THE CHLORINE INSTITUTE

Pamphlet 57

Emergency Shut - Off Systems for Bulk Transfer of Chlorine

Edition 5 - Revision 1

A LEGACY OF 1924 since SAFETY STEWARDSHIP

March 2009

Table of Contents

1. INTRODUCTION

1.1 SCOPE

This pamphlet provides recommended practices for emergency shut-off protection during chlorine transfers involving bulk containers. This pamphlet illustrates a basic shut-off system. For the purposes of this pamphlet the term bulk containers include tank cars and cargo tanks.

The concepts behind this design include:

- automatic shut-off upon container movement or utility failure.
- ability to activate the system at the tank or remotely for any reason, including a chlorine leak.

The pamphlet includes practical design options for a variety of industry accepted systems.

1.2 CHLORINE INSTITUTE STEWARDSHIP PROGRAM

The Chlorine Institute, Inc. exists to support the chlor-alkali industry and serve the public by fostering continuous improvements to safety and the protection of human health and the environment connected with the production, distribution and use of chlorine, sodium and potassium hydroxides, and sodium hypochlorite; and the distribution and use of hydrogen chloride. This support extends to giving continued attention to the security of chlorine handling operations.

Chlorine Institute members are committed to adopting CI's safety and stewardship initiatives, including pamphlets, checklists, and incident sharing, that will assist members in achieving measurable improvement. For more information on the Institute's stewardship program, visit CI's website at www.chlorineinstitute.org.

1.3 DEFINITIONS AND ABBREVIATIONS

In this pamphlet, the following meanings apply unless otherwise noted:

CFR	Code of Federal Regulations
chlorine	dry chlorine, either gas or liquid
DOT	U.S. Department of Transportation
dry air or nitrogen	air or nitrogen dried to a dew point of -40°F (-40°C) or below measured at the operating pressure; for ambient temperature below 10°F (-12°C), lower dew point settings will be necessary

fail-safe	design redundancy that will permit the isolation valves to close in the event that the utility supplied by the loading/unloading facility to operate the isolation valves is unavailable for any reason
Institute	The Chlorine Institute, Inc.

1.4 SAFETY PROGRAMS

Every site handling chlorine should have an on-going safety program. Periodic training sessions and safety inspections must be conducted in accord with government regulations. Special attention should be directed to the appropriateness of emergency procedures and to equipment to be used in an emergency. Additional information on safety programs is available from the Institute and from chlorine suppliers.

1.5 DISCLAIMER

The information in this pamphlet is drawn from sources believed to be reliable. The Institute and its members, jointly and severally, make no guarantee and assume no liability in connection with any of this information. Moreover, it should not be assumed that every acceptable procedure is included or that special circumstances may not warrant modified or additional procedures. The user should be aware that changing technology or regulations may require a change in the recommendations herein. Appropriate steps should be made to ensure the information is current when used. These suggestions should not be confused with federal, state, provincial, municipal or insurance requirements, or with national safety codes.

1.6 APPROVAL

The Institute's Transportation Issue Team approved Edition 5 on March 24, 2009.

1.7 REVISIONS

Suggestions for revision should be directed to the Secretary of the Institute.

1.7.1 Significant Revisions in Current Edition

Significant updates in this revision as approved include:

- Updates to formatting and terminology throughout
- Elimination of references to Barge Pamphlet 79 which has been discontinued
- Addition of Section 3.5 with recommendations for engineered breakpoints
- Modification of figure 3-1
- Update of the pamphlet checklist

1.8 REPRODUCTION

2. GENERAL

2.1 LOADING AND UNLOADING OF CHLORINE BULK CONTAINERS

2.1.1 Tank Cars

CI Pamphlet 66 should be consulted for industry recommendations and government requirements for loading and unloading of tank cars.

2.1.2 Cargo Tanks

CI Pamphlet 49 should be consulted for industry recommendations and government requirements for loading and unloading of cargo tanks and portable tanks in the highway mode.

2.1.3 Barges

Barge shippers should be consulted for their recommendations and government requirements for loading and unloading of chlorine barges.

2.2 PERSONAL PROTECTION

CI Pamphlet 65 should be consulted for personal protective clothing and respiratory protection.

2.3 TRAINING

There should be a documented procedure for the installation testing and maintenance operation of the emergency shut-off system.

