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CHLORINATION OPERATIONS MANUAL

Nukus and Urgench, Uzekistan

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Section 1
Introduction

1.1. Overview

The chlorination system equipment, materials and training provided are part of the activities included in the Memorandum of Understanding executed on 20 April 1994 between the Government of the United States and the Government of Uzbekistan. These activities are part of the Aral Sea Program financed by the Government of the United States through the U.S. Agency for International Development (USAID) and implemented by the Environmental Policy and Technology Project (EPT).

The Aral Sea Program is intended to provide technical assistance and material for improvements in potable water quality through a series of activities that include water monitoring improvements (laboratory equipment and materials), water quality improvements (chlorination equipment), water delivery improvements (pump station pumps and motors), and educational improvements (public health and sanitation program). This Training Manual summary has been prepared for the technical training associated with the provisions of the chlorination system. This summary is organized as follows:

I. Overview:	This section presents an overview of the history of chlorination and a summary of the physical properties of chlorine.
II. Installed System Description:	This section presents a summary of the description of the various components of the installed chlorination system and the start-up and shut-down procedures for the chlorination system.
III. Safety:	This section includes a summary of the safety precautions and emergency procedures related to the chlorination system.

1.2. The History of Chlorine

The earliest annals of chemistry mention chlorine compounds. In 77 A.D., Pliny the Elder published one of the first practical collections of chemical reactions. We know that his formula for gold purification generates hydrogen chloride. But over 800 years passed before written records show that the Arabs had learned to react that gas with water to produce hydrochloric acid.

Around 1200 A.D., alchemists discovered that a mixture of hydrochloric and nitric acids dissolved gold. This procedure generates chlorine, but there is no record that any notice was taken of the heavy greenish gas. In 1630, Belgian Jean Baptiste van Helmont wrote of a salt gas that we know contained chlorine, but it wasn't until 1774 that Swedish apothecary, Carl Wilhelm Scheele, generated, collected and studied chlorine.

In the 1823 Michael Faraday produced definitive work on both the electrolytic generation of chlorine and the ease of it's liquification. In 1851, Charles Watt an Englishman, obtained the first patent for an electrolytic chlorine production cell.

By 1913, the first permanent liquid chlorine water purification system had been installed in Philadelphia, Pennsylvania, U.S.A. The following year Altoona, Pennsylvania, U.S.A. became the first city to treat sewage with liquid chlorine.

1.2.1. Key Dates to Remember

77 A.D. Pliny the Elder	-	Published first practical collection of chemical reactions.
1630 A.D. Jean Baptiste van Helmont	-	Wrote about a salt gas known today as chlorine.
1744 A.D. Carl Wilhelm Scheele	-	Generated, studied and collected chlorine.
1823 A.D. Michael Faraday	-	Electrolytic generation of chlorine and liquification.
1853 A.D. Charles Watt	-	First English patent for an electrolytic chlorine production cell.
1913 A.D. Philadelphia, PA., U.S.A.	-	First permanent liquid chlorination system for water treatment.
1914 A.D. Altoona, PA., U.S.A.	-	First permanent liquid chlorination system for sewage treatment.

1.3. Physical Properties of Chlorine

IMPORTANT NOTICE:

CAREFULLY READ THE CHLORINE MATERIAL SAFETY DATA SHEET IN SECTION A OF THE CAPITAL CONTROLS MANUAL. THE MATERIAL SAFETY DATA SHEET HAS INFORMATION WHICH IS VITAL TO YOUR HEALTH AND WELL BEING.

Chlorine is a greenish yellow gas with a pungent odor, and a hazardous substance.

Appearance:	Greenish Yellow (gas), Amber (liquid)
Specific Gravity:	2.486 (gas) heavier than air
Boiling Point	-34.0 degrees Celsius
Freezing Point:	-100.98 degrees Celsius
Incompatibility:	Ammonia, elemental metals, certain metal halides, carbides, nitrides, oxides,phosphides, and sulfides, easily oxidized materials, organic materials and unstable and reactive compounds.
Decomposition:	Chlorine is one of the chemical elements and cannot decompose.
Flammability Limits in Air:	Non-flammable but does support combustion of ferrous materials.
Toxicity:	Chlorine is a respiratory and mucous membrane irritant. Prolonged exposure to concentrations of 25 mg/l or greater can cause unconsciousness and death.
% Volatile by Volume:	100%
Vapor Pressure (liquid):	Atmospheres = 2.65 @ 0C, 5.58 20C, and 10.21 @ 40 C
Vapor Density in Air:	2.5, Air = 1
Stability:	Unstable
Reactivity Data:	Dry chlorine is highly reactive with titanium and tin. Reacts with most metals at high temperatures. Reacts with water to produce hydrochloric and hydrochlorous acids, which are corrosive to most metals.
Solubility in Water:	Highly soluble in water. Concentrations of 1,000 mg/l and more will mix with one (1) liter of water.
Molecular Weight:	35.453

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Why the Chlorination System is Being Installed

The system is being installed to improve the quality of the drinking water supply by eliminating biological organisms and pathogens within the water which cause health risks.

What Effects will the Addition of Chlorine have on the Water Supply

By eliminating the organisms and pathogens, the water supply will be made safer for human consumption, thereby reducing the health risks associated with consuming and using non-chlorinated water. Sicknesses associated with drinking and using non-chlorinated water will be reduced significantly, provided the system is operated and maintained properly, and personal hygiene is properly accomplished at all times.

