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Environmental Policy and Technology Project

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NEW INDEPENDENT STATES

CHLORINATION OPERATIONS MANUAL

Kegeili and Chimbai, Karakalpakstan, Uzebekistan

August 1996

Prepared for:
Central Asia Mission
U.S. Agency for International Development

Prepared by:
Central Asia Regional EPT Office in Almaty, Kazakstan
Environmental Policy and Technology Project
For the New Independent States of the former Soviet Union
A USAID Project Consortium Led by CH2M Hill

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Introduction:

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:

1. Overview:	This section presents an overview of the history of chlorination.
2. Physical Properties:	This section provides a summary of the physical properties of chlorine.
3. Installed System Description:	This section presents a summary of the description of the various components of the installed chlorination system.
4. Safety:	This section includes a summary of the safety precautions and emergency procedures related to the chlorination system.
5. Chlorination System Operation:	The start-up and shut-down procedures for the chlorination system are summarized in this section.

SECTION 1: OVERVIEW

The History and Discovery 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.

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.

Chlorine - Physical Description

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

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: 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.

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):	2.65 atmospheres @ O C, 5.58 atmospheres@ 20 C, and 10.21 atmospheres @ 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

Section 3: Installed System Equipment Operation

A. Description of System Components Operation

Note:

Please refer to System Schematic Drawing # C-5737 in Section A of the CapitalControls Manual. The below listed components for the system are shown on this drawing.

Chlorine Cylinders, Manifold Piping and Vacuum Regulator with Flow Indicator:

The 68 kg cylinders are used to hold the chlorine liquid. The cylinders are connected to the manifold piping where two (2) cylinders can be connected at one time. Each manifold is equipped with a combination vacuum regulator/flow indicator which are manually set and automatically control 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.

Switchover Module:

The discharge side piping of the two (2) vacuum regulators are connected to the automatic switchover module. The module is used to automatically switch from one or the other pair of chlorine cylinders upon low or loss of cylinder pressure. This ensures that there is a constant uninterrupted supply of chlorine being feed to the system. This module will automatically switch back and forth between the two (2) manifolds provided that there are always two cylinders with an ample supply of chlorine in them. If there are empty cylinders on the second manifold and the operating cylinders loss pressure or become empty because of use, then there will be no switchover.

Refer to Section B of the Capital Controls Manual, Bulletins 100.3006.0, B3.7193.11, 100.6330.0 for detailed information on the switchover module.

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Flow Indicating Panel Meter

Downstream of the switchover module on the piping to each ejector/check valve assembly there are flow indicating panel meters. These meters are equipped with manual flow rate setting knobs and are used to meter the flow of chlorine solution (chlorine and water). Both meters have a flow rate capacity of 2 kg/h. These meters regulate the flow of chlorine solution to the ejector/check valve assembly for injection into the pumped water.

Refer to Section B of the Capital Controls Manual, Bulletins 100.7060.0, B3.8041.0, and Drawing CA-2391 for detailed information about the flow indicating panel meters.

Ejector/Check Valve Assembly and Pressure Indicators (gauges)

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 gas feed line. The vacuum across the orifice pulls the chlorine gas into the ejector and mixes it with the transport water, sending the combined mixture as a chlorine solution to the discharge piping for the resevoirs.

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

Chlorine Gas Vacuum	0-760 mm Hg
Injector Supply Water Pressure	0-1000 kPA
Injector Discharge Water Pressure	0-650 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.

Injection Point

There are two chlorine solution pipelines running to the reservoirs at Kegeili and three chlorine solution pipelines running to the reservoirs at Chimbai. Any one of the two injector assemblies can feed all the chlorine solution lines to the reservoirs by proper opening and closing control valves at the ejector assembly mounted on the wall. See Diagram 1.

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B. 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 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 future detailed information about the gas detection system.

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Section 4: Safety

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.

SCBA Breathing Apparatus

The breathing apparatus is of the pressure demands type, and has a capacity of 30 minutes per air cylinder. 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.

