Chemical Safety in Water and Wastewater Treatment Facilities

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PA AWWA SE Region Fall Conference

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- Mr. Jenkins has more than 30 years of experience in engineering and public infrastructure projects. He directs all aspects of municipal engineering services, land development, surveying, and environmental safety/health programs for SSM. His expertise includes planning, design, regulatory compliance, construction, and operation of water and wastewater treatment facilities for municipal and industrial clients.

- Temple University, Bachelor of Science, Environmental Engineering, 1990
- Professional Engineer in Pennsylvania
- PA Certified Water Treatment Plant Operator, Class A
- PA Certified Wastewater Treatment Plant Operator, Class A

About the Speaker

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- Review and discuss participant knowledge of common chemical use in treatment facilities.
- Test current participant knowledge on regulatory requirements.
- Provide participants with recommendations on conducting safety planning and Hazard Communication activities.
- Allow participants to share solutions for chemical use in various operations.
  - In the laboratory
  - Bulk storage operations
  - Chemical feed systems

A brief quiz will follow each section.

Course Objectives

Section 1

- Chemicals play an important role in many aspects of water treatment.
- Treatment operations fall under many specific regulations that apply to all site personnel.
- Developing written facility safety guidelines that are specific to the worksite is critical for compliance.
- Training and enforcing the safety procedures and processes are critical to employee safety.

Chemical Safety in W/WW Treatment Facilities

Common Chemicals used in Water Treatment

- Chlorine (gas)
- Sodium hypochlorite
- Calcium hypochlorite
- Aluminum sulfate
- Soda ash
- Sodium bicarbonate
- Ferric chloride
- Sodium bisulfite
- Hydrofluoric acid
- Sodium hydroxide
- Various polymer solutions for coagulation and flocculation

Knowing the Hazards in Chemical Situations

- Being aware of the type of chemical
  - Its physical state, whether it be liquid, solid or gas
  - Physiological effects, whether they be caused by toxins, carcinogens, asphyxiation or corrosives

Typical Operator Job Duties Involving Chemicals

- Laboratory analysis
- Set-up and maintenance of chemical feed systems
- Transfer of bulk storage chemicals

Causes of Most Operator Injuries

- Failure to follow established safety practices
- Lack of a safety policy

Important Workplace Safety Plans

- Safety Data Sheet (SDS) notebook
- Emergency Response Plan
- Spill Prevention Plan
- Operations and Maintenance Plan
- Standard Operations Procedures (SOPs)

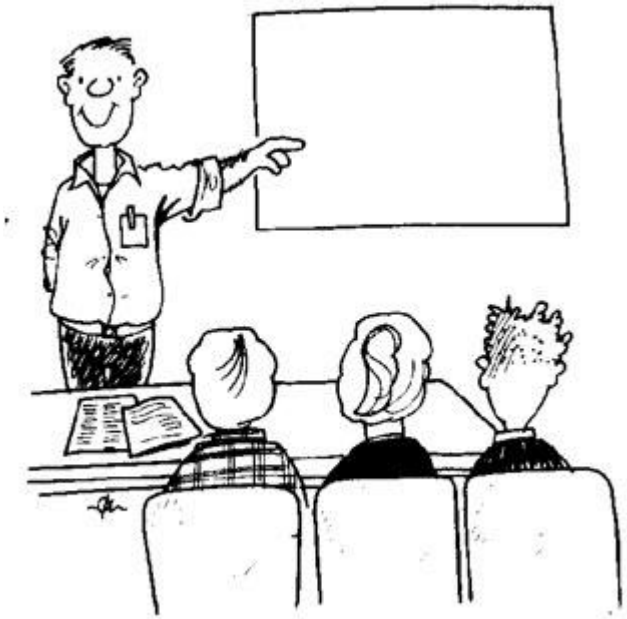
Permissible Exposure Levels (PEL)

- OSHA requires that employers provide a healthy workplace.
- Permissible Exposure Levels (PELs) are used to provide a level of exposure that is not harmful to employees.
  - Employers frequently control exposures to ½ PEL or to the "lowest achievable level."
  - Engineering controls are the primary method for hazard control.
  - Work procedures are the secondary method for hazard control.
  - Personal protective equipment is used when other controls are not feasible or are inadequate.

Employee Training

The most important component of safe chemical management

- Training must be thorough, frequent and focused on specific work tasks.
- Management must support training by providing adequate time and funding.
- Supervisors must lead by example.



Emergency Management

- Prepare for and prevent emergencies
  - Fires
  - Spills/releases
  - Injuries
- Emergency response must be part of basic work procedures and employees must be trained.
  - Evacuation
  - Fire brigade
  - Spill response
  - Medical response

Incident Investigations

- All incidents, regardless of severity, must be investigated and *lessons learned* used for prevention
- Formal investigation of serious incidents
- Accountability at all levels, from staff to management

Safety is everyone's responsibility

- Proper and safe chemical management
  - Part of the facility culture
  - Part of every employee's activity
  - Recognition of safety improvement

Four Elements of a Workplace Safety Program

1. Management, leadership and employee involvement
2. Worksite analysis
3. Hazard prevention and control
4. Safety and Health training and education

Management – Leadership - Employee Involvement

- Employer and employee involvement and communication on workplace-safety and health issues are essential.
- Post the company's written safety and health policy for all to see.
- Involve all employees in policy making on safety and health issues.
- Everyone must take an active part in safety activities.

