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Emergency Response Containment Vessels

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Emergency Response Containment Vessels (ERCV) also known as Salvage Pressure Receptacles (Cylinders) or Cylinder Salvage Containers are designed to completely contain and isolate a leaking gas cylinder have become indispensable ER devices for compressed gas emergency response teams. Some call these cylinder coffins which has a negative connotation, that's why I named them ERCV's a term that has been adopted worldwide.

In the US these are designed and fabricated as ASME pressure vessels with a quick opening flange. It can quickly and safely contain a leaking cylinder and allow it to be safely transported to another location for final mitigation. Over the years, the ERCV's have become a critical tool for ER teams (private and public) to respond to compressed gas incidents involving Toxic, Pyrophoric, Corrosive, Oxidizing or Flammable gases. In some cases, it represents the only convenient option.

ERCVs were originally designed and fabricated by gas suppliers or users for site use over 50 years ago. Each were custom designed by/for the user. They were expensive, difficult to use and difficult to move. To legally transport the leaking gas cylinder in the US, an emergency exemption had to be applied for after the cylinder was contained. This process could take months for approval and in the meantime the cylinder would continue to leak into the ERCV before it could be moved from the site. This increased the potential for the ERCV to leak. This also tied up the ERCV so it would not be available for another emergency.

Typical Site ERCV

For high pressure cylinder containment these used multibolt (20+) flanges that were extremely difficult to tighten evenly and get a seal. In one case it lowered the containment pressure from 2,000 psig to less than 300 psig.

ERCV's Used By NJ DEP after Gollub Explosion 1988

In the early 1980's two ERCV's designed by Sigri Elektrographit, GmBH, a German Company used flange closures that were easier to operate in an emergency, in addition the larger vessel was mounted on a moveable cart. The small unit, TG-12 (13.7 liters) had a screw cap that was easily tightened using a handle and the larger TG 168 (188 liter) had a breach closure. These were designed to TUV pressure vessel specifications and met the requirements of the Hazardous Goods Regulations for Road Transport GGVS/ADR of leaking gas cylinders in Europe.

Sigri ERCV, Model TG-168

A number of these were sold to gas suppliers and users in Europe. Over 20 were purchased in the United States primarily by gas suppliers. These received exemptions in the US from DOT for transportation of leaking gas cylinders (E10151 for TG-168)

I designed two models in 1989 for the Solkatronic Chemicals Inc ER team in Morrisville, PA. Model 5501 was the smaller one with an internal volume of 30.3 liters that could contain up to a 16 liter cylinder

while the larger one Model 5502 was 131 liters in volume and could hold up to a 50 liter high pressure cylinder.

These received US DOT exemptions for use in transporting leaking gas cylinders.

E10504 for model 5502
E10323 for model 5501

Solkatronic ERCV, Model 5502

Since that time over 400 units, primarily model 5502, by Solkatronic have been sold to gas companies, users, waste disposal companies and government agencies worldwide. A larger model 5503 was developed in 2003 for the larger diameter industrial grade low pressure Chlorine and Ammonia cylinders. Air Products and Chemicals acquired Solkatronic Chemicals Inc in 1998 and continues to supply and support the ERCV business.

During this time, the Chlorine Institute also developed a low pressure ERCV in 1988 for use on 150 lb Chlorine Cylinders. This has a pressure rating of 250 psig. The exemption E9781 only authorized its use for Chlorine. Exemption E10987 however extended the use to any gas with a pressure less than 250 psig

Chlorine Institute ERCV

It has a Viton O Ring which must be changed if used for other gases like ammonia or the amines.

In mid 2000 Integrated Environmental Services a waste disposal company also entered the ERCV market. Their large cylinder high pressure ERCV is the HP-10

IES HP-10 ERCV

In 2021, JD Cousins and Chemically Speaking LLC introduced the 1272H.

JD Cousin 1272H ERCV

Worldwide there are many other ERCV designs, however the predominant models used for high pressure gas cylinders are:

- Europe – Sigri TG 168 and Solkatronic/Air Products 5502
- North America - Solkatronic/Air Products 5502, IES-HP-10, JD Cousins 1272H
- Asia – Solkatronic/Air Products 5502 and , JD Cousins 1272H

Since the introduction of the first ERCV almost 50 years ago they have become the primary Emergency Response tool for leaking gas cylinders. They have become invaluable for compressed gas incidents since a properly trained and equipped team can safely and quickly isolate a leaking gas cylinder thus, mitigating the emergency.

Recognizing that ERCV's had been in use without major incident for over 20 years in the US, DOT on Jan. 24, 2005, published final rules titled ***"Hazardous Materials; Incorporation of Exemptions into Regulations"***, Federal Register Vol 70, No.14 pages 3302-3310 removing the requirement for ERCV exemptions. In addition, the hydrotest and inspection period of two years was extended to five years. The regulations are now under 49CFR173.3 Packaging and exceptions. (d) Salvage Cylinders.

