assigned to Employee

					Replacement	Road						Initial Cost:	$37,568,850	
				% Lost:	Age	Loco's:					Cost/Unit:	Training		Maint
	Inputs:		4 Years	5%	0	15,000	20%	1		$17	$550	$70 per hour		$80
											Discount Rate:	1.0 hours train		0.5
											7%	0.25 hours retrain		
												hydro test		$25
Year	Year	Available Units at Beginning of Year	Units Installed	Units Pilfered Lost or Damaged	Units Scrapped	Total T&E Employees	T&E Employees Retired, Left	T&E Employees Hired	T&E Employees Trained	T&E Employees Retrained	Costs (in Millions of $) Capital	Training	Maintenance	Total
	NPV										$46.30	$16.99	$3.92	**$67.20**
0	2008	0	20,000	500	0	68,307	6,120	6,120	68,307	0	$11.00	$4.78	$0.00	$15.78
1	2009	19,500	20,500	1,488	0	68,307	6,212	6,212	6,212	62,095	$11.28	$1.52	$0.00	$12.80
2	2010	38,513	21,488	2,463	0	68,307	6,212	6,212	6,212	62,095	$11.82	$1.52	$0.00	$13.34
3	2011	57,537	12,463	3,188	0	68,307	6,181	6,181	6,181	62,126	$6.85	$1.52	$0.00	$8.37
4	2012	66,812	3,188	3,420	0	68,307	6,068	6,068	6,068	62,239	$1.75	$1.51	$1.30	$4.57
5	2013	66,580	3,420	3,414	0	68,307	5,902	5,902	5,902	62,405	$1.88	$1.51	$1.33	$4.72
6	2014	66,586	3,414	3,415	0	68,307	5,696	5,696	5,696	62,611	$1.88	$1.49	$1.40	$4.77
7	2015	66,585	3,415	3,415	0	68,307	5,434	5,434	5,434	62,873	$1.88	$1.48	$0.81	$4.17
8	2016	66,585	3,415	3,415	0	68,307	5,123	5,123	5,123	63,184	$1.88	$1.46	$0.21	$3.55
9	2017	66,585	3,415	3,415	0	68,307	4,790	4,790	4,790	63,517	$1.88	$1.45	$0.22	$3.55
10	2018	66,585	3,415	3,415	0	68,307	4,459	4,459	4,459	63,848	$1.88	$1.43	$0.22	$3.53
11	2019	66,585	3,415	3,415	0	68,307	4,132	4,132	4,132	64,175	$1.88	$1.41	$0.22	$3.51
12	2020	66,585	3,415	3,415	0	68,307	3,824	3,824	3,824	64,483	$1.88	$1.40	$0.22	$3.50
13	2021	66,585	3,415	3,415	0	68,307	3,566	3,566	3,566	64,741	$1.88	$1.38	$0.22	$3.48
14	2022	66,585	3,415	3,415	0	68,307	3,358	3,358	3,358	64,949	$1.88	$1.37	$0.22	$3.47
15	2023	66,585	3,415	3,415	0	68,307	3,225	3,225	3,225	65,082	$1.88	$1.36	$0.22	$3.46

Cost Schedule - Positive Pressure, Open Loop SCBA with Hood, Grade D Pressurized Air Supply, Assigned to Locomotive