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Section 2
System Operation

2.1. Description of System Components

2.1.1. Chlorine Containers and Piping

The 1,000 kg containers are used to hold the liquid chlorine. The containers are connected to the manifold piping where six (6) containers can be connected at one time. Each manifold is equipped with a pressure gauge. Each manifold is connected to the vacuum regulator which is manually set and automatically controls the flow of chlorine gas to the system.

Refer to Section B of the Capital Controls Manual, Bulletins A2.62107.8 and B3.8021.4 for detailed information on the manifold piping, and Bulletins 100.0002.1, 100.3009.0, A2.62120.4, and 100.70005.0 for detailed information on the combination vacuum regulator and flow indicator.

2.1.2. Vacuum Regulators

Vacuum regulators are used to reduce chlorine gas under pressure to a vacuum.

There are several basic functions of the vacuum regulator component in a gas feeder:

A. Reduction of gas pressure to a regulated vacuum.

The vacuum regulator reduces the gas pressure entering its inlet to a constant vacuum level of 20" of water.

B. Safety shut-off of gas pressure upon loss of vacuum.

Upon loss of vacuum in the spring loaded vacuum regulator, whether from a severed vacuum line, ejector failure, etc., the safety shut-off valve will immediately close.

Vacuum Regulator Specifications

Maximum allowable inlet pressure:	300 psig (20.7 bar)
Maximum recommended inlet pressure:	150 psig (10.3 bar)
Maximum Temperature:	140°F (60°C)
Minimum Temperature:	40°F (4.4°C)
Minimum recommended inlet pressure:	20 psig (1.4 bar)
Operating vacuum level:	20 inches (500 mm) water column (minimum)

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Vacuum Regulator (40 to 200 kg/h)

Vent Lines

1. **DO NOT MANIFOLD** vent lines from several vent equipped devices. Run separate, independent lines.
2. Run the vent line to a safe area where a discharge of gas being dispensed can be tolerated.
3. Slope the vent line downward from the vacuum regulator to provide a positive drain to prevent accumulation of any moisture.

Drip Leg Heater

1. Prior to starting up the system, apply power to the heater located at the bottom of the trap assembly. This heater keeps the gas from reliquefying in the trap. Heaters should be kept powered at all times.

Start-up

1. **Ejector Check**
   The ejector must be operating before checking the gas feeder.
2. **Gas Feeder Check**
   Have a plastic squeeze bottle available 1/4 full of leak test solution. Use 26° Baume ammonia solution to check for chlorine leaks.

2.1.3. Automatic Switchover Module, Vacuum Type

Principle of Operation

Each of two vacuum regulators with flow indicators are connected to independent sources of gas under pressure. An automatic switchover module allows chlorine gas to flow under vacuum from the vacuum regulator in service to the flowmeter and rate control panel and the ejectors, until that source is depleted.

The vacuum sealing valve in the vacuum regulator then closes and the vacuum level increases, initiating the switching of two sealing valves in the switchover module. The open valve on the depleted source closes, with the aid of a spring-loaded toggle assembly, while the valve on the standby source opens to permit chlorine gas to flow.

When the operator replaces the depleted source, the replenished source is placed on automatic standby. The module will not access the replenished supply until the supply in service is exhausted.

2.1.4. Valve Assembly and Pressure Indicators

There are two (2) types of ejectors, variable orifice and fixed orifice. The type provided for your installation are fixed orifice. The ejector works on the principle that as the injection water flows through the main body of the ejector and across the orifice, a vacuum is produced, on the chlorine solution feed line. The vacuum across the orifice pulls the chlorine solution into the ejector and mixes it with the transport water, sending the combined mixture to the discharge piping of the operating pump.

Pressure and vacuum gauges are supplied on the ejector/check valve assembly piping to monitor the following:

Chlorine Gas Vacuum	0-30 inches Hg (0-760 mm Hg)
Injector Supply Water Pressure	0-140 PSIG (1000 kPA)
Injector Discharge Water Pressure	0-85 PSIG (650 kPA)

Refer to Section B of the Capital Controls Manual, Bulletins 122.3010.0,122.3063.0, 122.7001.0, B3.8027.2, and Drawing CA-2392 for further detailed information about the ejector/check valve assembly.

2.1.5. Injection Point

There are two chlorine solution pipelines running to the two reservoirs at Nukus and two pipelines running to six reservoirs at Urgench. Any one of the two ejector assemblies can feed all the chlorine solution lines to the reservoirs by properly opening and closing valves at the ejector assemblies mounted on the wall. See Diagram 1.

2.1.6. Gas Detection System

The installed gas detection system is used as a safety device. The detector is designed to give early warning of chlorine gas. When chlorine gas is detected, an audible alarm sounds, and an alarm indication is illuminated.

The gas detector is adjustable from 0.5 mg/l to 10.0 mg/l. Your device is set to alarm at 3.0 mg/l. Should an alarm occur, immediately leave the chlorination area. It is important that the ventilation system is operable and running, otherwise the chlorine vapors will not be removed from the area. Remember, chlorine gas is 2.5 times heavier than air and will settle to the floor and other low lying areas.

Refer to Section D of the Capital Controls Manual, Bulletins 325.0001.0, B3.71019.1, B3.71035.2, B3.81600B.3, and B3.8028.2 for further detailed information about the gas detection system.

2.1.7. Multipoint Gas Detector

Capital Controls Series 1660 Multipoint Gas Detector detects chlorine, bromine chlorine or sulphur dioxide gas in air, depending on the type of sensor installed.

The detector dynamic graph display consists of 20 indicators with automatic ascending and descending range change.

All setup is accomplished from the control panel eliminating the need for internal access.