Handling and Use of Cylinders

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

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

3. Chlorine cylinder valves should be operated only with the special wrenches that are provided. Under no circumstances use a pipe wrench or any wrench longer than 15 cm long. Always use the special clamps and adapters 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 cylinder, the cylinder must be in the upright position.

6. Close valves on chlorine cylinders 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 cylinder. It is dangerous to allow any chlorine cylinder, which has emptied its contents into water or other liquid, to remain connected with the process line. In such cases liquid could be sucked back into the cylinder causing danger to the operator and damage to the cylinder.

7. Replace outlet caps on chlorine cylinder valves when not actually in use. Replace valve protection caps as soon as the cylinders are disconnected.

8. Do not alter or repair chlorine cylinders or their valves.

Emergency Repair Kit A

The Emergency Kit A is designed for use with chlorine cylinders with an outside diameter of 20.625 and 26.875 cm. The kit contains all the necessary devices to stop leaks at valves and fusible plugs, and in the sidewalls of cylinders. This kit does not contain respiratory equipment which must always be worn when investigating and correcting chlorine leaks. The kit is not designed to be used on liquid full cylinders.

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.

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 cylinders

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Cylinder Rupture

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 . Follow the instructions in this bulletin to repair/dispose of a leaking chlorine cylinder.

Personnel Exposure

Common Name: Chlorine

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.

IDENTIFICATION

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

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.

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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 15minute 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).

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.

HEALTH HAZARD INFORMATION

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.

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.

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.

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.

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.

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

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.

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.

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.

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 cylinders in a cool, well ventilated area away from HEAT. Heat may cause cylinders to burst.

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 cylinders cool.

* POISONOUS GAS IS PRODUCED IN FIRE.

* CYLINDERS MAY EXPLODE IN FIRE.

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

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 cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and, repair the leak or allow the cylinder to empty.

  Make cylinder "EMERGENCY" repairs using the Chlorine Institute Emergency "A" 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.

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First Aid

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.

Skin Contact

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

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.

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Section 5: CHLORINATION SYSTEM

Please refer to DIAGRAM - I when referring to the START-UP & SHUT DOWN procedures listed below.

START-UP PROCEDURE:

Note:

Prior to starting up the chlorination system, replace empty chlorination cylinders. This will ensure that the automatic switchover system will function correctly for each set of chlorine cylinders.

1. "OPEN" the appropriate globe valves on the supply and discharge sides of the ejector for each reservoir that will be fed.

Note:

Make sure there is a vacuum reading at the vacuum gauge located at the chlorine gas feed side of the ejector.

2. "OPEN" the valves on the chlorine cylinders. Use only the correct approved wrenches to accomplish this task.

3. "SET or ADJUST" the gas feed rate for desirable rate at the gas feeder, located at the vacuum regulator. Gas feeder is rated for 45 kg/day (100 lbs/day).

4. "SET or ADJUST" the chlorine gas flowrate for the appropriate quantity kg/hr. Each meter is rated for 2 kg/hr.

5. Check the chlorine residual to ensure that the feed rate set is what is actually being fed. Make appropriate feed rate adjustments based on the results of the chlorine residual test conducted.

Please refer to DIAGRAM - I when referring to the START-UP & SHUT DOWN procedures listed below.

SHUTDOWN PROCEDURE:

1. "CLOSE" the chlorine cylinder valves.

2. "CLOSE" ejector supply and discharge valves.

Note:

Before dismantling any equipment, components, or piping make sure that the system has been purged of all chlorine gas. If you are in doubt, then wear the SCBA breathing apparatus which has been supplied.