3. TRANSFER SYSTEM DESCRIPTION

3.1 PURPOSE

The purpose of an emergency shut-off system is to provide a positive means to isolate both sides of the flexible transfer connections attached to the bulk chlorine container. A well-designed and maintained emergency shut-off system significantly reduces the potential for a failure in any of the transfer connections to impact people or the environment by minimizing or eliminating the release of chlorine in the event of any failure in the transfer connections. The emergency shut-off system must be operational during each transfer. Relying upon the container's excess flow valves for shut-off protection is not recommended.

3.2 THE TRANSFER SYSTEM

A typical transfer system is illustrated in Figure 3-1. The purpose of this figure is to illustrate concepts; detailed designs will vary due to specific location requirements. The transfer system consists of the chlorine-containing components connecting the bulk container to the fixed process piping. Components of the transfer system include:

- Flexible Connector

  Hoses or copper loops allow for variations in alignment between the fixed piping and the container. These are described in CI Pamphlet 6.

- Manual Valves

  Manual valves are positioned for isolation of automatic valves and to facilitate venting and purging. The angle valve on the container serves as the isolation valve at one end. Valves are described in CI Pamphlet 6.

- Angle Valve Connector

  This is a nominal 15 inch long section of one-inch pipe threaded at one end to connect to the angle valve allowing pipe connection outside the protective housing in accordance with CI Pamphlet 66.

- Expansion Protection

  If liquid chlorine can be trapped between two valves, thermal expansion protection capabilities should be in place in accordance with CI Pamphlet 6.

- Evacuating/Purging

  A means of evacuating/purging the lines in the transfer system must be provided.

- Engineered Breakpoint - See Section 3.5 for details.

- Pressure Indication

  Local pressure indicators should be provided to facilitate operation and line breaking.

- Atmospheric Monitoring Equipment

  Atmospheric monitoring equipment should be provided in accordance with appropriate regulations and or plant practice. Reference is made to CI Pamphlet 73 for design, installation, maintenance and selection of a chlorine monitoring system

- Emergency Shut-Off System

  The emergency shutoff system consists of components and controls that provide means to positively isolate both ends of all flexible connectors connected to a bulk chlorine container. It provides means to automatically close the isolation valves if the container moves excessively and to manually activate the system.

3.3 EMERGENCY SHUT-OFF SYSTEM - PRINCIPLE OF OPERATION

During the unloading or loading of the chlorine container, automatic isolation valves in the liquid and vapor piping are in the open position, which allows the flow of liquid chlorine, chlorine vapor, or padding/venting gas. Control of isolation valves during routine transfer is covered in other pamphlets.

Upon excessive container movement or manual system activation the isolation valves at both ends of the flexible connector portion of the liquid and vapor lines automatically close. These valves should be located in close proximity to the flexible hoses at the loading rack to minimize the amount of chlorine released in the event of a hose failure. When it is desirable to remove chlorine from the piping system, the operator may open the evacuation/purging system.