The gas sensors used with the Series 1660 Gas Detector have an expected life of 18-24 months under normal use.

Important Notice: Test the sensors at least once a month.

Gas Detector Operation

I. Start up

A. Turn the power switch to the ON position.

B. The alpha/numeric display will show

CAPITAL
CONTROLS
1660
GAS DETECTOR GAS: (CL2)
TIMER 180

C. The timer counts down 180 seconds to allow the sensor to stabilize before normal operation proceeds.

D. Normal operation is indicated when:

1. The alpha/numeric display shows:
GAS: (CL2)

2. The sensor indicator automatically displays each sensor scanned with increasing count beginning with sensor 1.

NOTE: Sensor scanning will return to automatic scanning after 2 minutes, if left in manual scanning.

E. Display of Gas sensing

1. When the lower set point is exceeded, the alarm emits a pulsed tone that increases in pitch with increases in gas level.

2. When the upper set point is exceeded, annunciation changes to a constant tone.

3. While the number of an activated sensor is displayed, the gas detector continues to scan all sensors.

4. Should a second sensor detect gas presence, the SENSOR indicator alternately displays the numbers of the activated sensors.

5. To silence annunciation or reset the latched alarm outputs, depress the RESET button on the front panel.

II. Setup

During normal operation, the alpha/numeric display shows:

GAS: (CL2)

To enter the setup mode, depress the forward MODE button (↑) on the front panel. To return to a previous setup entry, depress the backward MODE button (↓). Setup is completed for any parameter when that parameter is displayed and the forward or backward MODE button is depressed.

If no setup entries are made within five (5) minutes, the gas detector automatically returns to the operating mode.

A. Alarm Level and Reset

1. Alarm 1 Level

a. Select manual scanning by depressing MAN and continue depressing MAN until Sensor 1 displayed on the SENSOR indicator.

b. While in operating mode, depress the MODE button. The display shows:

SET → ALM 1

c. Depress SET button to increment the alarm level as shown by the graphic display. Note that the range automatically increments (moves from 10 mg/l range to 20 mg/l, from 20 mg/l to 40 mg/l, from 40 mg/l to 10 mg/l)

2. **Alarm 1 Manual Reset (latch)/Automatic Reset (unlatch)**

a. When in the Alarm 1 level selection mode, depress the MODE button. The display shows:

A1 →(MAN) (AUTO)

b. Depress the SET button to toggle between the manual and automatic reset modes. When the automatic reset (unlatch) mode is selected, the Alarm 1 relay returns to the normal state when the gas level falls below Alarm 1 level.

When the manual reset (latch) mode is selected, the Alarm relay is returned to the normal state by depressing the RESET button after the gas level falls below the alarm level.

3. **Alarm 2 Level**

a. From the Alarm 1 reset mode, depress the MODE button. The display shows:

SET → ALM2

b. Depress the SET button to increment the alarm level as shown by the graphic display. The Alarm 2 level can be higher or lower than the Alarm 1 level.

4. **Alarm 2 Manual Reset (Latch)/ Automatic Reset (Unlatch)**

a. When in the Alarm 2 level selection mode, depress the MODE button. The display shows:

A2 → (MAN) (AUTO)

b. Depress the SET button to toggle between the manual and automatic reset modes.

5. **Error Manual Reset (Latch)/Automatic Reset (Unlatch)**

a. From the Alarm 2 reset mode, depress the MODE button. The display shows:

ER → (MAN) (AUTO)

b. Depress the SET button to toggle between the manual and automatic reset modes.

6. Event

The Event counter accumulates the number of times that the lower alarm setting is exceeded.

a. From the Error reset mode, depress the MODE button. The display shows:

EVENT XX (XX = number of gas leaks)

b. To return the event counter to 00, depress the SET button.

Note: Complete setup for each sensor.

7. Operation

To return to normal operation, depress either (↑) or (↓) MODE button until the display shows:

GAS: (CL2)

B. Operating Time

The gas detector accumulates the number of days that the sensor has been operating which is useful for monitoring sensor life and planning maintenance schedules.

1. Select manual scanning by depressing MAN and continue depressing MAN until Sensor 1 is displayed on the SENSOR indicator.

2. Depress either the (↑ or ↓) MODE button until the alpha/numeric display shows:

SENSOR

3. Depress the SET button. The display shows:

AGE = XXX (XXX = number of operating days)

4. To reset the count to zero, depress the SET and then RESET button.

5. Repeat to each sensor.

C. Test

Gas detector has built-in diagnostics to test sensor modules and the receiving unit.

1. Test Initiation

a. Select manual scanning by depressing MAN and continue depressing MAN until Sensor 1 displayed on the SENSOR indicator.

b. Depress either the (↑ or ↓) MODE button until the display shows:

TEST

2. DC Fuse Check

a. Depress the Set button.

b. The display will show: **FUSE:DC+** if the fuse is good.

c. If the fuse is blown, the display shows: **FUSE:DC-**.

3. Calibration Check

Note: Calibration Check must be completed for each sensor.

a. From the DC fuse test, depress the SET button.

b. The display will show: MODE: 0

c. Depress the RESET button to increment trough calibration modes (0-7).

Note: Each calibration modes relates to the illumination of a specific number of bar graph segments as shown in the Table 1. The numeric display inside the sensor module also indicates the calibration mode number.

