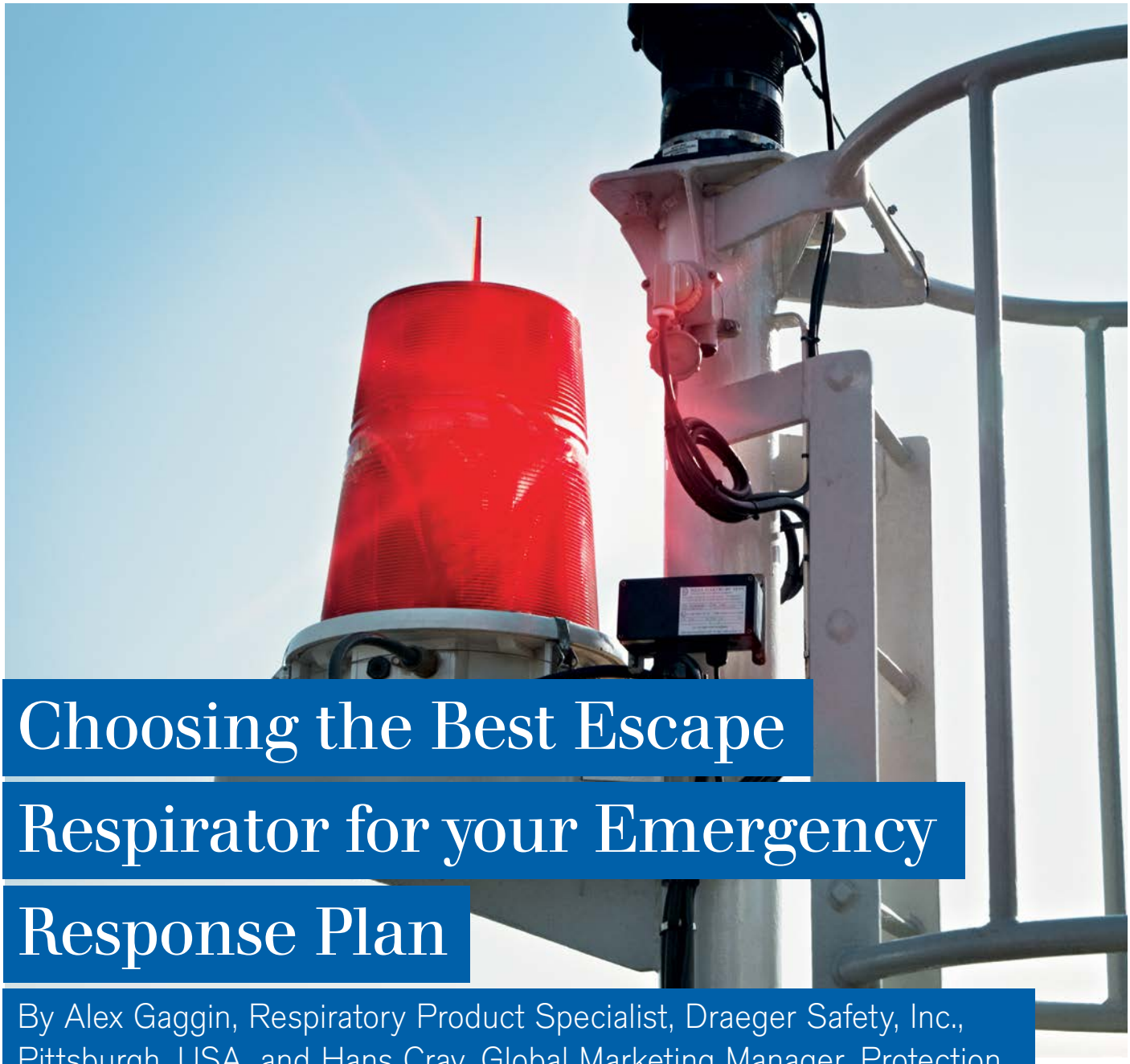

Choosing the Best Escape Respirator for your Emergency Response Plan

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With any process involving hazardous materials, the primary goal is to prevent the release of the substance. However, there should also be a means of protecting workers in the event that those controls fail or do not function as designed.