ELEMENT #1: Involvement

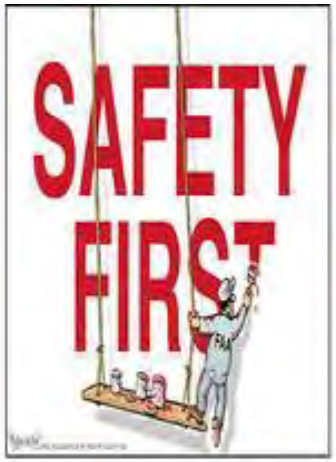
Basic Principles of Good Safety Management

- Management commitment
- Documented safety philosophy
- Safety goals and objectives
- Committee organization for safety
- Line responsibility for safety
- Supportive safety staff
- Rules and procedures
- Audits
- Safety communications
- Safety training
- Accident investigations
- Motivation

ELEMENT #1: Involvement

Basic Safety Philosophy

- Every incident can be avoided.
- No job is worth getting hurt for.
- Every job will be done safely.
- Incidents can be managed.
- “Safety is everyone’s responsibility”.
- Safety/best manufacturing practices
- Safety standards, procedures and practices must be developed.
- Training
  - Everyone must understand AND meet the requirements.
- Working Safely is a **condition of employment**.



ELEMENT #1: Involvement

Benefits of a Zero Incident Safety Policy

- Safety standards are communicated to all employees.
- Responsibilities for implementing standards are understood and accepted.
- Records document how standards and Best Management Practices (BMPs)are met.
- Internal management control.
- Cost avoidance.
- Improved quality.
- Better productivity.
- Team building.
- Unsafe behavior stands out.
- Unsafe behavior is unacceptable.
- Safe work is influenced through peer pressure.
- Consistent planning and task execution.

ELEMENT #1: Involvement

Key Safety Principles

- Working safely is a condition of employment.
- Each employee is expected to give consideration to the prevention of injury to self and co-workers.
- Involvement and thinking of all people in the safety process is valued and expected.
- Continual improvement is the goal.
- Individuals and teams must be recognized for their adherence to and advancement of safety.

ELEMENT #1: Involvement

Four Elements of a Workplace Safety Program

1. Management, Leadership and Employee Involvement
2. Worksite Analysis
3. Hazard Prevention and Control
4. Safety and Health Training and Education

Analyze all workplace conditions.

- Identify and eliminate existing or potential hazards.
- Outline the procedure for reporting hazards.
- Perform analysis on a regular and timely basis.
- Ensure employee understanding.
  - Current hazard analysis for all jobs and processes.
  - Emergency Response Plans and procedures.

Element #2: Worksite Analysis

Focus workplace design on all physical aspects of the work environment.

- Size and arrangement of work space.
- Physical demands of the tasks to be performed.
- Design of tools and other devices people use.
- The fundamental goal of a workplace design is to improve people's ability to be productive, without error or accident, for extended time periods.
    - Proper workplace design improves both safety and productivity.

Element #2: Worksite Analysis

Review incident causes

- Inspection results to help identify trends.
- Practice
  - Employee participation in drills

Element #2: Worksite Analysis

Four Elements of a Workplace Safety Program

1. Management, Leadership and Employee Involvement
2. Worksite Analysis
3. Hazard Prevention and Control
4. Safety and Health Training and Education

Regularly and thoroughly maintain equipment

- Ensure that employees know how to use and maintain personal protective equipment (PPE)
- Train employees in proper procedures for handling specific situations
- Emergency Action Plans and procedures - fire, life safety and first aid issues

ELEMENT #3 - Hazard Prevention & Control

Standard Operating Procedures

- Drug-free workplace
- Recognition and awards
- Audits and surveillances
- Incident reporting & investigation
- Lessons learned
- General safety SOPs – Let's discuss

ELEMENT #3 - Hazard Prevention & Control

Personal Protective Equipment (PPE)

- Use
- Maintain

ELEMENT #3 - Hazard Prevention & Control

Protect Employees from Workplace Hazards

- Employers must protect employees from hazards that can cause injury.
  - Falling objects
  - Harmful substances
  - Noise exposures
- Employers must:
  - Use all feasible engineering and work practice controls to eliminate and reduce hazards.
  - Use personal protective equipment (PPE) if the controls don't eliminate the hazards.
  - PPE is the last level of control.

ELEMENT #3 - Hazard Prevention & Control

Select the right PPE for the job.

ELEMENT #3 - Hazard Prevention & Control

Examples of PPE

Body Part	Protection
Eye	Safety Glasses, Goggles
Face	Face Shields
Head	Hard Hats
Feet	Safety Shoes
Hands and Arms	Gloves
Bodies	Vests
Hearing	Earplugs, Earmuffs

PPE Compliance

- Employer
  - Assess workplace for hazards.
  - Determine when to use PPE.
  - Provide PPE.
  - Provide PPE training.
- Employee
  - Use PPE in accordance with training received and other instructions.
  - Inspect daily.
  - Maintain in a clean and reliable condition.