Table 1

Test	Mode	Test Point Voltages	Bargraph Segments	Function
Sensor	0	0	0	Sensor signal OFF
Sensor	1	0.95-1.00	0	10 ppm gas level
Sensor	2	0.95-1.00	0	20 ppm gas level
Sensor	3	0.95-1.00	0	40 ppm gas level
Not Applicable	4	Not Applicable	-	Not Applicable
Electronics	5	2.9-3.1	9, 10, or 11	Sensor internal voltage
Electronics	6	3.9-4.1	14, 15, or 16	Sensor internal voltage
Electronics	7	4.0-5.0	11 or greater	dc voltage to sensor

d. If the number of illuminated bar graph segments corresponds to the information in the Table 1, proceed to Temperature Measurement.

e. If the number of illuminated bar graph segments do not agree with Table 1 for modes 1,2 or replace the sensor.

f. If the number of illuminated bar graph segments do not agree with Table 1 for modes 5,6, or 7 continue the Calibration Check by completing steps **g**, **h**, and **I** as follows.

g. Connect a voltmeter to Test Point **GND** and **V OUT** located on the sensor printed circuit board.

h. Using Mode 7, the voltage should be in the range shown in Table 1. If the voltage is less than the specified range, use heavier gauge wire between the sensor and receiver.

i. Using Modes 5 and 6 the voltage should be in the range shown in Table 1. If the voltages are not correct, the sensor should be replaced.

4. Temperature Measurement

a. From the Calibration Check mode, depress the SET button.

b. The display will show the temperature at the sensor.

c. Depress the RESET button to toggle between degrees C and F.

d. If the display temperature is less than room temperature by 8°C or more than room temperature by 22°C replace the sensor.

e. Repeat for each sensor.

5. Relay Test

a. From the Temperature Measurement Mode, depress the SET button.

b. The display will show **ALM1 ON** or **ALM1 OFF**.

c. Depress the RESET button to toggle between ON and OFF noting that the relay energizes and de-energizes. Proper relay operation can be verified either by audible indication or by connecting an ohmmeter between Common (C) and Normally Open (NO) or Normally Close (NC) terminals and observing continuity indication.

d. Depress SET to select ALM2 and repeat step c to test ALARM2 relay operation.

e. Depress SET to select ERR and repeat step c to test ERROR relay operation.

f. Depress SET to select PWR and repeat step c to test POWER FAILURE relay operation.

2.1.8. Compact Gas Feeder

The Series 4800/4900 COMPACT floor cabinet mounted gas feeder is manually or automatically controlled, vacuum operated system for feeding chlorine, sulphur dioxide, or carbon dioxide gas in water treatment or other industrial process applications.

All models are completely vacuum operated and equipped with a spring-opposed inlet valve that seals off the gas supply in the event of a vacuum loss.

Gas Feed Operation Manual Control

The Series 4800/4900 COMPACT Floor Cabinet Gas Feeders are operated by the vacuum produced when water flows through the ejector. The vacuum travels through the vacuum line to the regulator and causes the inlet valve to open, and gas begins to flow into the system.

The spring-opposed diaphragm regulates the vacuum and acts as an automatic gas shut-off if the vacuum stops.

Gas passes through the flowmeter, rate controls and system tubing or piping to the ejector check valve. Here the gas is thoroughly mixed with water and applied as a solution.

Troubleshooting Chart

Trouble	Probable cause	Corrective action
1. Required gas flow not achieved at start-up	a. Insufficient ejector vacuum caused by insufficient water supply pressure or excessive back pressure.	a. Refer to trouble 9.
	b. Leakage at vacuum line connection at outlet from flowmeter, rate control valve, differential from flowmeter, rate control valve, differential pressure regulator, and/or inlet to ejector.	b. Inspect each connection and remake if necessary.
	c. Vacuum line(s), if flexible, crimped.	c. Replace vacuum tubing and arrange line(s) to eliminate crimping.
2. Required gas flow rate is not achieved on start-up following an extended period of shutdown	a. Insufficient ejector vacuum.	a. Refer to trouble 8.
	b. Leakage at vacuum line connection at outlet from flowmeter, rate control valve, differential pressure regulator, or inlet to ejector.	b. Inspect each connection and remake if necessary.
	c. Vacuum line(s), if flexible, crimped.	c. Replace vacuum tubing and arrange line(s) to eliminate crimping.
	d. Leakage around flowmeter gaskets.	d. Inspect and align flowmeter or replace gaskets.
3. Flowmeter float observed bouncing and/or maximum gas flow cannot be achieved during normal operation	a. Gas inlet filter of vacuum regulator - dirty.	a. Replace gas inlet filter assembly.
	b. Rate valve dirty.	b. Clean rate valve.
	c. Flowmeter dirty.	c. Clean flowmeter.
	d. Ejector water supply pressure fluctuating too wide (float bounce). Insufficient ejector vacuum.	d. Correct water supply pressure as necessary.
4. Maximum gas flow failed to provide desired level of chemical residual at point of sampling.	a. Air leakage upstream of flowmeter.	a. Refer to Troubles 1 and 2.
	b. Chemical demand and/or water flow has increased above original design capacity.	b. Contact supplier and review equipment requirements.
5. Minimum gas flow provide too high level of chemical residual at point of sampling.	a. Chemical demand and/or water flow has decreased below original design capacity.	a. Contact supplier and review equipment requirements.