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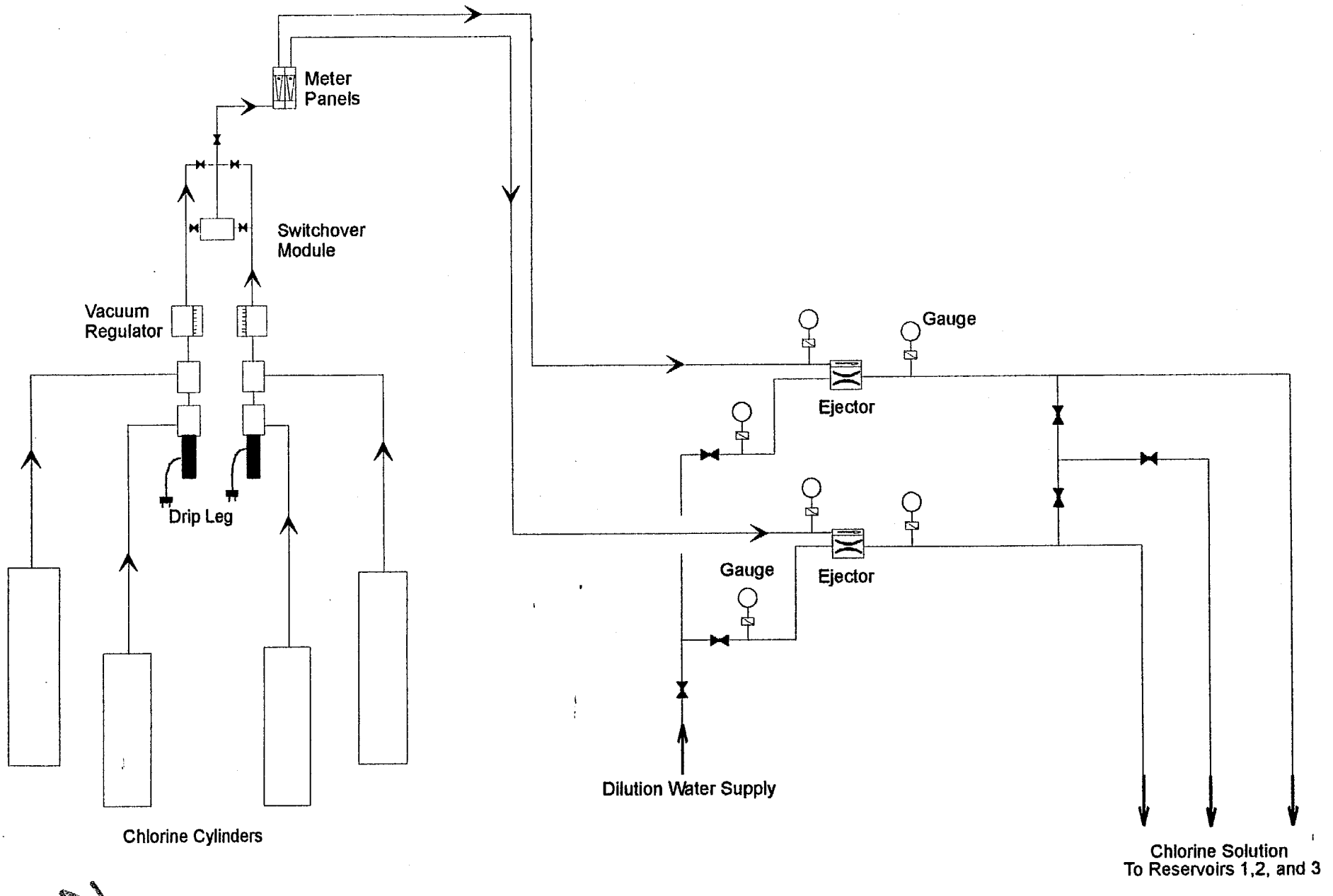
CHIMBAI WATER BOOSTER PUMP STATION