ELEMENT #3 - Hazard Prevention & Control

PPE Summary: Employers must implement a PPE program

- Assess the workplace for hazards.
- Use engineering and work practice controls to eliminate or reduce hazards before using PPE.
- Select appropriate PPE to protect employees from hazards that cannot be eliminated.
- Inform employees why the PPE is necessary, how and when it must be worn.
- Train employees how to use and care for their PPE, including how to recognize deterioration and failure.
- Require employees to wear selected PPE.

Element #3 – Hazard Prevention & Control

Four Elements of a Workplace Safety Program

1. Management, Leadership and Employee Involvement
2. Worksite Analysis
3. Hazard Prevention and Control
4. Safety and Health Training and Education

Activity Hazard Analysis

Activity hazard analysis requires everyone to be proactive in **aggressively identifying hazards** that can be anticipated and **controlling** them rather than looking back with 20/20 hindsight.

ELEMENT #4 – Training and Education

Activity

Workers in their first year with their employer account for more than 50% of accidents.

Why?

(list three possible explanations)

ELEMENT #4 – Training and Education

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Activity Hazard Analysis - Key Terms

- What's the Job or Activity?
- What are the Hazards?
- What's an Exposure?
- What is Analysis?

ELEMENT #4 – Training and Education

Chemical Reactions

- Can be violent.
- Can cause explosions.
- Dispersion of materials and emission of heat, or acute bodily injuries through direct contact.

ELEMENT #4 – Training and Education

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Section 1 Quiz

Section 2

- The following slides are credited to the PA Department of Labor and Industry for the explanation of Chemical Hazard Communication Requirements.
- The slides are excerpts from a larger presentation on the subject.

Hazard Communication

pennsylvania
DEPARTMENT OF LABOR & INDUSTRY

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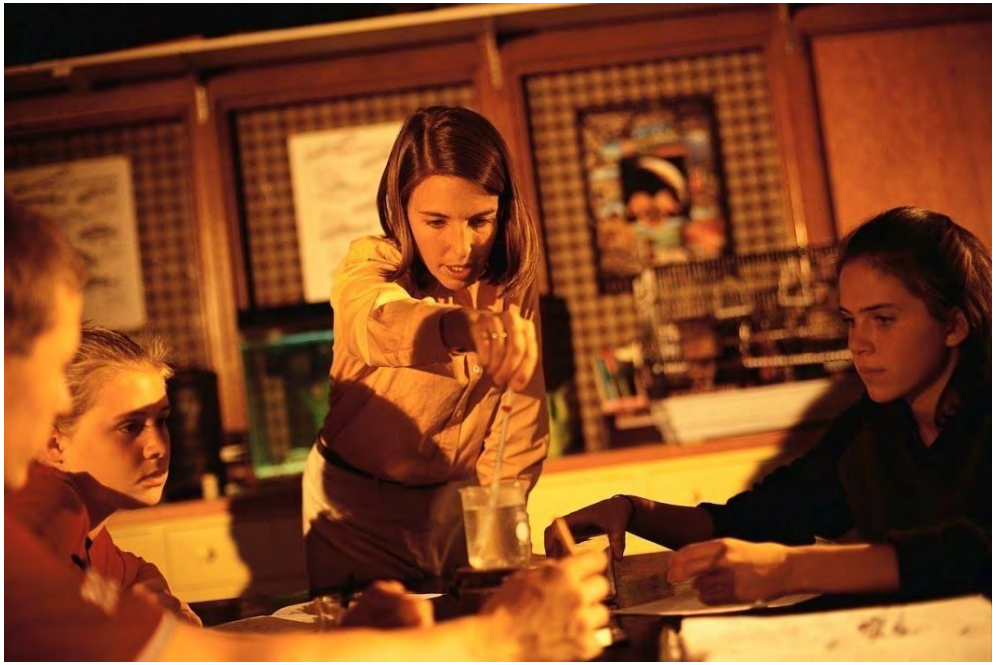
Hazard Communication

- OSHA
- 29 CFR 1910.1200
- (HCS-2012) & United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS, Rev 3)

Hazard Communication Standard (1910.1200)

- Intent - To provide employees with information to help them make knowledgeable decisions about chemical hazards in their workplace



Standard Requirements

- Written program for each location to cover issues of chemical safety and hazard communication (HAZCOMM)
- Labels to identify each chemical
- Material Safety Data Sheets (MSDSs) (now SDSs under the Globally Harmonized System: GHS)
- Safe work procedures/practices
- Employee training on SDS information and safe chemical procedures and practices

Training

- Upon initial employment
- When a new hazardous product/chemical is introduced into the workplace
- Change in process
- As deemed necessary by supervision/management

“Right to Know” Law

- Ensures all employees’ right to know the hazards of chemicals they work with at their job
- Mandates that employees must be provided with information about chemicals they work with through:
  - Information on chemical labels
  - Safety Data Sheets (SDSs)
  - Training on hazard communication
  - Written HAZCOMM plan

Why is a Standard Necessary?