Trouble	Probable cause	Corrective action
6. Flow meter fails to indicate gas flow during normal operation but there is no out-of-gas indication.	a. Gas flowmeter plugged. b. Vacuum lines, if flexible, crimped.	a. Clean gas flowmeter. b. Replace vacuum tubing and arrange lines to eliminate crimping.
7. Out of gas indication occurs during normal operation.	a. Gas supply valve(s) closed. b. Gas supply exhausted. c. Filter in vacuum regulator or automatic valve inlet plugged. d. Loss of gas supply indicator not reset or faulty.	a. Open gas supply valves. b. Replenish gas supply. c. Replace filter. d. Reset or replace gas supply indicator.
8. Unstable chemical residual.	a. Oversized system. b. Dirty differential pressure regulator.	a. Consult factory for resizing. b. Clean differential pressure regulator.
9. Insufficient ejector vacuum.	a. Y- strainer in water supply line is dirty reducing available supply pressure. b. Back pressure is greater than value listed for one of the following reasons: a) solution valve, if present, not fully open; b) solution line ,if present, partially blocked; c) back pressure at point of application has increased above its original value. c. Ejector nozzle and/or throat dirty.	a. Clean Y-strainer and refer to ejector instructions. b. Open solution valve, clean solution line, determine cause of abnormally high back pressure and take steps to correct. c. Clean nozzle and/or throat.
10. Gas leak.	a. Gas leak at container valve or isolating valve packing. b. Leak at lead gasket. c. Leak across gas inlet valve seat causes gas to leak from vent line.	a. Tighten container valve packing nut without excessive force. If it does not eliminate the leak, close the valve and call the gas supplier. b. Replace gasket. c. Clean inlet valve seat.
11. Loss of gas feed.	a. Dirty or plugged ejector nozzle. b. Insufficient water pressure to operate ejector. c. No gas supply.	a. Check for vacuum in ejector. Clean nozzle. b. Provide proper water pressure. c. Replenish gas supply.
12. Flooded feeder.	a. Dirt lodged on the ejector check valve seat.	a. Clean or replace seat or O-ring.
13. Erratic operation.	a. Oversized system.	a. Consult factory for resizing.

2.1.9. Chlorine Gas Filter C-282

This filter has two chambers. The lower portion acts as a trap for liquid impurities (reliquefied gas). The upper portion has a removable filter cartridge. The filter element is especially impregnated so that the ferric chloride "plates out" rapidly as it passes through the element. Therefore the filter acts as both a filter and a condensate trap.

Maintenance Instructions

A. Filter pads should be replaced every 6 months and the screen cleaned.

B. To remove the filter pads, follow the below instructions.

Note: Turn off the chlorine containers and purge the chlorination system before dismantle of the gas filter.

1. Remove the eight hex cap screws from the bottom of the filter.

2. Remove the filter cap.

3. Remove the used lead gasket and clean the surface area of any excess lead. Do not reuse the lead gasket - always use a new lead gasket to ensure good seal.

4. Pull down on the handle of the filter element holder.

5. Remove the used filter elements - quantity four (4) - and throw away. Elements will be saturated with chlorine gas and ferric chloride. Be sure to have protective rubber gloves on, and rubber apron and protective goggles. The room should be well ventilated. Personnel should be present with a SCBA (self contained breathing apparatus) air mask during this phase of maintenance.

   Local and remote alarms may be actuated. Proper personnel should be alerted to this phase of maintenance for false alarms. At least two (2) personnel should be present. One (1) performing work and one (1) acting as supervisor.

6. Clean the filter element holder with warm soapy water and thoroughly air dry before replacing the filter elements with four (4) new filter pads.

7. Place four (4) new filter pads in filter element holder. Insert the filter element holder back into the filter with the screen facing upward. Use the handle to insert the holder pushing upward.

8. Use new lead gasket by placing it onto the filter trap.

9. Replace cap screws. Do not ever overtighten.

10. Turn chlorine on and check for leaks by using 26% Baume ammonia solution fumes.

2.2. Chlorination System Startup

2.2.1. Chlorination room

1. Select reservoir and open distribution valve(s) downstream of the appropriate ejector. **Note:** Open all valves SLOWLY.
2. Open chlorine solution valve downstream of ejector.
3. Open water supply valve upstream of ejector. Listen for sound of running water and ejector creating vacuum; observe vacuum level on gauge.
4. Select chlorinator and open appropriate isolation valve(s) to the selected chlorinator to be placed in service; observe vacuum level on the chlorinator.
5. Open chlorine supply valve.
6. Open chlorine control valve two turns.

2.2.2. Container Room

7. Select which containers to feed chlorine gas from and find the ammonia bottle; check for ammonia fumes. Note: Use ammonia fumes to detect chlorine leak. DO NOT apply liquid ammonia to the equipment.
8. All chlorine valves should be closed and all heaters must be hot.
9. Connect flexible connector to manifold valve and isolation valve using new lead gaskets.
10. Connect one isolating valve to one chlorine container, top valve only for chlorine gas withdrawal.
11. Open and immediately close the container valve. Check for leaks at container valve/isolating interface and at container valve stem packing with ammonia fumes. Correct as necessary.
12. Open container valve only slightly, less than one turn.
13. Open slightly, and immediately close the isolating valve.
14. Check for leaks at the isolating valve stem/packing nut and at the flexible connector/manifold valve interface and flexible connector/isolation interface areas with ammonia fumes. Correct as necessary.
15. Close container valve.
16. Open and immediately close manifold valve. Check all manifold valve stems/packing nuts and all joints up to and including valve on vacuum regulator stand for leaks with ammonia fumes and correct as necessary.
17. Open manifold valve maximum one turn.
18. Open and immediately close the container valve. Check for leaks.
19. Check the manifold valve stem/packing nut and all joints up to and including the valve on the vacuum regulator with ammonia fumes and correct as necessary. Confirm presence of chlorine pressure by observing gauge on manifold stand.
20. Close container valve.
21. Open and immediately close the ball valve on the vacuum regulator stand.
22. Check the valve stem/packing nut area and all joints up to and including the vacuum regulator for leaks with ammonia fumes. Correct as necessary. Confirm the presence of chlorine gas by observing the pressure gauge on the vacuum regulator.
23. Open the container valve one turn. Open ball valve on vacuum regulator stand. Chlorine gas is now flowing into the water. Recheck all valves and joints for leaks with ammonia fumes. Correct as necessary.