The three-legged stool of hazardous material risk management

According to several regional regulations and recommendations, e.g for the US OSHA 29 CFR 1910.110 Appendix C (Compliance Guidelines and Recommendations for Process Safety Management), risk assessments need to be undertaken and counter measures must be implemented. Personnel working with any hazardous process should be protected by at least three lines of defense. These lines of defense must operate in unison to provide an effective hazard control plan. You can think of this approach as a 3 step approach in evaluating working with hazardous materials:

1. **Containment:** Standard Operating Procedures (SOPs) and engineering controls designed to control all hazardous substances. (For example, keep it contained by using approved devices, piping, values, and process design specifications.)
2. **Back-up controls:** Control or mitigate exposure to workers and the environment in the event that the first step of defense is compromised or fails. (For example, control the substance with relief valves, scrubbers, flares, surge/overflow tanks, fire suppression systems, etc.)
3. **Emergency Response Plan:** Protect plant and human assets by providing a means of escape/response in the event that steps 1 and 2 fail. Depending on the risk and hazard, this can range from a simple evacuation plan to a complex emergency response scenario including escape respirators, escape refuge chambers/safe zones, HAZMAT (or fire) control teams, and search and rescue procedures.

If these three elements are not operating together, then the likelihood of a disaster or fatality is exponentially higher. In many cases, it is the third step that is neglected. Escape respirators as part of the emergency response plan are sometimes seen as a necessary evil or redundant compliance requirement, because an escape respirator will not prevent an emergency situation from occurring. In other words, an organization with good SOPs and fail safe plans may feel that it can prevent an incident from occurring, so it does not need to invest in good escape respirators. However, many industrial disasters of the past have resulted from a false sense of security in SOPs and fail safes. In many of those cases, loss of life could have been prevented by a strong emergency response program.

Acquiring the correct type and quantity of escape respirators is just as much of a part of risk management as trying to prevent the release of the hazard in the first place.
This article focuses on the "third step" of hazardous material risk management. Specifically, it covers the types of escape respirators that are available, identifies the best applications for each, and evaluates the pros and cons of each technology.

Performing a Process Hazard Analysis (PHA) or Risk Analysis

If you are interested in strengthening the third step of your organization's hazardous material risk management plan, the first thing to do is to perform a Process Hazard Analysis (PHA) to identify the risks in the workplace and the consequences that will result if your SOPs and fail safes malfunction.
While there are many industrial hazards and risks, this article focuses on the three most common types of industrial hazards that present a high risk to the human respiratory system:

- Risk of Fire – Fire is a risk in virtually every industrial setting, but the highest risk occurs when personnel are exposed to accumulating smoke. Most fire-related deaths are due to carbon monoxide poisoning, not burns. Any industry using high heat processes or flammable materials should be well prepared for fire hazards.
- Release of Toxins – This includes the release of a chemical, vapor, or gas from a process or vessel at high concentrations. The toxins are typically known because they are identified by the PHA. For example, hydrogen sulfide could be released from an oil drilling rig or toxins such as chlorine, phosgene or ammonia can be released from a chemical process.
- Environmental Volatility – The third most common risk to the human respiratory system is an atmosphere that is likely to change or become dangerous, such as confined spaces where conditions can change quickly. Here, toxins can accumulate or an oxygen deficiency can occur, causing asphyxiation.

Once the type of risk has been identified, the next step is to understand the degree of severity that would accompany an emergency situation. This information is important when it comes to selecting the appropriate escape respirator. For the purpose of this article, the degree of severity is classified according to the definitions of High, Specific, and Low established by e.g. NIOSH in its document Concept for CBRN Air-Purifying Escape Respirator Standard:

High – Any scenario involving a release or existence of unknown toxic substances in high or unknown concentrations, as well as oxygen-deficient atmospheres (less than 19.5 Vol. %)

Specific – Any scenario involving the release or existence of known toxic substances in any concentration. (Environments with 'Specific' hazards always have sufficient oxygen.)

Low – Any scenario involving the release or existence of known toxic substances in low concentrations. (Environments with 'Low' hazards always have sufficient oxygen.)