Open Loop Breathing Apparatus

Cost Estimate if Assigned to Locomotive Number EEBA per Loco 3

Breathing Apparatus BCA.xls					Replacement	Road						Initial Cost:	$24,750,000	
				% Lost:	Age	Loco's:					Cost/Unit:	Training		Maint
	Inputs:		4 Years	20%	0	15,000	20%	1		$17	$550	$70 per hour		$80
											Discount Ra	1.0 hours train		0.5
											7%	0.25 hours retrain		
												hydro test		$25
Year	Year	Available Units at Beginning of Year	Units Installed	Units Pilfered Lost or Damaged	Units Scrapped	Total T&E Empl.	T&E Empl. Ret./Left	T&E Empl. Hired	T&E Empl. Trained	T&E Empl. Retrained	Costs (in Millions of $) Capital	Training	Maintenance	Total
	NPV										$60.89	$14.64	$4.23	**$79.76**
0	2008	0	11,000	1,100	0	68,307	0	0	68,307	0	$6.05	$4.78	$0.00	$10.83
1	2009	9,900	12,100	3,190	0	68,307	0	0	0	68,307	$6.66	$1.20	$0.00	$7.85
2	2010	18,810	14,190	5,181	0	68,307	0	0	0	68,307	$7.80	$1.20	$0.00	$9.00
3	2011	27,819	16,181	7,182	0	68,307	0	0	0	68,307	$8.90	$1.20	$0.00	$10.09
4	2012	36,818	18,182	9,182	0	68,307	0	0	0	68,307	$10.00	$1.20	$0.00	$11.20
5	2013	45,818	9,182	10,082	0	68,307	0	0	0	68,307	$5.05	$1.20	$0.72	$6.96
6	2014	44,918	10,082	9,992	0	68,307	0	0	0	68,307	$5.55	$1.20	$0.79	$7.53
7	2015	45,008	9,992	10,001	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.92	$7.61
8	2016	44,999	10,001	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$1.05	$7.75
9	2017	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$1.18	$7.88
10	2018	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.60	$7.29
11	2019	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.66	$7.35
12	2020	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.65	$7.34
13	2021	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.65	$7.35
14	2022	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.65	$7.35
15	2023	45,000	10,000	10,000	0	68,307	0	0	0	68,307	$5.50	$1.20	$0.65	$7.35

Cost Schedule - For Positive Pressure, Closed Loop SCBA with Mouthpiece, Oxygen Pressurized Air Supply, Assigned to Employee

Closed Loop Breathing Apparatus
Cost Estimate if Assigned to Employee

					Replacement	Road						Initial Cost:	$44,399,550	
				% Lost:	Age	Loco's:					Cost/Unit:		Training	Maint
	Inputs:		4 Years	5%	10	15,000	20%		1	$20	$650	$70	per hour	$80
											Discount Rate:	1.0	hours train	0.5
											7%	0.25	hours retrain	

Year	Year	Available Units at Beginning of Year	Units Installed	Units Pilfered Lost or Damaged	Units Scrapped	Total T&E Employees	T&E Employees Retired, Left	T&E Employees Hired	T&E Employees Trained	T&E Employees Retrained	Costs (in Millions of $) Capital	Training	Maintenance	Total
	NPV										$66.34	$16.99	$0.00	**$83.32**
0	2008	0	20,000	500	0	68,307	6,120	6,120	68,307	0	$13.00	$4.78	$0.00	$17.78
1	2009	19,500	20,500	1,488	0	68,307	6,212	6,212	6,212	62,095	$13.33	$1.52	$0.00	$14.85
2	2010	38,513	21,488	2,463	0	68,307	6,212	6,212	6,212	62,095	$13.97	$1.52	$0.00	$15.49
3	2011	57,537	12,463	3,188	0	68,307	6,181	6,181	6,181	62,126	$8.10	$1.52	$0.00	$9.62
4	2012	66,812	3,188	3,420	0	68,307	6,068	6,068	6,068	62,239	$2.07	$1.51	$0.00	$3.59
5	2013	66,580	3,420	3,414	0	68,307	5,902	5,902	5,902	62,405	$2.22	$1.51	$0.00	$3.73
6	2014	66,586	3,414	3,415	0	68,307	5,696	5,696	5,696	62,611	$2.22	$1.49	$0.00	$3.71
7	2015	66,585	3,415	3,415	0	68,307	5,434	5,434	5,434	62,873	$2.22	$1.48	$0.00	$3.70
8	2016	66,585	3,415	3,415	0	68,307	5,123	5,123	5,123	63,184	$2.22	$1.46	$0.00	$3.68
9	2017	66,585	3,415	3,415	0	68,307	4,790	4,790	4,790	63,517	$2.22	$1.45	$0.00	$3.67
10	2018	66,585	3,415	3,115	11,975	68,307	4,459	4,459	4,459	63,848	$2.22	$1.43	$0.00	$3.65
11	2019	54,910	15,090	2,816	12,274	68,307	4,132	4,132	4,132	64,175	$9.81	$1.41	$0.00	$11.22
12	2020	54,910	15,090	2,801	12,865	68,307	3,824	3,824	3,824	64,483	$9.81	$1.40	$0.00	$11.20
13	2021	54,334	15,666	2,922	7,462	68,307	3,566	3,566	3,566	64,741	$10.18	$1.38	$0.00	$11.57
14	2022	59,616	10,384	3,193	1,909	68,307	3,358	3,358	3,358	64,949	$6.75	$1.37	$0.00	$8.12
15	2023	64,898	5,102	3,321	2,048	68,307	3,225	3,225	3,225	65,082	$3.32	$1.36	$0.00	$4.68