24. Connect additional containers as required to achieve required chlorine gas feed rate by following steps #8 through #14 plus #23.
Note: Maximum sustainable chlorine gas withdrawal rate is of 230 kg/day/container.

2.2.3. Chlorinator Room

25. Adjust chlorinator flow control valve for desired feed rate.

Note: The system is designed for a chlorine feed rate of 1,000 kg/day per chlorinator. The chlorinator feed tubes have been downsized from 1,000 kg/day to 91 kg/day to allow for better control of the actual amount of chlorine that is presently being added to the reservoirs.

2.3. Chlorination System Shutdown

2.3.1. Container Room

1. Close all containers and feed chlorine until all pressure gauges indicate zero pressure.
2. Close all isolation, manifold and ball valves.

2.3.2. Chlorinator Room

I. Close all valves in the following order:
   - A. chlorinator control valve
   - B. chlorine supply valve
   - C. isolation valve
   - D. water supply valve
   - E. solution valve

II. For long term shutdown, open union at the ejector check valve and save the o-ring from the union.

2.4. Container Change

1. Check vacuum regulator to confirm which side is feeding chlorine; should be the side with full containers
2. Close all valves on side with empty containers; this includes the container valves, isolation valves, manifold valves, and ball valve.
3. Carefully remove isolation valve from container valve. Check for excessive chlorine with ammonia fumes.
4. Remove empty containers after replacing container valve covers.
5. New Containers must be positioned with the valves aligned vertically i.e. 12 o'clock & 6 o'clock.
6. Remove valve covers from full containers after chocking and securing the containers in place. All chlorine valves should be closed and all heaters must be hot.
7. Connect one isolating valve to one chlorine container, top valve only for chlorine gas withdrawal.
8. Open and immediately close the container valve. Check for leaks at container valve/isolating interface and at container valve stem packing with ammonia fumes. Correct as necessary.
9. Open container valve only slightly, less than one turn.
10. Open slightly, and immediately close the isolating valve.
11. Check for leaks at the isolating valve stem/packing nut and at the flexible connector/manifold valve interface and flexible connector/isolation interface areas with ammonia fumes. Correct as necessary.
12. Open isolation valve only slightly, less than one turn.
13. Open manifold valve maximum one turn.
14. Open the ball valve on the vacuum regulator stand.
15. Check the valve stem/packing nut area and all joints up to and including the vacuum regulator for leaks with ammonia fumes. Correct as necessary. Confirm the presence of chlorine gas by observing the pressure gauge on the vacuum regulator. Chlorine gas is now available. Recheck all valves and joints for leaks with ammonia fumes. Correct as necessary.
16. Connect additional containers as required to achieve required chlorine gas feed rate by following steps #6 through #13 plus #15.
    Note: Maximum sustainable chlorine gas withdrawal rate is 230 kg/day/container.

Section 3
Safety

3.1. Safety Shower

The shower is used when a person or persons come in contact with large amounts of chlorine gas or liquid. Since chlorine is a skin irritant, it is important for your well being to remove as quickly as possible any chlorine which has come in contact with the body.

The first thing that should be done if possible, is to remove your clothing and foot wear, then get under the emergency shower for at least 15 minutes and wash the entire body with large amounts of soap and water only. Then immediately seek medical attention. If it is not possible to remove your clothing and foot wear, then get under the shower and begin flushing the entire body with water. At the same time have a co-worker assist your in removing your clothing and foot wear, then begin washing with large quantities of soap and water.

You do not want to leave any clothing or foot wear on your body which has come in contact and has been saturated with chlorine gas or liquid, remove immediately.

3.2. SCBA Breathing Apparatus

The breathing apparatus is of the pressure demands type, and has a capacity of 30 minutes per air container. **It is imperative that these masks be inspected on a weekly basis and after each use.**

It is also extremely important to wear the proper type of clothing when entering a chlorine gas or liquid contaminated area.

Refer to Section E of the Capital Controls Manual and follow the detailed inspection instructions and requirements in O&M R-2145 booklet.

3.3. Handling and Use of Containers

1. If a chlorine container or it's valve are damaged, **do not use** the container, dispose of the container in the proper manner.

2. Handle all chlorine containers with extreme care. Do not drop containers or allow them to strike any object with force. Do not apply heat to chlorine containers or their valves.

3. Chlorine container valves should be operated only with the wrenches that are provided. Under no circumstances use a pipe wrench or any wrench longer than 15 cm long. Always use the tools provided.

4. Use valves, gauges, regulators and fittings which have been approved for chlorine service. Ordinary devices are not suitable.

5. If chlorine gas is to be taken from a container, the container must be in the horizontal position and flexible connector is to be attached to the container top valve.

6. Close valves on chlorine containers when chlorine is not being withdrawn and especially as soon as contents are removed in order to prevent moist air or foreign substances entering the container.

7. Do not alter or repair chlorine containers or their valves.

3.4. Emergency Repair Kit B

The Chlorine Institute Emergency Kit B is designed for use with chlorine containers with the standard DOT 106A500X Chlorine Ton Container in chlorine service only. These containers have an outside diameter of approximately 30 inches (76.2 cm) and overall length from 80-3/4 (205 cm) to 82-1/4 (208 cm) inches. The kit is not designed for use on liquid full ton containers. This kit does not contain repiratory equipment which must always be worn when investigating and correcting chlorine leaks.