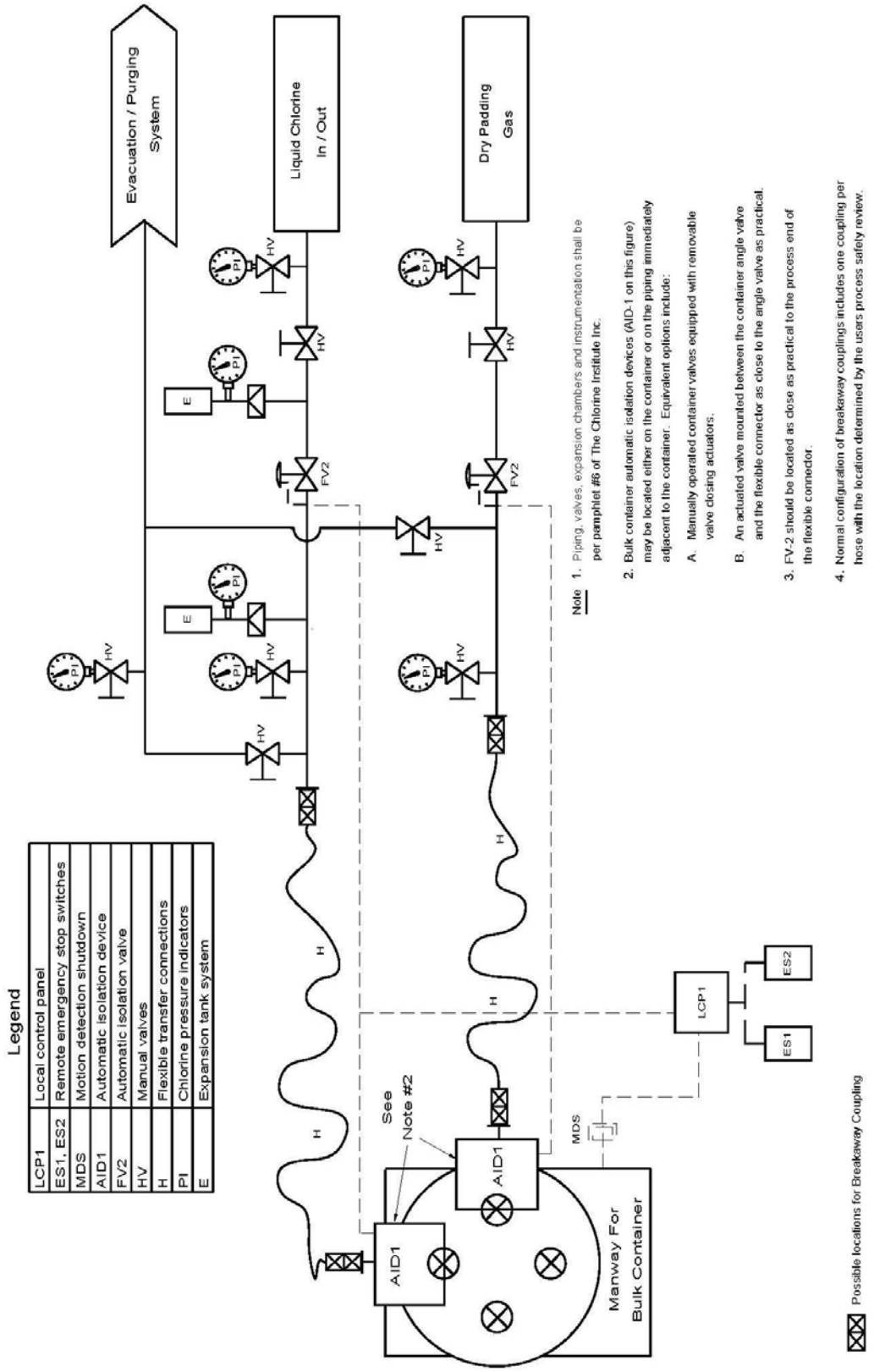
The system should be designed to close the isolation valves rapidly. The time to close the valve should be appropriate for the system design. Experience with current available technology has shown that this can typically be accomplished within 8 to 10 seconds of activation.

3.4 COMPONENT DESCRIPTION - FIGURE 3-1

Following are comments on the key components of the emergency shut-off system that is part of the transfer system outlined in Figure 3.1. The comments are intended to offer guidance on the system function rather than to dictate details.

3.4.1 LCP1 - Local Control Panel

LCP1 is the local control panel at the transfer platform that contains the system startup and emergency control. It receives input from the motion detector and stop switches and activates the isolation valves. The logic in this panel may be performed by a plant-wide control system.



Typical Transfer System With Emergency Shutoff Operation

Figure 3-1

3.4.2 ES1 and ES2 - Remote Emergency Stop Switches

At least two remote emergency stop buttons should be located strategically to shut down the system.

3.4.3 MDS - Motion Detection System

A motion detection sensor will indicate movement of the container and initiate emergency shutdown. There are two main technologies to meet this requirement:

a) Infrared Reflector System – The source is placed near the car and a reflector is placed on the car. Any movement of the car will break the beam, initiating the emergency shutdown. Other technologies that accomplish the same result, such as laser or microwave, are also acceptable. This technology typically has the advantage of initiating the shutdown system with minimal car movement.

b) Physical System – One end of a chain or cable is connected to the car and the other is connected to a magnetic switch or to pneumatic tubing connected to a pressure switch. When the car moves, the chain or cable pulls the magnet off the magnetic switch or the tubing is broken, reducing the pressure, initiating the emergency shutdown. It is important to ensure the chain or cable length is less than the hose length.