Internationally ERCV's have long been recognized as a safe means of transporting a problem cylinder. In 2008 a proposal to authorize ERCV's internationally was submitted to the UN Transport of Dangerous Goods Committee. This was approved in Dec 2010. Relevant sections of the Recommendations on the TRANSPORT OF DANGEROUS GOODS, Model Regulations, Volume II

> 4.1.1.19 Use of salvage pressure receptacles
>
> 4.1.1.19.1 In the case of damaged, defective, leaking or non-conforming pressure receptacles, salvage pressure receptacles according to 6.2.3 may be used.
>
> NOTE: A salvage pressure receptacle may be used as an overpack in accordance with 5.1.2. When used as an overpack, marks shall be in accordance with 5.1.2.1 instead of 5.2.1.3.
>
> 4.1.1.19.2 Pressure receptacles shall be placed in salvage pressure receptacles of suitable size. The maximum size of the placed pressure receptacle is limited to a water capacity of 1000 litres. More than one pressure receptacle may be placed in the same salvage pressure receptacle only if the contents are known and do not react dangerously with each other (see 4.1.1.6). In this case the total sum of water capacities of the placed pressure receptacles shall not exceed 1000 litres. Measures shall be taken to prevent movement of the pressure receptacles within the salvage pressure receptacle e.g. by partitioning, securing or cushioning.

Besides the gas suppliers, the Semiconductor Device Fabrication Industry is the other primary user of ERCV's. A typical semiconductor fabrication facility (Fab) uses a wide variety of gases with various hazards, many of which have multiple hazards. These include:

- Highly Toxic (Arsine Phosphine, Diborane)
- Toxic (Boron Trichloride, Germane
- Pyrophoric (Silane, Methyl Silane, Disilane)
- Flammable (Hydrogen, Methane)
- Oxidizer (Nitrous Oxide, Oxygen)
- Corrosive, Acid (Chlorine, Hydrogen Chloride, Hydrogen Bromide)
- Corrosive, Alkaline (Ammonia)

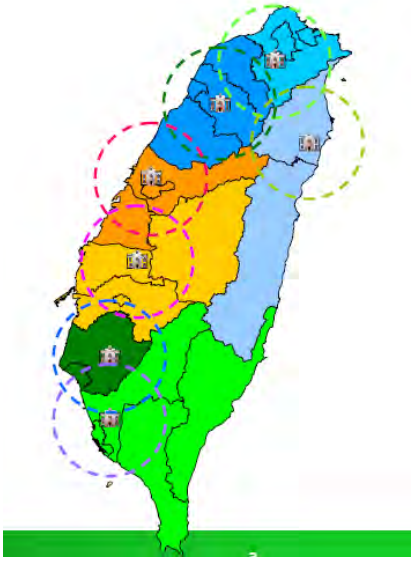
Having a ERCV on site allows the site ER team to quickly isolate a problem cylinder and allow the supplier to then arrange for the transportation offsite. This minimizes the shutdown of a $5 billion Fab which cost millions per day to operate. Most Fabs have established a best practice to have at least one ERCV at each site for use by the site ER team. Many have 2 or more.

Recognizing this value in an emergency, the Uniform Fire Code in 1990 recognized an exception of having an ERCV onsite and a trained ER team by allowing its use in place of having a leaker gas cabinet and scrubber. This exception has been continued in the International Fire Code which replaced the UFC as well as NFPA.

Some public agencies have ERCV's

FDNY ERCV and Cherry Hill FD ERCV

All seven of the Taiwan EPA funded regional Chemical Emergency Response Teams have a 5502 ERCV.



Taiwan ER Teams

ERCV Availability

Having ready access to an ERCV is key part of emergency planning. When they were first developed in the 1980's there were not many worldwide.

At Solkatronic we had a 40' cylinder trailer that made a weekly trip from the Morrisville, PA manufacturing site to the Phoenix warehouse. In an emergency we could dispatch an ER Team to the location of an incident however getting a 5502 ERCV there could be a challenge. This is the reason why and enclosure was fabricated for the trailer to hold a 5502 ERCV.

ERCV Enclosure on Cylinder Trailer

To support our customers and ER teams worldwide a custom built 5502 ERCV enclosed in a aircraft suitable shipping crate was located in the Phoenix warehouse that could be airfreighted anywhere in the world.

ERCV In Air Cargo Crate

Problems:

A common problem is forgetting to remove the leaking cylinder from the ERCV. In one emergency response that I was involved in, a team brought an ERCV to the incident only to find that there was a leaker still inside!

Leaking HCl Cylinder in 5502 ERCV after 1 year

Securing the ERCV properly to the vehicle is another common problem. Many users mistakenly believe the brakes will hold it in place during shipment. Serious damage has occurred during transit

Damaged ERCVs from Transport

The Jan 2013 BF_3 incident in Taiwan was due to a local company copying the design of the 5502 ERCV but the door did not have any flange safety nuts. In addition, the gas supplier ER team did not secure cylinder. As a result, the cylinder slid back and forward as it was being driven 40 km to their site causing the cylinder cap to spin off. This allowed the cylinder valve to be impacted many times until it badly damaged it causing it to leak heavily. It fully pressurized the ERCV with BF_3 to a pressure of 600 psig. Since the copycat ERCV had no flange safety nut, this pressure was not detected when they tried to open the ERCV. The sudden release of pressure ripped off the door propelling it over 100 ft.