Refer to Section E of the Capital Controls Manual, Bulletin R-1147 which is comprised of eight (8) pages for detailed information about Emergency Kit A.

3.5. Leak Testing and Leaks

Testing for chlorine leaks is accomplished by using the plastic squeeze bottles provide. The bottle should be one-quarter filled with aqueous ammonia that was provided. The bottle is squeezed in such a manner as to expel the ammonia vapors and not the liquid. When ammonia vapor comes in contact with chlorine a dense white cloud is formed, this pinpoints the leak. **Never use water or a soap solution to locate chlorine leaks. Do not squirt liquid ammonia on the leak or equipment, devices or piping. Ammonia is corrosive.**

When leak testing and repairing leaks, always use the SCBA breathing apparatus provided along with the proper clothing.

Leaks can occur in the following locations:

Metal piping, plastic tubing, PVC pipe
Equipment components and devices
Chlorine containers

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3.6. Personnel Exposure

Common Name: Chlorine

3.6.1. HAZARD SUMMARY

* Chlorine will affect you when breathed in.

* Exposure will cause irritation of the eyes, nose, and throat, and also tearing, coughing and chest pain. Higher levels burn the lungs and can cause a buildup of fluid in the lungs (pulmonary edema) and death.

* Contact can severely burn the eyes and skin.

* Repeated exposures or a single high exposure may permanently damage the lungs. It can also damage the teeth and cause a skin rash.

3.6.2. IDENTIFICATION

Chlorine is a greenish yellow gas with an irritating odor. It is used in making solvents, many chemicals, disinfectants, and chlorine bleach cleaners.

3.6.3. HOW TO DETERMINE IF YOU ARE BEING EXPOSED

* **ODOR THRESHOLD** = 0.31 mg/l

* The odor threshold only serves as a warning of exposure. Not smelling it does not mean you are not being exposed.

3.6.4. WORKPLACE EXPOSURE LIMITS

Airborne permissible exposure limit (PEL) is 1 mg/l, not to be exceeded at any time.

The recommended airborne exposure limit is 0.5 mg/l, which should not be exceeded during any 15 minutes period.

The recommended airborne exposure limit is 1 ppm averaged over an 8 hour workshift and 3 mg/l as a STEL (short term exposure limit).

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3.6.5. WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.

* Wear protective work clothing.

* Wash thoroughly immediately after exposure to liquid Chlorine or Chlorine solutions.

* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of Chlorine to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

3.7. HEALTH HAZARD INFORMATION

3.7.1. Acute Health Effects

The following acute (short term) health effects may occur immediately or shortly after exposure to Chlorine:

* Exposure causes irritation of the eyes, nose, and throat. It can include tearing, coughing, sputum, bloody nose, and chest pain. Higher levels cause a buildup of fluid in the lungs (pulmonary edema) and death.

* Contact can severely burn the eyes and skin, causing permanent damage.

3.7.2. Other Long Term Effects

* Chlorine can irritate the lungs. Repeated exposure may cause bronchitis to develop with cough, phlegm, and/or shortness of breath.

* Long term exposure can damage the teeth.

3.7.3. Mixed Exposures

Because smoking can cause heart disease, as well as lung cancer, emphysema, and other respiratory problems, it may worsen respiratory conditions caused by chemical exposure. Even if you have smoked for a long time, stopping now will reduce your risk of developing health problems but will make no difference to the effects of exposure to chlorine.

3.7.4. Workplace Controls

Good WORK PRACTICES can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by Chlorine should change into clean clothing promptly.

* Work clothes contaminated with Chlorine liquid should be laundered by individuals who have been informed of the hazards of exposure to Chlorine.

* Provide eyewash fountains in the immediate work area.

* Provide emergency shower facilities.

* Do not eat, smoke, or drink where Chlorine is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.

3.8. Personal Protective Equipment

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT.

However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

3.8.1. Clothing

* Avoid skin contact with Chlorine. Wear protective gloves and clothing. Safety equipment suppliers/manufacturers can provide recommendations on the most protective glove/clothing material for your operation.

* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

3.8.2. Eye Protection

* Wear splashproof chemical goggles and face shield when working with chlorine liquid.

* Wear gas proof goggles and face shield if there is a possibility of exposure to the gas, unless full facepiece respiratory protection is worn.

3.8.3. Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Only trained personnel should use the repirators that were provided.

* Where the potential exists for exposures over 0.5 mg/l, use the approved Self Contained Breathing Appratus (SCBA) which has been provided and is located in the yellow cabinet mounted on the wall outside the chlorination room.

* Exposure to 25 mg/l is immediately dangerous to life and health. If the possibility of exposures above 25 mg/l exists use an approved self contained breathing apparatus with a full facepiece operated in continuous flow or other positive pressure mode.

3.9. Handling and Storage

* Chlorine must be stored to avoid contact with GASOLINE and other PETROLEUM PRODUCTS, TURPENTINE, ALCOHOLS, ACETYLENE, HYDROGEN, AMMONIA and SULFUR, and finely divided METALS, since violent reactions occur.

* Store in tightly closed containers in a cool, well ventilated area away from HEAT. Heat may cause containers to burst.

3.10. Fire Hazards

* Extinguish fire using an agent suitable for the type of surrounding fire. Chlorine itself does not burn. Use water to keep fire exposed containers cool.

