



Safety Best Practices and Security Management

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The Chlorine Institute



CloroSur
2022

COSTA DO SAUÍPE



The Chlorine Institute's Mission



The Chlorine Institute exists to support the chlor-alkali industry in advancing safe, secure, environmentally compatible, and sustainable production, distribution, and use of its mission chemicals*.

The Chlorine Institute accomplishes its mission by:

- 1.Improving the safety, human health and environmental protection performance of chlor-alkali producers, packagers, distributors, and users.
- 2.Fostering the development of regulations that support the achievement of continuous improvement and voluntary mechanisms that preclude the need for new government regulations.
- 3.Positioning the Institute as an authoritative and credible source of technical and safety related information and emergency response procedures to prevent and mitigate the release of chlorine and other mission chemicals.

**CI's mission chemicals: chlorine, sodium and potassium hydroxides, sodium hypochlorite, the distribution of vinyl chloride monomer (VCM), and the distribution and use of hydrogen chloride.*



Safety First

The 10 WCC Cardinal Rules

1. Remain in safe concentration range for hydrogen in chlorine
2. Use titanium only with wet enough chlorine
3. Ensure low moisture content for dry chlorine handling and uses
4. Control chlorine maximum temperature to avoid iron fire
5. Avoid contact between chlorine and organics
6. Avoid formation/concentration of nitrogen trichloride
7. Write operating procedures/Manage the changes
8. Ensure sufficient training/information of all personnel
9. Prepare and test emergency response plans
10. Do not forget incidents investigation and experience sharing

Use titanium only with wet enough chlorine

Never Expose Titanium to Dry Chlorine*

If the chlorine is not wet enough, the titanium will burn !



< 0.4wt% H₂O

Low temperatures reduce the moisture content

High pressures reduce the moisture content

High surface areas *increase* the required moisture content

- ⇒ Monitor the temperature
- ⇒ Add water vapour if necessary
- ⇒ Do not mix up stainless steel and titanium !

Gaseous chlorine pipeline explosion



Titanium thermometer well in dry chlorine !



Avoid contact between chlorine and organics

Non fully halogenated organic compounds can react exothermically with chlorine, causing iron fire ...

- ⇒ Degrease equipment completely where possible
- ⇒ Use only greases and oil fully compatible with chlorine where a contact is not impossible
- ⇒ Avoid any possible backflow from user's plant

Refer to CI Pamphlet 6) *Piping Systems for Dry Chlorine* and
CI Pamphlet 164) *Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials*

Avoid contact between chlorine and organics



Video of
Chlorine +
Oily Rag

The consequences of a chlorine – organics reaction can be disastrous !



Avoid formation/concentration of nitrogen trichloride

- Reaction of nitrogen compounds in electrolysis cells to form NCl_3 (very strong explosive)
- Unstable oily product, less volatile than chlorine: accumulates where liquid chlorine is vaporised
- ⇒ Check all possible sources (salt, added water / HCl / caustic soda, ammonia from cooling systems ...)
- ⇒ Eliminate nitrogen compounds from the brine
- ⇒ Analyze periodically the brine and the chlorine or measure NCl_3 continuously in gas phase
- ⇒ Destroy NCl_3 before reaching too high concentration
- ⇒ Bulk shipping containers should not be unloaded in the gas phase (CI Pamphlet 66)

Refer to CI Pamphlets:

21) *Nitrogen Trichloride - A Collection of Reports and Papers*

152) *Safe Handling of Chlorine Containing Nitrogen Trichloride*

Explosion in chlorine pipeline !



Case Study: Accidental Mixing of Sodium Hypochlorite + Ammonium Sulfate

- Delivery of ammonium sulfate pumped into sodium hypochlorite storage tank
- There were concerns that nitrogen trichloride, a reactive byproduct was still present, days after the explosion occurred
- The roof was damaged due to the explosion



Damage to the roof of the Greenbrook Pumping Station can be seen Thursday, the day after an explosion there.