Understanding the type and degree of risk will serve as a good foundation for selecting the respirators that are qualified for your applications. However, just because a respirator will work doesn't mean that it's the best choice. You must also consider the pros and cons of all qualified respirators to ensure that you are maximizing safety and reducing cost of ownership. For example, even though a compressed air type of respirator may work for an application, there may be many good reasons to use a smaller, more portable, and less expensive escape device. Ultimately, you can save money and make a workplace safer by evaluating all of the available options.

Identifying the Best Escape Respirator for the Application

Once you have identified the risk, the next step is to identify the correct escape respirator for the application. This is essentially a two-step process: First, narrow down the options to the escape respirators that will provide effective protection. Second, consider the pros and cons of different respirator types to identify the best option. There are a number of widely accepted escape respirator technologies on the market, including:

- Air Purifying Respirators (APR) – including Escape Mouth-bits, Full Face Gas Masks, APR Escape Hoods
- Self contained Emergency Escape Breathing Apparatus (EEBA)
- Pressure demand Supplied Air Respirator (SAR) w/ escape cylinder
- Self Contained Breathing Apparatus (SCBA)

Many of these respirators can be used in multiple applications. This chart summarizes the types of hazards that each technology will protect against.

Type of Harazd & Degree of Severety	Air Purifying Respirator			Supplied Air Respirator	Self Contained Respirator	
	Escape Mouth-bit	Full Face Gas Mask	APR Escape Hood	SAR w/escape cylinder	EEBA	SCBA
Fire Escape			X		X	X
Toxin Release / High Hazard				X	X	X
Toxin Release / 'Specific' Hazard		X	X	X	X	X
Toxin Release / 'Low' Hazard	X	X	X	X	X	X
Atmospheric Volitility / O_2 deficiency				X	X	X
Atmospheric Volitility / Toxic Accumulation		X	X	X	X	X

Attention: To identify the best respiratory protection escape device the local exposure limits of the potential hazard as well must been taken into consideration, e.g. if the exposure limit of a hazard is set at 5 ppm and the potential level of contamination is 60,000 ppm a device with a higher protection factor than 10,000 must be chosen. See below chart for exposure limits for e.g. H_2S

REGIONAL OCCUPATIONAL EXPOSURE LIMIT H_2S

Authority/Country	Description	Time Weighted Average (TWA)	Short term exposure limit (STEL)
NIOSH	REL	10 ppm TWA	15 ppm STEL
OSHA	PEL	20 ppm Ceiling	50 ppm for 10 min
ACGIH	TLV	10 ppm TWA	15 ppm STEL
United Kingdom	WEL	5 ppm TWA	10 ppm STEL
Canada	OEL	10 ppm TWA	15 ppm
Australia	OEL	10 ppm TWA	15 ppm STEL
Germany	AGW	5 ppm	
South Africa		10 ppm TWA	15 ppm STEL
Brazil	OEL	8 ppm (max 48hrs/wk.)	

REL: Recommended Exposure Limit is a level that NIOSH believes would be protective of worker safety and health over a working lifetime

TWA: Time-Weighted Average is the average exposure over a specified period of time, usually a nominal eight to ten hours depending on national regulations

STEL: Short-Term Exposure Limit (is the acceptable average exposure over a short period of time, usually 15 minutes)

PEL: Permissible Exposure Limit is a legal limit in the United States for exposure of an employee to a chemical substance or physical agent

TLV: Threshold Limit Value is a level to which it is believed a worker can be exposed day after day for a working lifetime without adverse health effects

WEL: Workplace Exposure Limit is an upper limit in the UK on the acceptable concentration of a hazardous substance in workplace air for a particular material or class of materials

OEL: Occupational Exposure Limit is an upper limit in Australia on the acceptable concentration of a hazardous substance in workplace air for a particular material or class of materials

AGW: Arbeitsplatzgrenzwert is an upper limit in Germany on the acceptable concentration of a hazardous substance in workplace air for a particular material or class of materials

Pros and Cons of Respirator Types

Each type of respirator has specific pros and cons. Understanding the benefits and drawbacks will help you make informed decisions that will increase safety and reduce your cost of ownership.