* POISONOUS GAS IS PRODUCED IN FIRE.

* CONTAINERS MAY EXPLODE IN FIRE.

* If employees are expected to fight fires, they must be trained and equipped.

3.11. Spills and Emergencies

If Chlorine is spilled or leaked, take the following steps:

* Restrict persons not wearing protective equipment from area of spill or leak until cleanup is complete.

* Ventilate area of spill or leak.

* If the gas is leaked, STOP THE FLOW OF GAS. If the source of the leak is a container and the leak cannot be stopped in place, remove the leaking container to a safe place in the open air, and, repair the leak or allow the container to empty.

* Make container "EMERGENCY" repairs using the Chlorine Institute Emergency "B" leak repair kit that was provided. Leaking gas can be passed through a reducing agent (sodium bisulfite) and sodium bicarbonate solution with a trap in the line.

* If in liquid form, collect for reclamation. Absorb in vermiculite, dry sand, earth, or similar material.

* It may be necessary to contain and dispose of Chlorine as a HAZARDOUS WASTE. Contact the proper authorities for recommendations.

3.12. First Aid

3.12.1. Eye Contact

* Immediately flush with large amounts of water. Continue without stopping for at least 30 minutes, occasionally lifting upper and lower lids. Seek medical attention immediately.

3.12.2. Skin Contact

* Quickly remove contaminated clothing. Immediately wash area with large amounts of soap and water. Seek medical attention immediately.

3.12.3. Breathing

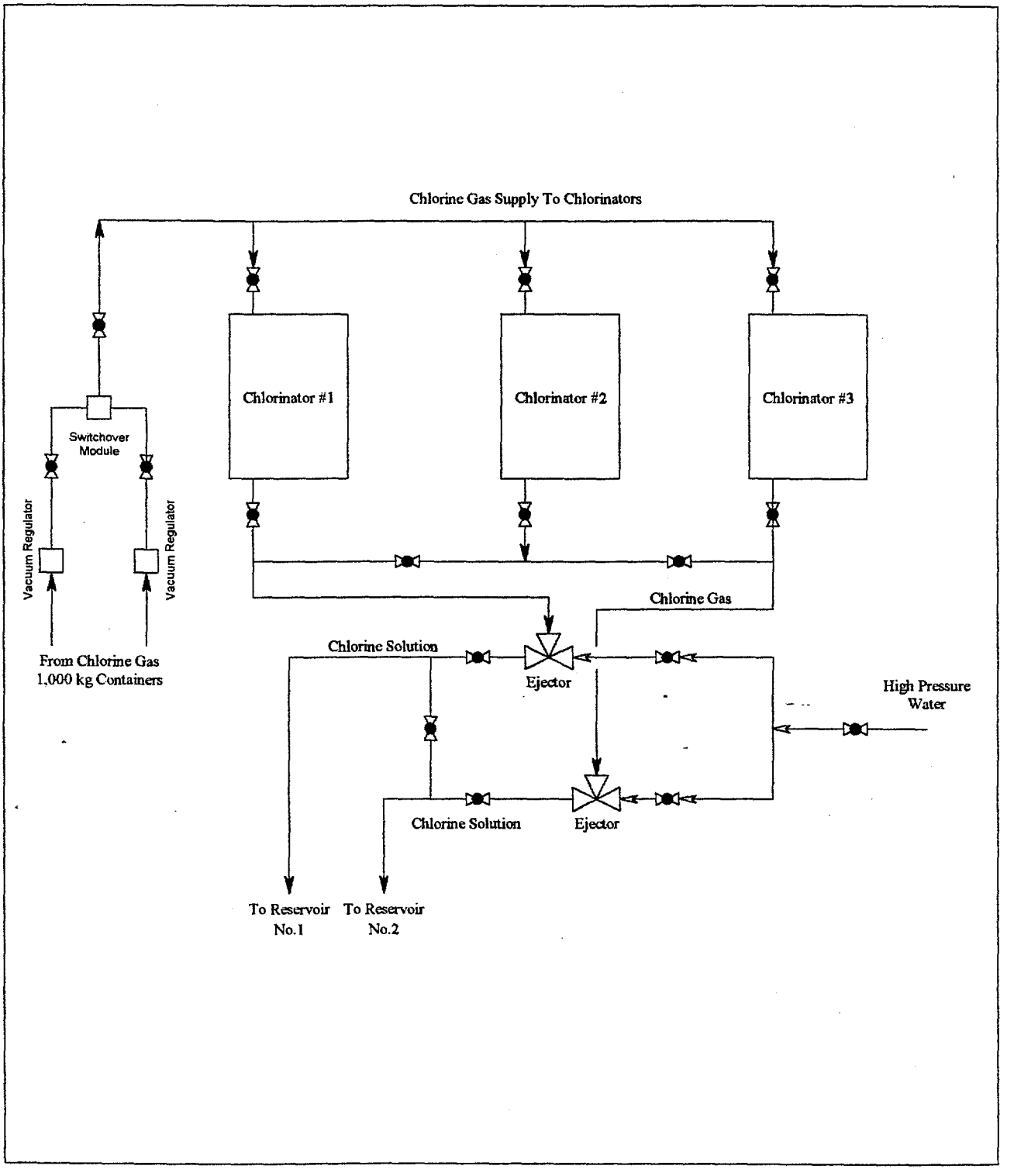
* Remove the person from exposure.

* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.

* Transfer promptly to a medical facility. Medical observation is recommended for 24 to 48 hours after breathing overexposure, as pulmonary edema may be delayed.

DIAGRAM 1

Nukus
Booster Station



Urgench
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