Cost Schedule - For Positive Pressure, Closed Loop SCBA with Mouthpiece, Oxygen Pressurized Air Supply, Assigned to Locomotive

Closed Loop Breathing Apparatus
Cost Estimate if Assigned to Locomotive Number EEBA per Loco 3

Breathing Apparatus BCA.xls					Replacement	Road						Initial Cost:	$29,250,000	
				% Lost:	Age	Loco's:					Cost/Unit:		Training	Maint
	Inputs:		4 Years	20%	10	15,000	20%	1		$20	$650	$70	per hour	$80
											Discount Rate:	1.0	hours train	0.5
											7%	0.25	hours retrain	

Year	Year	Available Units at Beginning of Year	Units Installed	Units Pilfered Lost or Damaged	Units Scrapped	Total T&E Empl.	T&E Empl. Ret./Left	T&E Empl. Hired	T&E Empl. Trained	T&E Empl. Retrained	Costs (in Millions of $) Capital	Training	Maintenance	Total
	NPV										$52.44	$14.64	$0.00	**$67.08**
0	2008	0	10,000	1,000	0	68,307	0	0	68,307	0	$6.50	$4.78	$0.00	$11.28
1	2009	9,000	11,000	2,900	0	68,307	0	0	0	68,307	$7.15	$1.20	$0.00	$8.35
2	2010	17,100	12,900	4,710	0	68,307	0	0	0	68,307	$8.39	$1.20	$0.00	$9.58
3	2011	25,290	11,710	6,229	0	68,307	0	0	0	68,307	$7.61	$1.20	$0.00	$8.81
4	2012	30,771	6,229	6,777	0	68,307	0	0	0	68,307	$4.05	$1.20	$0.00	$5.24
5	2013	30,223	6,777	6,722	0	68,307	0	0	0	68,307	$4.41	$1.20	$0.00	$5.60
6	2014	30,278	6,722	6,728	0	68,307	0	0	0	68,307	$4.37	$1.20	$0.00	$5.56
7	2015	30,272	6,728	6,727	0	68,307	0	0	0	68,307	$4.37	$1.20	$0.00	$5.57
8	2016	30,273	6,727	6,727	0	68,307	0	0	0	68,307	$4.37	$1.20	$0.00	$5.57
9	2017	30,273	6,727	6,727	0	68,307	0	0	0	68,307	$4.37	$1.20	$0.00	$5.57
10	2018	30,273	6,727	6,620	1,074	68,307	0	0	0	68,307	$4.37	$1.20	$0.00	$5.57
11	2019	29,306	7,694	6,513	1,181	68,307	0	0	0	68,307	$5.00	$1.20	$0.00	$6.20
12	2020	29,306	7,694	6,492	1,385	68,307	0	0	0	68,307	$5.00	$1.20	$0.00	$6.20
13	2021	29,123	7,877	6,487	1,257	68,307	0	0	0	68,307	$5.12	$1.20	$0.00	$6.32
14	2022	29,256	7,744	6,559	669	68,307	0	0	0	68,307	$5.03	$1.20	$0.00	$6.23
15	2023	29,772	7,228	6,604	728	68,307	0	0	0	68,307	$4.70	$1.20	$0.00	$5.89