Alternatively, the installation of motion prevention systems through chocks with instrumentation is acceptable.

3.4.4 AID-1 - Automatic Isolation Device

The automatic isolation device is used to isolate the transfer hose from the container. The automatic isolation device closes with the activation of the emergency shut-off. There are two types of isolation devices (AID-1) that can be used to isolate the bulk container:

- Manually operated closing actuators attached by the user to the container valves equipped with removable valve closing actuators

- A user provided automated valve mounted between the container angle valve and the flexible connector as close to the angle valve as practical

3.4.5 FV2 - Automatic Isolation Valve(s)

An automated fail-safe isolation valve is used to isolate the flexible connector from process piping. The valve should be located as close to the flexible connector as possible in the loading rack area. The location of this valve is important in determining the potential amount of chlorine that could be released should a flexible hose fail. Table 1 details the amount of chlorine contained in various pipes.

Table 1. Liquid Chlorine Temperature at 32°F

Pipe Size	Pounds of Chlorine/Foot
1 inch, Sch 80	0.46
1 ½ inch, Sch 80	1.12
2 inch, Sch 80	1.88
2 inch, Sch 40	2.13

The piping system should be designed so that any failure caused by container movement will occur between the valve and AID-1. There may be situations where loading or unloading must be done using two chlorine lines in parallel. If this mode of operation is contemplated, the design should provide for means to prevent flow from one hose backing up into and releasing from a failed hose. Periodic process hazard reviews should address single and multiple hose failure scenarios.

3.4.6 Auxiliary Equipment

Auxiliary equipment may be installed to alert personnel to manually activate the system or directly interlock to activate the system. These include atmospheric monitoring systems, video monitoring, low loading line pressure monitoring or derailer position sensors. The decision to interlock these additional features should be based on site specific risk analysis.

3.5 ENGINEERED BREAKPOINTS

Because flexible transfer connections such as chlorine hoses or copper loops are not necessarily the mechanical weak point of a chlorine transfer system, it is recommended that chlorine unloading systems should include engineered breakpoints that will protect the chlorine piping system from forces applied when a connected tank car, cargo tank, or barge is moved or pulled away. An engineered breakpoint design should meet the following criteria:

- An engineered breakpoint should be capable of trouble free service without maintenance for approximately one year in chlorine service
- Materials of construction must be suitable for use in dry liquid chlorine service
- Force required to separate an engineered breakpoint should be less than force required to bend or damage chorine piping, other piping components, or supporting structures

- An engineered breakpoint must be located (See Fig. 3-1) such that the emergency shut-off system will still function effectively when the engineered breakpoint is compromised or separates

- An engineered breakpoint should be included within each line extending from connected chlorine shipping containers, i.e., each loading/unloading line as well as any gas pressure padding lines

3.5.1 Breakaway Couplings

Breakaway couplings are one form of an engineered breakpoint that has been developed and meets the criteria outlined in Section 3.5.

Testing of breakaway couplings was conducted by a Chlorine Institute task group. Results of the testing are documented in a report available from the Chlorine Institute.

Periodic inspection and maintenance of breakaway couplings should be at a minimum in accordance with the manufacturer's recommendation.

Location Considerations

- Only one breakaway coupling is required per hose. The installation location of the breakaway coupling in the piping system should be determined by the owner and should allow for adequate visual inspection and maintenance access. The location must be between the automatic isolation devices located upstream and downstream of the flexible connector. Possible locations are depicted in Figure 3-1. The breakaway coupling can be located on either side of the flexible connector.

- If a breakaway coupling is not mounted to the angle valve connector of a rail car, the chlorine flexible connector should be short enough to not touch the ground after a pull-away to prevent potentially breaking the angle valve connector and/or automatic isolation device on the railcar.

- Thermal expansion of chlorine should be considered if the breakaway couplings contain shut-off devices internally which may trap liquid chlorine between the device and an automatic isolation device (AID-1 or FV2). System design and/or procedures should insure trapped liquid chlorine will not cause the automatic isolation device to fail.

3.5.2 Other Engineered Breakpoints

Engineered breakpoints that are different from the breakaway couplings that have been tested in chlorine service are not precluded by the recommendations of this pamphlet provided they meet the criteria in Section 3.5.