- To evaluate the hazards of all chemicals imported into, produced, or used in workplaces in the United States
- To prevent or minimize employee exposure to chemicals
- Because chemical exposure can contribute to serious health effects:
  - Heart ailments
  - Burns/rashes
  - Kidney/lung damage
  - Sterility
  - Cancer
  - Central nervous system damage

Globally Harmonized System

GHS

- Created by United Nations
- A system for standardizing chemical classification and labeling for world-wide implementation

Labels

- Signal words
  - Danger/Warning
- Hazard statements
- Precautionary statements
- Pictograms (9)
  - SDS-16 categories
  - Training

GHS

- Rationale:
  - "To provide a single, harmonized system to classify chemicals, labels and SDS with the primary benefit of increasing the quality and consistency of information provided to workers, employers and chemical users"*
- Effective, in part, on June 26, 2012, with a built-in transition period and a fully effective date of June 1,2016

*Ruth Mayo, EHS Today, "GHS: The Power of One," December 1, 2009

Updating GHS/HCS

- The adoption of this will affect the OSHA 29 CFR 1910.1200 Hazard Communication Standard with changes
- GHS is updated every two years
- Hazard Communication Standard, (HCS), to remain current, can be updated by:
  - Technical updates (minor terminology changes),
  - Direct final rules (for text clarification), and
  - Notice and comment rulemaking (for more substantive updates or changes)

OSHA HazComm Modifications due to GHS

- Hazard classification of chemical hazards
  - Revised labeling provisions that include requirements for:
    - Standardized signal words
    - Pictograms
    - Hazard statements
    - Precautionary statements
  - Specified format for safety data sheets in 16 section format and Revisions to definitions of terms used in the standard and requirements for employee training on labels and Safety Data Sheets (SDS)

Other OSHA Label Elements for:

- Pyrophoric Gases:
  - Signal Word: Danger
  - Hazard Statement: “Catches fire spontaneously if exposed to air”
- Simple Asphyxiates:
  - Signal Word: Warning
  - Hazard Statement: "May displace oxygen and cause rapid suffocation”
- Combustible Dusts:
  - Signal Word: Warning
  - Hazard Statement: “May form combustible dust concentrations in the air”

Hazard Communication & Chemical Safety

- Chemicals are all around us every day
- Chemicals can be:
  - Corrosive
  - Reactive
  - Flammable
  - Explosive
  - Oxidizing
  - Inert

Chemical Safety

- In many cases, the chemicals you may deal with at work are no more dangerous than those you use at home.
- But in the workplace exposure may be greater, concentrations higher, exposure time longer: potential danger could be greater on the job.

Routes of Occupational Exposure

- Inhalation
  - Nearly all materials that are airborne can be inhaled
- Skin Absorption
  - Skin contact with a substance can result in a possible reaction
- Ingestion
  - Most workers do not deliberately swallow materials they handle
- Injection
  - Normally associated with bloodborne pathogens
- Ocular
  - Absorbed through the eyes

Hazards

- A chemical can pose a “physical hazard” or a “health hazard”
- The hazard communication standard applies to both types of hazards
- GHS looks at:
  - Class-nature of hazard
  - Category-degree of severity

Physical Hazards

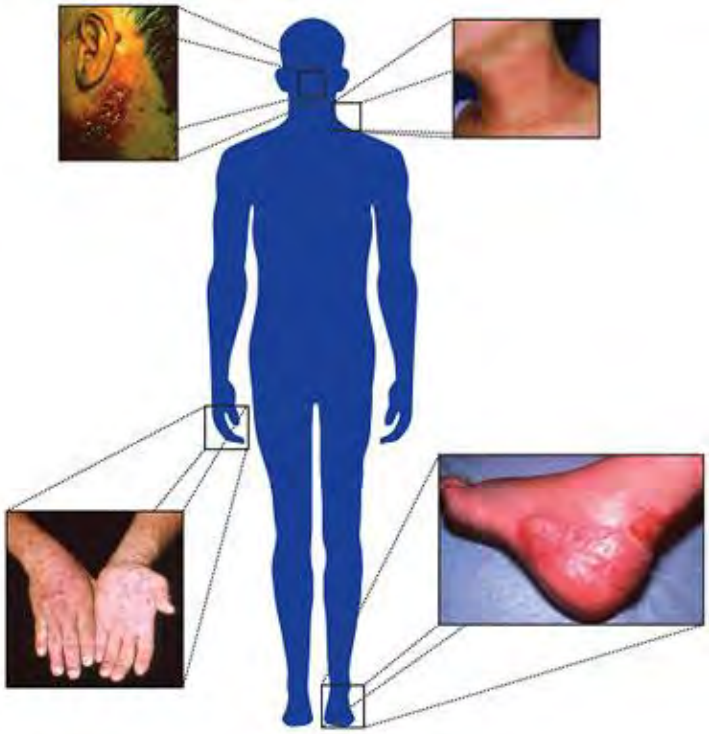
- Physical hazards are exhibited by certain chemicals because of their physical properties (e.g. flammability, reactivity, etc.)
- These chemicals fall into the following classes
  - Flammable liquids or solids
  - Combustible liquids
  - Compressed gases
  - Explosives

Physical Hazards

- Organic peroxide
  - May react explosively to temperature/pressure changes.
- Oxidizers
  - Chemicals that initiate or promote combustion in other materials.
- Pyrophoric materials
  - May ignite spontaneously in air temperatures of 130°F or below
- Unstable materials
- Water reactive materials

Health Hazard

- Occurs when a chemical produces an acute or chronic health effect on exposed employees