CI and Euro Chlor Resources



- Pamphlet 6) *Piping Systems for Dry Chlorine*
- Pamphlet 66) *Recommended Practices for Handling Chlorine Tank Cars*
- Pamphlet 100) *Behavior And Measurement Of Moisture In Chlorine*
- Pamphlet 164) *Reactivity and Compatibility of Chlorine and Sodium Hydroxide with Various Materials*

<https://bookstore.chlorineinstitute.org/>



- GEST 73/25 – Transfer Of Dry Chlorine By Piping Systems
- GEST 79/79 – Transfer Of Liquid Chlorine By Padding With A Chlorine Compressor
- ANALYTICAL 13 – Determination Of Moisture In Dry Gaseous Chlorine

<https://www.eurochlor.org/technical-safety/technical-documentation/document-search/>



Security Management

Detection – Start with Your People

Detection starts with training:

- Awareness
- How to report
- How to respond to suspicious activity

Trained employees and contractors execute the security plan by reporting suspicious activity



Identifying Suspicious Activities

What to report: Any suspicious activity, event, or anomaly that warrants a reaction, response, or investigation.

Who Reports: Everyone in the chemical industry, from retailers, manufactures, distributors, storage facilities, and end users, needs to be aware of any and all suspicious activities

Identifying Suspicious Activities

Examples:

- Frequent “False” Alarms
- Document Discrepancies
- Cash Payment request
- Loss of Keys, Data, Codes, or Personnel Information
- Security Probing
- Fence Holes or Property Vandalism
- Customers Who Don’t Fit Your Standard Customer Base
- Unusual Inquiries about Chlorine
- Hacking Attempts
- Alarm/Control System Failures



Detection and Technology

Detection technology that works best is specific to the site and assets to be protected. Some options include:

- Cameras
- Intrusion detection on doors and other access points
- Chemical monitors
- Motion detectors
- GPS Units

Be ware of false positives, such as a motion detector sensitive to wind

Chlorine Tank Car GPS Units

Examples: Used for safety and security measures



Security Resources

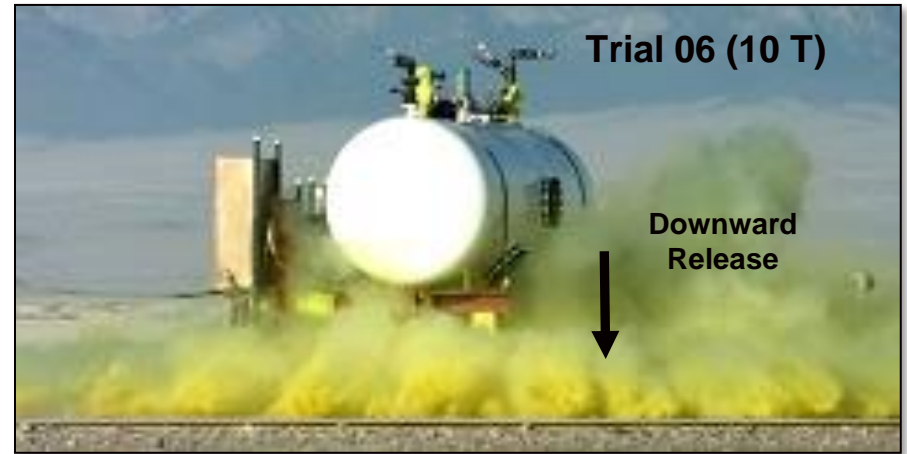
- Chemical Facility Anti-Terrorism Standards (CFATS)
<https://www.cisa.gov/cfats-laws-and-regulations>
- NIST Cybersecurity Framework
<https://www.nist.gov/cyberframework>



Jack Rabbit Chlorine Release Trials

Jack Rabbit Chlorine Release Trials

- Series of large-scale, controlled releases of chlorine conducted by the US government
- Chlorine is not an ideal gas due to its high density
- The purpose of the tests was to observe chlorine's fluid flow characteristics
- The releases took place in 2010, 2015, and 2016