3.6 INTEGRATION AND RELIABILITY

The component assembly should be in accordance with CI Pamphlet 66 for tank cars and CI Pamphlet 49 for cargo tanks. Removable air-motor actuators are not fail close. Installation generally requires air accumulators and sufficient hose length to allow the valve to close within a specified bulk container movement distance.

The emergency shut-off system shall be thoroughly tested at least annually to assure system reliability. Each facility should have a documented testing program. The program shall be structured so that the entire system is tested and shortcomings found during testing shall be corrected through system repair/modification or more frequent preventative maintenance.

The operation of AID-1 and FV2 should be checked at each loading or unloading operation as part of the facility's normal operating procedure.

Each facility shall, within its emergency plan, provide the ability to manually access the container valves in the event of emergency shut-down system failure.

4. REFERENCES

4.1 INSTITUTE PUBLICATIONS

Pamphlet #	Title
1	*Chlorine Basics (Formerly The Chlorine Manual)*, ed. 7; Pamphlet 1; The Chlorine Institute: Arlington, VA, **2008**.
6	*Piping Systems for Dry Chlorine*, ed. 15; Pamphlet 6; The Chlorine Institute: Arlington, VA, **2005**.
49	*Recommended Practices for Handling Chlorine Bulk Highway Transports*, ed. 9; Pamphlet 49; The Chlorine Institute: Arlington, VA, **2009**.
65	*Personal Protective Equipment for Chlor-Alkali Chemicals*, ed. 5; Pamphlet 65; The Chlorine Institute: Arlington, VA, **2008**.
66	*Recommended Practices for Handling Chlorine Tank Cars*, ed. 4, Revision 1; Pamphlet 66; The Chlorine Institute: Arlington, VA, **2009**.
73	*Atmospheric Monitoring Equipment for Chlorine*, ed. 7; Pamphlet 73; The Chlorine Institute: Arlington, VA, **2003**.

4.2 DOT REGULATIONS

4.2.1 *Code of Federal Regulations*; Title 49; Office of the Federal Register National Archives and Records Administration. U.S. Government Printing Office: Washington, DC, (revised annually).

4.3 NFPA PUBLICATIONS

4.3.1 *National Electric Code*; NFPA 70; National Fire Protection Agency: Quincy, MA, **2002**.

4.4 FURTHER ASSISTANCE

For further assistance and information on items referenced, contact:

Superintendent of Documents
Government Printing Office
Washington, D.C 20402
202-512-0000
www.access.gpo.gov

Director, Office of the Federal Register
National Archives and Records Administration
Washington, D.C. 20408
1-866-272-6272
301-837-0483 (fax)
www.archives.gov

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02269-9101
617-770-3000
617-770-0700 (fax)
www.nfpa.org

Transport Canada
Transport Dangerous Goods
330 Sparks Street, Mailstop: ASD
Ottawa, Ontario K1A 0N5
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888-675-6863
613-954-4731 (fax)
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CHECKLIST

This checklist is designed to emphasize major topics for someone who has already read and understood the pamphlet. Taking recommendations from this list without understanding related topics can lead to inappropriate conclusions.

Place a check mark (✓) in the appropriate box below:

Yes	No	N/A		
❒	❒	❒	1. Are the recommended practices for emergency shut-off protection in use for cargo tanks and tank cars?	{1.1}
❒	❒	❒	2. Does the emergency shut-off system isolate both sides of all of the flexible transfer connections?	{3.1}
❒	❒	❒	3. Do the components of the transfer system meet the material recommendations contained in Pamphlet 6?	{3.2}
❒	❒	❒	4. Are the automatic isolation devices (AID-1) on the container valves or immediately adjacent to the container?	{Figure 3-1}
❒	❒	❒	5. Do the isolation valves close within 10 seconds of activation?	{3.3}
❒	❒	❒	6. Does the isolation system have at least two remote buttons?	{3.4}
❒	❒	❒	7. Is a procedure in place to properly maintain and frequently test the system as well as the components?	{3.5}
❒	❒	❒	8. Are engineered breakpoints in use?	{3.5}

REMINDER:

Users of this checklist should document exceptions to the recommendations contained in this pamphlet.

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