Acute Health Effects

- Happen quickly
- High, brief exposure
- Examples:
  - Carbon monoxide poisoning
  - Cyanide inhalation
  - Hydrogen sulfide inhalation

Chronic Health Effects

- May be caused by chemical exposures that do not cause immediate, obvious harm or make you feel sick right away
- May not see, feel, or smell the danger
- Effects are long, continuous and follow repeated long-term exposure
  - Lung cancer from cigarette smoking
  - Black lung from coal mine dust

Keeping It Safe

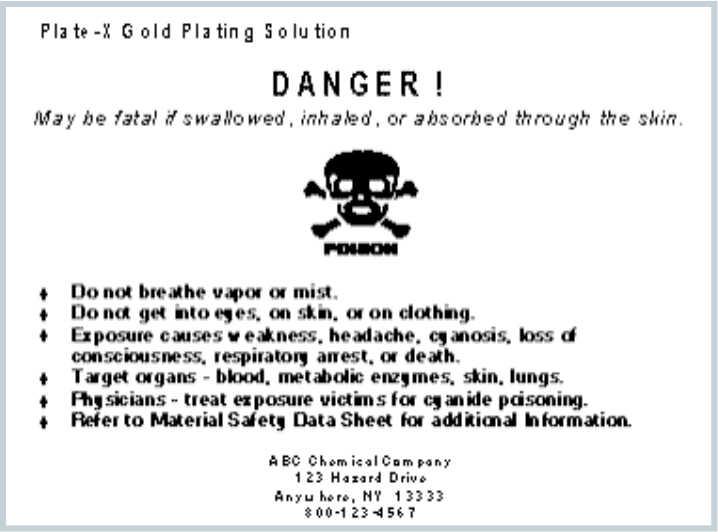
- Corrosives, solvents and other chemical substances can be potentially dangerous
- Safe handling procedures
  - Read container labels
  - Check SDS(s)
- Never sniff a chemical for identification
- Use appropriate personal protective equipment

Labeling

- Example of one type of labeling system used

Chemical Labels

- Each container must be labeled, tagged or marked.
- Warning can be a message, words, pictures or symbols.
- Labels must be written in English and prominently displayed.

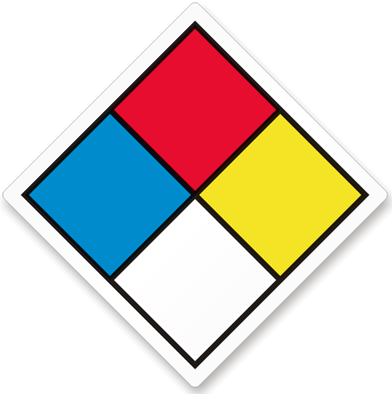


Reading Chemical Labels

- Warning labels provide important information about the chemical:
  - DANGER
  - WARNING
- Always read the label before you begin a job using a potentially hazardous chemical

GHS Comparison

- GHS classification ratings order of severity differ from NFPA and HMIS:
  - HMIS/NFPA
    - 0 = Least Hazardous
    - 4 = Most Hazardous
  - GHS
    - 5 = Least Hazardous
    - 1 = Most Hazardous



Health Hazard

- Used to describe:
  - Carcinogen
  - Mutagenicity
  - Reproductive toxicity
  - Respiratory sensitizer
  - Target organ toxicity
  - Aspiration toxicity
  - Germ cell mutagens

Flame

- Describes:
  - Flammables
  - Pyrophorics
  - Self-heating
  - Emits flammable gas
  - Self-reactives
  - Organic peroxides

Exclamation Mark

- Describes:
  - Irritant (skin and eye)
  - Skin sensitizer
  - Acute toxicity (harmful)
  - Narcotic effects
  - Respiratory tract irritant
  - Hazardous to ozone layer (non-mandatory)

Gas Cylinder

- Describes:
  - Gases under pressure

Corrosion

- Describes:
  - Skin corrosion/burns
  - Eye damage
  - Corrosive to metals

Exploding Bomb

- Describes:
  - Explosives
  - Self-reactives
  - Organic peroxide

Flame Over Circle

- Describes:
  - Oxidizers

Flame Over Circle

- Describes:
  - Oxidizers

Anything wrong with this picture?

Flame Over Circle

- Describes:
  - Oxidizers

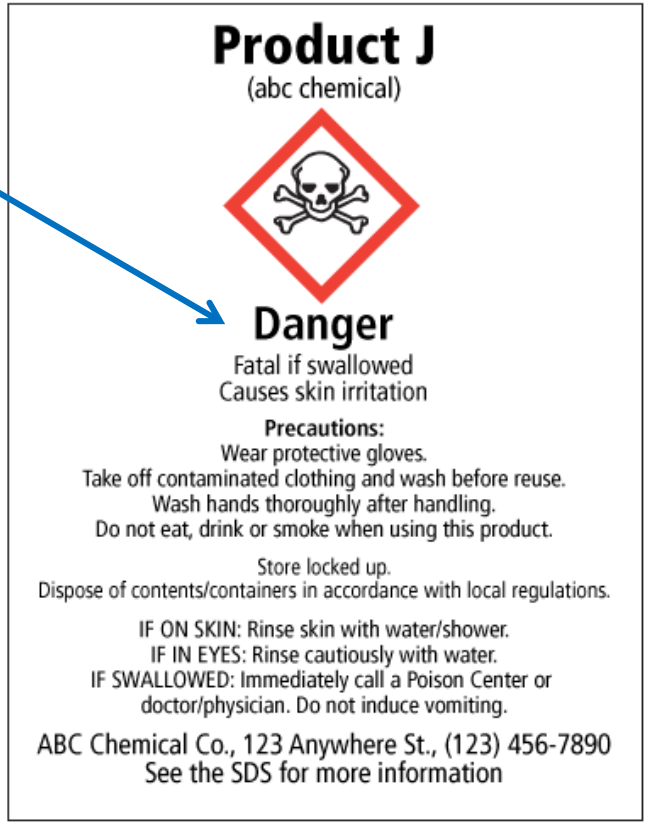
Anything wrong with this picture?
YES!
Unsafe storage. Cylinders falling over.