BF_3 Cylinder Containment, Taiwan Jan 2013

In Jan 2004 a Fab ER Team used a new 5502 ERCV to contain a ClF_3 cylinder that they didn't realize had the valve wide open. Use of a ERCV for strong oxidizers like ClF_3 is prohibited by the procedures since the ERCV cannot be cleaned and passivated. As the flange was being closed the ClF_3 immediately started to react with the O Rings and Seal. The ER Team panicked and pushed it out into the parking lot where the leaking ClF_3 liquid proceeded to burn a hole through the carbon steel. The reaction was so hot that it charred the epoxy paint.

ERCV With ClF_3 Liquid Reacting With Carbon Steel

Questions:

How long will they last?

ERCV's over the last 40+ years have demonstrated that they can safely contain and transport leaking gas cylinders. With proper care, ERCV's can last for a long time. The first 2 that I had fabricated in 1989 are still in service.

Two have been destroyed in facility fires, one 5502 ERCV went through 2 gas facility fires was rebuilt and tested the first time and then burned again. Another was destroyed in a waste disposal facility lithium battery fire.

At least three Sigri ERCVs had to be cut open and scrapped because the leaking HCl caused the breach closure door to gall since they were exposed to HCl for an extended period of time.

The leaking cylinder will be empty before the ERCV is used.

Not likely, outside of a catastrophic failure (rupture) of the cylinder such as due to a severe physical impact it will take some time for the gas to leak out of the cylinder. In the rare event of a leak during use it would be very small, in the order of 0.1-10 cc/min. (Bubbler)

Bubbler Leak 0.1 – 10 cc/min

Soap solution is the most common leak detection method for gases and the lowest detection limit for soap solution is a leak rate of 0.1 cc/min (Foamer). A full Hydrogen Chloride cylinder (60 lbs) contains 17,900,00 cc of gas. At this leak rate it would take **340 years** to empty! Needless to say it would not be practical to leave it in the ERCV until it empties. Even a leak 100 times larger (10 cc/min) would take 3.4 years.

Even a violent physical event for a cylinder may not develop a leak rate significant enough to empty the cylinder in a short time. For example, if one assumes a worse case event of someone opening a cylinder valve fully on a Hydrogen Chloride cylinder containing 60 lbs of liquid, only a third (20 lbs) of the liquid would be vented within the first few minutes. The remaining (40 lbs) would be subcooled by the vaporizing liquid and would take more than a day to completely empty even if the valve remained open. This would be true even if the valve were to somehow be removed from the cylinder.

The user must be careful not to exceed the pressure rating of the ERCV.

The most common ERCV's in use (Solkatronic 5502 or Sigri TG-168) are designed to hold a high pressure 50 liter cylinder has a working pressure of 1100 & 1047 psig respectively. These have an internal volume of 133 liters & 168 liters. A leaking 50 liter cylinder containing full 2400 psig pressure will equalize in the ERCV to a pressure less than 1000 psig since the internal volumes of the ERCVs are more than 2.5 times that of the cylinder. This will be less than the working pressure of the ERCV. The highest pressure liquefied gas that would be contained in a ERCV is Hydrogen Chloride, which has a vapor pressure of 635 psig. This is well below the working pressure of the ERCVs.

Only in the case of a lower pressure rated ERCV (i.e. Chlorine Institute) would pressure become an issue.

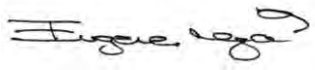
Why can't the gas be vented at the location rather than moved?

Typically, most user locations are not setup to scrub and neutralize the entire contents of a gas cylinder, they just want the leaking cylinder to be taken off site as soon as possible. Even if this was the case, it would require a large scrubber that can handle a large flow rate and of sufficient capacity to absorb the heat of reaction. In addition as noted earlier a large gas cylinder containing a liquefied gas such as Chlorine would take 2 days to vaporize the contents of the cylinder even if the valve was completely open due to subcooling of the liquid as the vapor is vented.

Opening the ERCV to offload the leaking cylinder requires special protocols and a high capacity ventilation system to capture the gases released when the flange is opened.
These special types of facilities are typically located at a gas supplier or waste disposal company site. In some cases these are located overseas. For many countries in Asia these facilities do not even exist. It is safer and more efficient for the gas suppliers or waste disposal companies to handle the leaking cylinder at their facility.

In some cases it might make more sense to collect and repurify the gas rather than disposing of it. Only these special facilities have the experienced personnel to make this decision and the equipment to do it.

UN Approval For Ocean Transport
In some cases the ERCV must be moved from Asia to North America or Europe for mitigation. Since Air Cargo is prohibited, the only other mode would be water. This need was recognized by DOT when Special Permit SP14168 authorizing the transportation of ERCV's by cargo vessel was issued on Nov 2005. This has also been approved the UN TDG in Dec 2010.



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