DIAGRAM - 1



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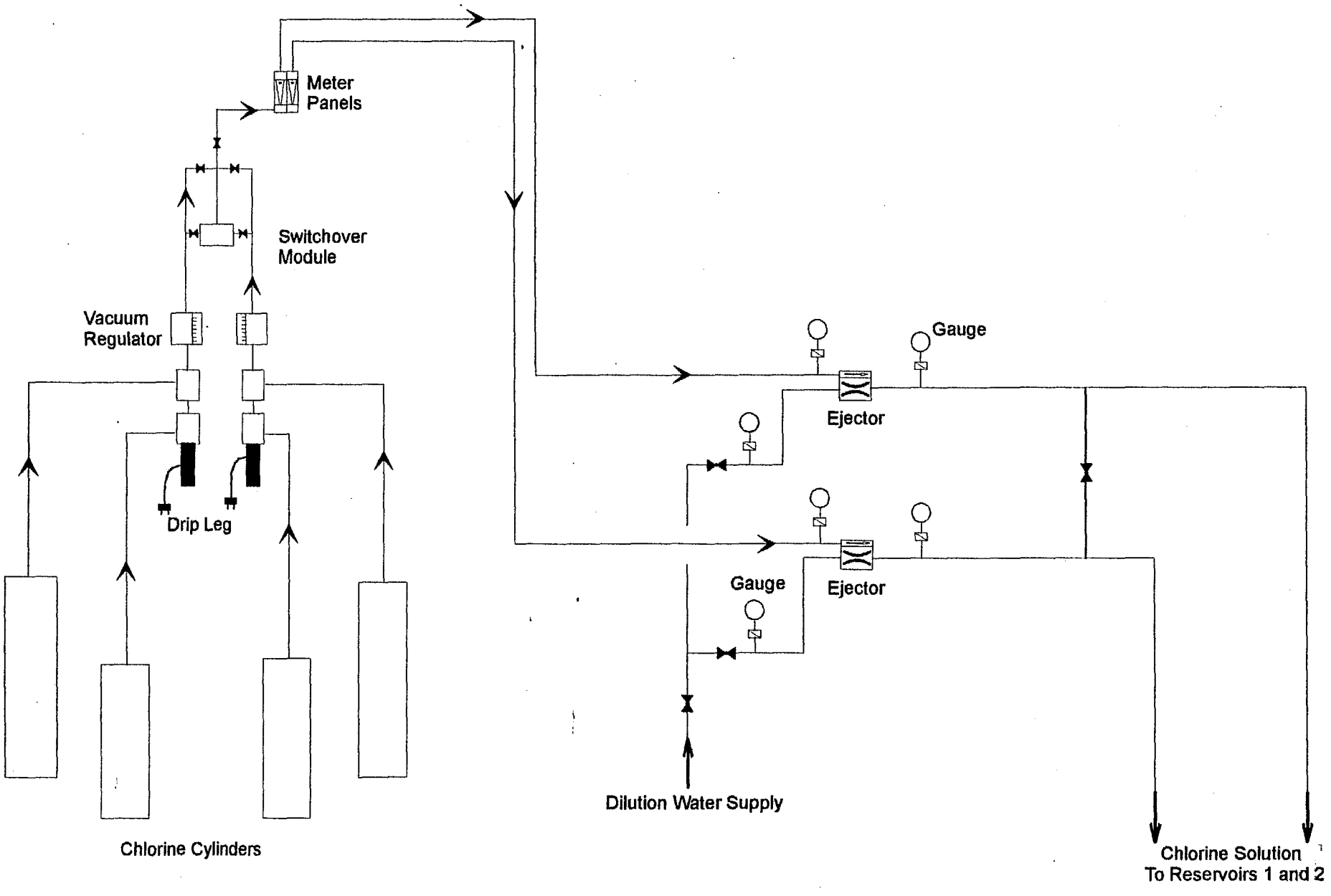
KEGEILI WATER BOOSTER PUMP STATION

DIAGRAM - 1



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ENVIRONMENTAL POLICY AND TECHNOLOGY PROJECT
Central Asian Regional Office
Ulitsa Abai 4, Suite 112; Almaty 480024 Kazakstan
Tel: (7-3272) 654-695 or 645-951; Fax: 646-849

DATE: 3 October 1996
TO: Barry Primm, USAID/Almaty
FROM: Paul Dreyer, EPT/Almaty
SUBJECT: Uzbekistan Activities
Chlorination Manuals

We are providing to you the following EPT documents in English and Russian:

* Chlorination Manuals, Nukus and Urgench, Uzbekistan, and
* Chlorination Manuals, Kegeili and Chimbai, Uzbekistan.

Please advise if you need additional information. Thank you.

Enclosures
cc: David Mandel, USAID/Tashkent
James Westfield, EPT/W
Pervez Shaikh, EPT/A
AID240

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Central Asian Regional Office
Ulitsa Abai 4, Suite 112; Almaty 480024 Kazakstan
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