Skull and Crossbones

- Describes:
  - Acute toxicity (fatal or toxic)

Signal Word

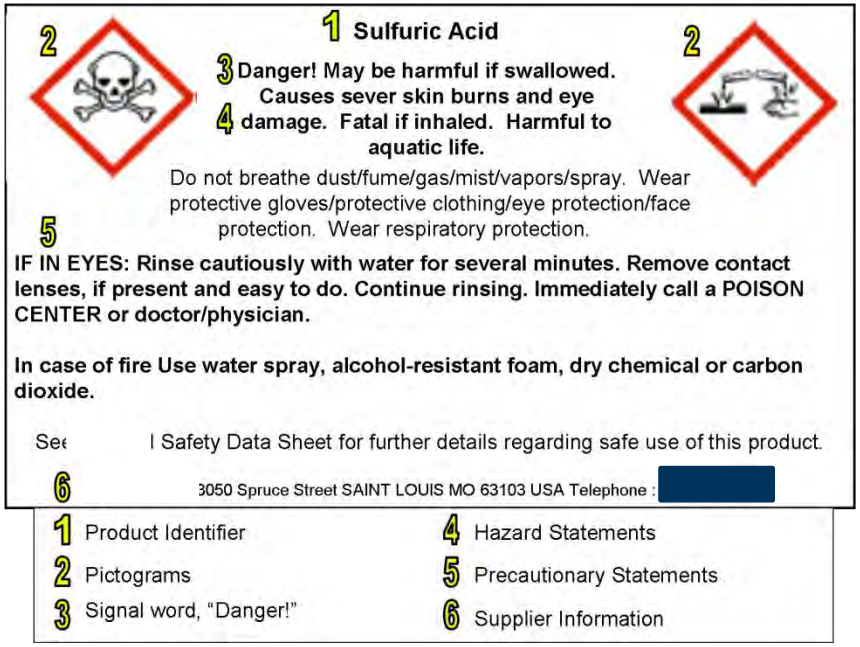
- A single word indicating relative hazard severity
- “Danger” for more severe hazards
- “Warning” for less severe hazards



Warning

Labels

- Information required on a GHS label:
  1. Product identifier
  2. Pictograms
  3. Signal word
  4. Hazard statement
  5. Precautionary statement
  6. Supplier information



SDS

- Under the GHS, MSDSs (material safety data sheets) become SDS (safety data sheets)
- Categories (16) to be listed in a specific order
- Adheres to ANSI standard Z400.1
- GHS requires new SDSs be in uniform format by June 1, 2015
- Information for mixtures not individual chemicals in a mixture

SDS

- Safety Data Sheet
- Developed by chemical manufacturers and importers
- An SDS must be on hand for each hazardous chemical used

Technical Publication

Calor Safety Data Sheet - Liquefied Propane Gas

Data Sheet No 2 Revision 8 Replaces Revisions 03/00, 04/03, 08/05, 03/06, 06/09, 02/10, 12/10

This data sheet has been prepared in accordance with the requirements of Article 31 of EU Regulation 1907/2006 (as amended) on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

1. Identification of the Substance or Preparation and of the supplier

Identification of the substance or preparation:	Calor Liquefied Propane Gas including products marked as Calor Propane Calor Autogas, Calor Patio Gas & Calor High Purity Propane
Substance Type:	Petroleum product
Physical Status:	Liquefied Gas
Use of the substance or preparation:	Calor Liquefied Propane is a multi-purpose product intended for uses including fuels for equipment which has been specifically designed to run on commercial propane, an internal combustion engine fuel feedstock for the petrochemical industry
Company:	Calor Gas Limited
Address:	Athena House, Athena Drive, Tachbrook Park, Warwick, CV34 6RL
Telephone:	01926 330088
Emergency Number:	0845 7 444 999
Web Address:	www.calor.co.uk
Technical Help Desk	0845 602 1143

2. Hazard Identification

- Extremely Flammable (F+)
- Readily forms and explosive air-vapour mixture at ambient temperature.
- Vapour is heavier than air and may travel to remote sources of ignition (e.g. along drainage systems, into basements etc.).
- Liquid leaks generate large volumes of flammable vapour (approximately 250:1).
- Cold burns (frostbite) will result from skin/eye contact with liquid product
- Liquid release or vapour pressure jets present a risk of serious damage to the eyes.
- Abuse involving wilful inhalation of very high concentrations of vapour, even for short periods can produce unconsciousness and might prove fatal. Inhalation may cause irritation to the nose and throat, headache, nausea, vomiting, dizziness and drowsiness. In poorly ventilated or confined spaces, unconsciousness or asphyxiation may result.