ESCAPE MOUTH-BIT OR HALF MASK

KEY FACTS:
Escape time: 5 to 15 minutes
Service intervall: 4 to 12 years (possible with 2 times filter exchange)
Protection performance: up to 2,500 ppm against many industrial gases, up to 10,000 ppm against H_2S

PROS:
- Very small, lightweight, and portable
- Inexpensive
- Provides effective protection against specific toxins (such as organic vapors or acid gases)
- Easy to don

CONS:
- Does not protect the eyes or head
- Prohibits verbal communication
- Cannot be used in O_2 deficient atmospheres
- Does not protect against multiple hazards simultaneously
- Single use only
- Partly shorter shelf life
- Designated as an 'Escape Only' respirator

FULL FACE MASK + FILTER IN A SEALED BAG

KEY FACTS:
Escape time: not specified, depending on the performance of the filter
Service intervall: 6 years, prolongation with each filter exchange
Protection performance: up to 5,000 ppm depending on gase and filter type

PROS:
- Provides protection against higher concentrations of specific hazards
- Provides tight-fitting elastomeric sealing surface
- Enables verbal communication
- Provides eye protection
- Reusable (interchangeable filter cartridge)
- Can be used for more applications than 'Escape Only'

CONS:
- Difficult to carry, store and access in emergency
- Difficult to don quickly
- Cannot be used in O_2 deficient atmospheres
- Not designed as escape unit, approved as working protection equipment

APR INDUSTRIAL /SMOKE ESCAPE HOOD

KEY FACTS:
Escape time: 15 minutes
Service intervall: 5-16 years
Protection performance: up to 2,500 ppm against many industrial gases, up to 10,000 ppm against H_2S

PROS:
- Provides effective protection against specific toxins (such as organic vapors or acid gases)
- Provides protection against higher concentrations of specific hazards
- Can protect against multiple hazards simultaneously
- Cost efficiency alternative to EEBAs in certain applications
- Protects eyes, face and head
- Highly visible and flame retardant
- Enables verbal communication
- Easy to don
- Easy to carry (belt-worn), lightweight
- Low maintenance, and easy to store
- Long service life

CONS:
- Cannot be used in O_2 deficient atmospheres
- Single use only

OXYGENE SELFRESCUER

KEY FACTS:
Escape time: 25-60 minutes
Service intervall: 10 years

PROS:
- Provides protection against higher concentrations of specific hazards
- Acceptable for use in O_2 deficient atmosphere
- Can protect against multiple hazards simultaneously
- Cost effective alternative to EEBAs in certain applications
- Hood versions protect eyes, face and head
- Highly visible and flame retardant
- Enables verbal communication (hood versions)
- Easy to don
- Easy to carry (belt-worn), low maintenance, and easy to store
- Long shelf life

CONS:
- Single use only
- Designated as an 'Escape Only' respirator
- Special regulations for disposal

SAR / ESCBA WITH ESCAPE CYLINDER

KEY FACTS:
Escape time: 10-15 minutes
Service intervall: 10 years
Protection performance: Standard NPF* 10,000 (some manufacturers confirm higher protection factors e.g. Dräger 33,000 for gaseous hazards)

PROS:
- Allows workers to seamlessly switch from supplied air to escape mode without exposure to hazard
- Utilizes positive pressure full-face mask to provide maximum protection from IDLH conditions for 5-15 minutes
- Can be utilized for more applications than 'Escape Only'
- Acceptable for use in O_2 deficient atmospheres and high contaminations
- Reusable

CONS:
- Only practical for applications that require the constant use of SARs
- Apparatus and air supply systems are higher priced and more complex
- Requires consistent maintenance

**Nominal Protection Factor (NPF): Minimal level of protection the equipment has to demonstrate under laboratory conditions to gain approval to the appropriate class of the performance standard.*

EEBA

KEY FACTS:
Escape time: 10-15 minutes
Service intervall: 10 years
Protection performance: Standard NPF* 1,000

PROS:
- Acceptable for use in O_2 deficient atmospheres
- Independent of ambient air
- Continuous flow from the air source provides 5-15 minutes of protection against any harmful gas, vapor or chemical
- Enables verbal communication
- Easy to don and operate- minimal user training
- Reusable
- Automatic activation
- Suitable for use on board ships