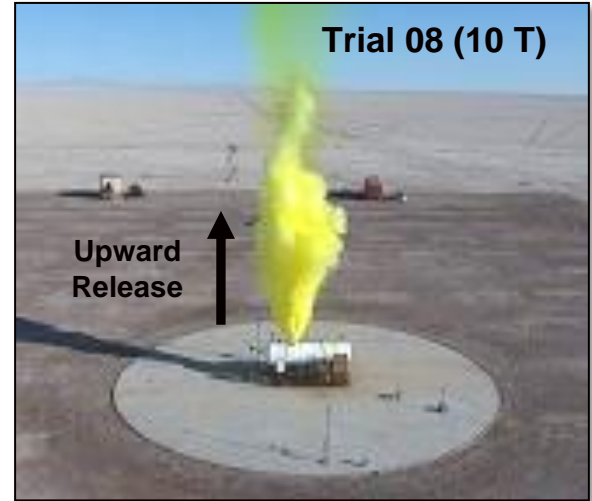
Jack Rabbit Chlorine Release Trials

Terabytes of data were generated

This resulted in:

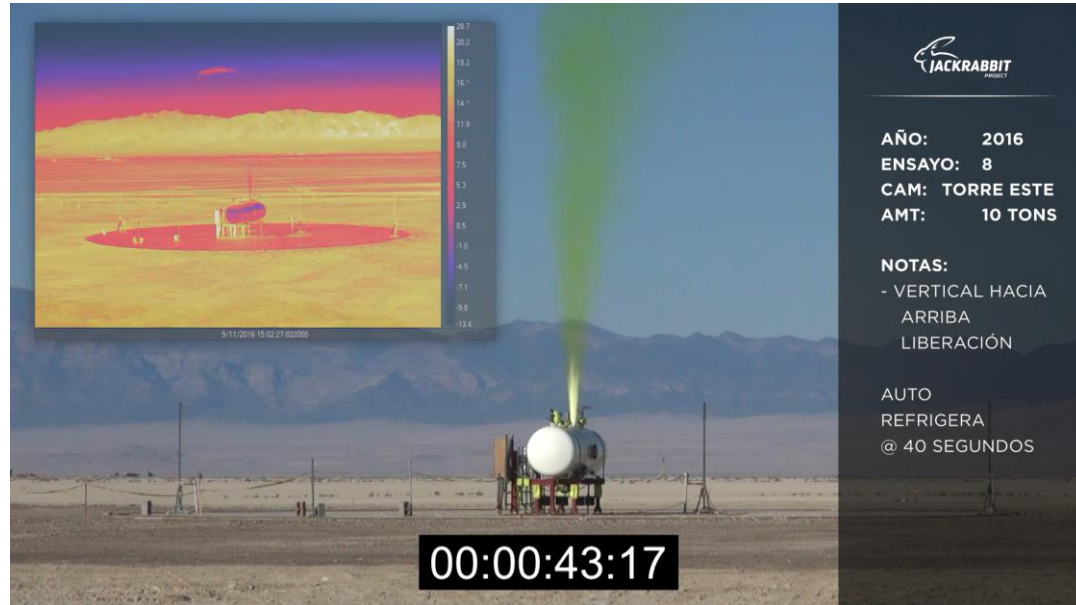
- Academic papers*
- Pamphlet 74) Guidance on Estimating the Area Affected by a Chlorine Release
- JRCL2-VIDEO) Jack Rabbit: Chlorine Properties

* <https://www.sciencedirect.com/journal/atmospheric-environment/special-issue/10FRFPWRB27>



Jack Rabbit Chlorine Release Trials

JRCL2-VIDEO) Jack Rabbit: Chlorine Properties
¡ahora disponible en español!



JACKRABBIT PROJECT

AÑO: 2016
ENSAYO: 8
CAM: TORRE ESTE
AMT: 10 TONS

NOTAS:
- VERTICAL HACIA ARRIBA
LIBERACIÓN

AUTO REFRIGERA
@ 40 SEGUNDOS

00:00:43:17

<https://www.chlorineinstitute.org/videos/jack-rabbit-chlorine-properties/jack-rabbit-chlorine-properties-spanish/>

A tropical landscape featuring a body of water in the foreground, a line of palm trees on a small island in the middle ground, and a blue sky with white clouds. A large, curved yellow banner is overlaid on the image, containing the text.

¡Obrigado!
¡Muchas Gracias!

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