3. Composition and Information on Ingredients

Description
Liquefied petroleum gas consisting predominately C_3 Hydrocarbons supplied as a fuel in a closed system meeting the requirements for commercial propane of BS4250.

As a liquefied petroleum gas, which occurs in nature and is not chemically modified, this is exempted from Titles II (Registration), V (Downstream Users)

104800 V 8 07/11- Calor Liquefied Propane Gas Safety Data Sheet
Published by the Safety, Health and Environment Department

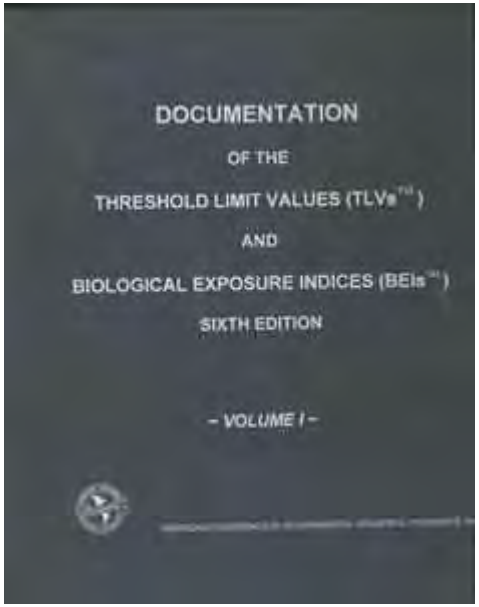
Page 1 of 9

Information on a SDS

- Chemical names
- Manufacturer info (name, address and telephone numbers)
- List of chemical ingredients
- Permissible exposure limits (PELs) and threshold limit values (TLVs)

Information on a SDS

Any other exposure limit used or recommended by chemical manufacturer, importer or employer preparing the SDSs now are required on the SDS



Information on a SDS

- Reactions with other chemicals
- Physical appearance
- Date of preparation
- Plus:
  - How to put out a fire caused by a chemical
  - How to handle spills
  - How to prevent dangerous exposures

Where are your SDSs?

- SDSs:
  - Must be readily accessible to employees during their work shift
  - Are typically kept in a centralized location
  - Must be updated as new information becomes available

SDS Categories

- Section 1: Identification
- Section 2: Hazard identification
- Section 3: Ingredients
- Section 4: First-aid measures
- Section 5: Fire fighting measure
- Section 6: Accidental release measures
- Section 7: Handling and storage

SDS Categories

- Section 8: Exposure controls and personal protection
- Section 9: Physical and chemical properties
- Section 10: Stability and reactivity
- Section 11: Toxicological information
- Section 12: Ecological information*
- Section 13: Disposal considerations*
- Section 14: Transport information*
- Section 15: Regulatory information*
- Section 16: Other information

*OSHA indicated that since other agencies regulate sections 12-15, OSHA will not be enforcing them

Written Hazard Communication Plan

- The standard requires industry:
  - To develop and implement a written hazard communication program
  - To provide hazard communication training for employees:
    - Initially (to newly hired personnel)
    - Whenever a new hazard is introduced into the workplace

Special Hazards

- Management of process spills or leaks:
  - Implement the facility's emergency control program
  - Secure the area

Summary

- All facilities should have a hazard communication plan in a location that is accessible to all employees.
- All hazardous products should be labeled and all employees should be aware of what and where they are.
- SDSs should be available and accessible for all hazardous products.

Do you see any problems here?

Do you see any problems here?

Large containers balanced on edge of shelf- not safe

If chemical, coffee can is not proper type of storage container

Maybe improperly labeled container- what's in the coffee can?
Coffee not allowed with chemicals; if chemical, not labeled properly.

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Laboratory Safety

Acquisition Recommendations

- Order the smallest quantity possible for each chemical
  - No discounts, but final cost is less
- Never accept “left-over” or “donated” chemicals
  - There’s no guarantee of its purity
  - If you don’t normally use it, you probably don’t need it

VS.

Safe Storage & Handling

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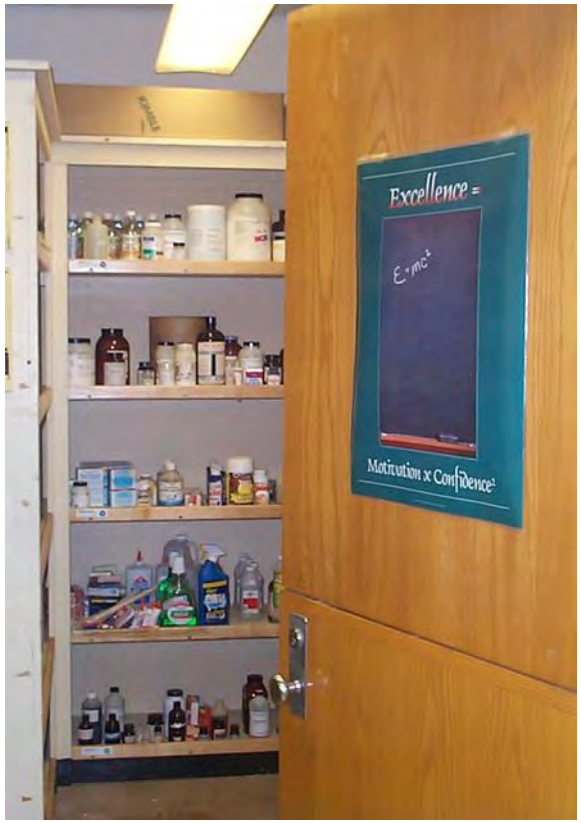
Recommended Practices