CONS:
- Heavy and difficult to carry (cannot be belt-worn) - waist belt accessory for EN available for additional comfort if it is to be used for long periods of work duration
- Designated as an 'Escape Only' respirator
- Requires periodic maintenance
- Higher priced escape device
- Hood material is basic flame retardant - but not for use in fire

**Nominal Protection Factor (NPF): Minimal level of protection the equipment has to demonstrate under laboratory conditions to gain approval to the appropriate class of the performance standard.*

ESCBA

KEY FACTS:
Escape time: 10-15 minutes
Service intervall: 10 years
Protection performance: Standard NPF* 10,000 (some manufacturers confirm higher protection factors e.g. Dräger 33,000 for gaseous hazards)

PROS:
- Maximum protection from hazards for short durations (NPF* 33,000 for gaseous hazards)
- Independent of ambient air
- Enables verbal communication
- Reusable
- Long shelf life
- Due to external air supply wearing time can be extended at muster point with an airline supply
- First breath activation

CONS:
- Heavy and difficult to carry (cannot be belt-worn) - see above
- Designated as an 'Escape Only' respirator
- Requires periodic maintenance
- Higher priced escape device

**Nominal Protection Factor (NPF): Minimal level of protection the equipment has to demonstrate under laboratory conditions to gain approval to the appropriate class of the performance standard.*

SCBA

KEY FACTS:
Escape time: 10-15 minutes
Service intervall: 10 years
Protection performance: Standard NPF* 10,000 (some manufacturers confirm higher protection factors e.g. Dräger 33,000 for gaseous hazards)

PROS:
- Maximum protection from hazards for longer durations (NPF* 33,000 for gaseous hazards)
- Enables verbal communication
- Can be utilized for more applications than 'Escape Only' (including operations and search and rescue)
- Reusable
- Long shelf life

CONS:
- Heavy and impractical to carry (unless being used as a SAR)
- Difficult to don quickly in a emergency situation (especially when not often practiced or used)
- Requires periodic maintenance
- Very high priced escape device

**Nominal Protection Factor (NPF): Minimal level of protection the equipment has to demonstrate under laboratory conditions to gain approval to the appropriate class of the performance standard.*

Training: The Final Step to Creating an Effective Emergency Preparedness Program

Once you have chosen the best respirator for your application, there is one final step that is necessary to turn a good Emergency Preparedness Program into a great one: Training! You can have the best respirator in the world, but it is useless if the users do not know how to put it on. While most people hope they will never have to use an escape respirator, anyone who could potentially need to use one should be trained – regularly and frequently – how to don the device quickly and effectively. It is important to realize that panic can easily take over in an emergency. Donning and using the escape equipment needs to be automatic. Even a few seconds of exposure to some toxins can be catastrophic.

It is also essential to train personnel about the reasons why the escape respirator is necessary in the first place. A healthy respect for the consequences of exposure to a hazard will increase the likelihood that workers will actually use an escape respirator in an emergency.

Solidifying the third step

In summary, by spending the time to choose and deploy the best respirator for your emergency response application, you will support a solid third line of defense that will help protect your workers, and ultimately, your organization's assets: the Emergency Response Plan.

For more information, go to www.draeger.com or contact alexander.gaggin@draeger.com or hans.cray@draeger.com.

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RESOURCES:

CDC article on CO related deaths: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5650a1.htm, Status: 2014/03/28

Editorial on deaths related to smoke inhalation poisoning: http://www.firesmoke.org/2011/06/01/resolution-to-reduce-smoke-inhalation-deaths/, Status: 2014/03/28

OSHA 1910.119 App. C: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9763&p_table=STANDARDS, Status: 2014/03/28

OSHA 1910.38: https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=INTERPRETATIONS&p_toc_level=3&p_keyvalue=1910.38&p_status=CURRENT , Status: 2014/03/28

NIOSH_CDC document: Concept for CBRN Air Purifying Escape Respirator Standard: http://www.cdc.gov/niosh/npptl/standardsdev/cbrn/papr/concepts/paprcon-103004.html, Status: 2014/03/28

Cautions and limitations of Escape respirators: http://www2a.cdc.gov/drds/cel/cl.htm, Status: 2014/03/28

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