Examine your currently available storage space

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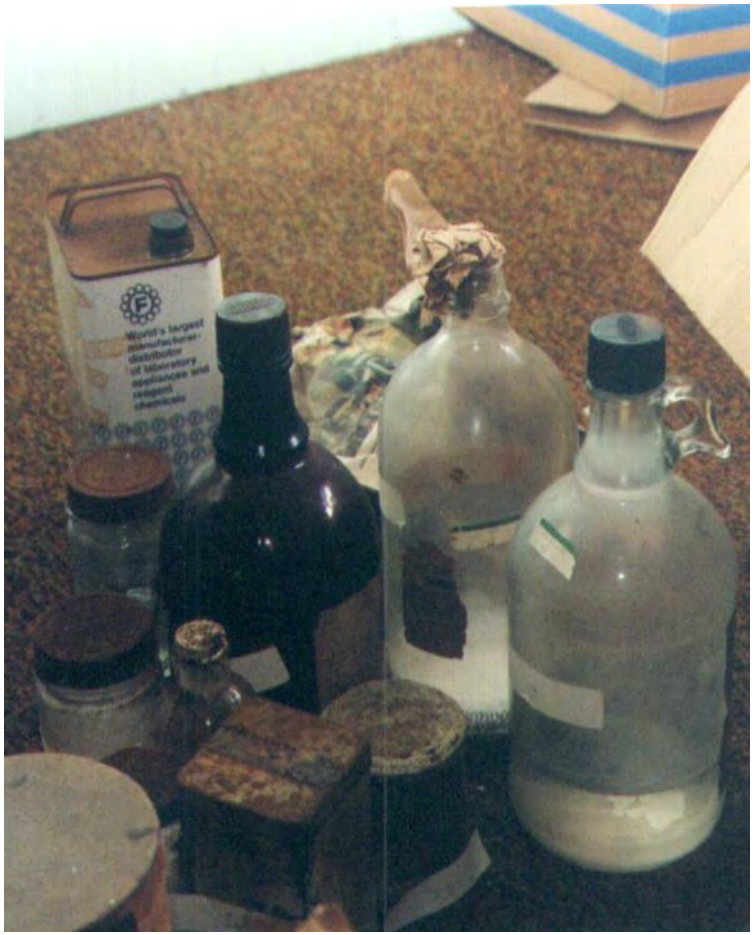

Avoid floor clutter

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Avoid shelf clutter

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Avoid desk clutter

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Use storage containers for small or loose items

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Arrange containers based on compatibility

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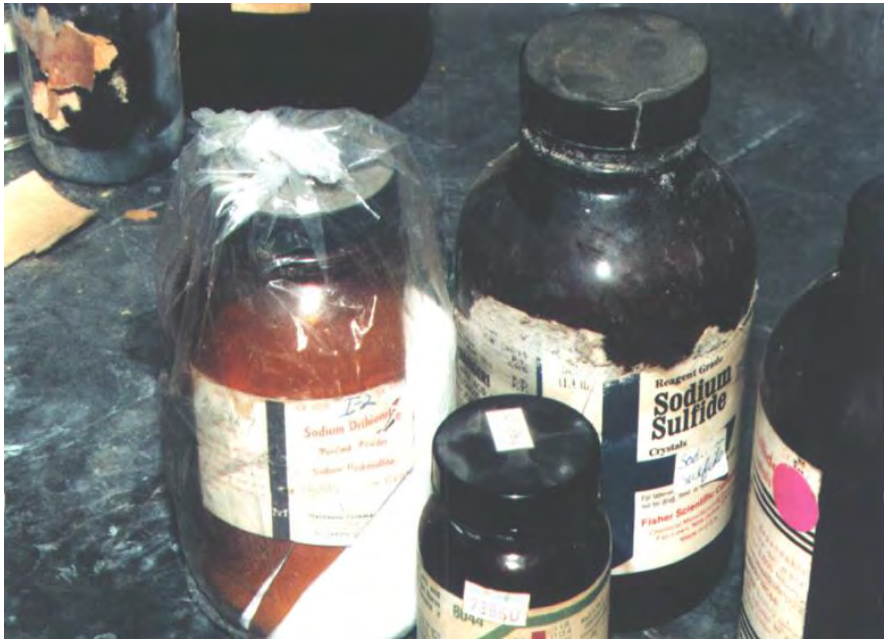

Keep your containers in good condition

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Use edging to prevent containers from falling off.

Sturdy shelving units

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Store acids in an Acid Cabinet

SSM

Store flammables in a Flammables Cabinet

SSM

Avoid overhead storage

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An eye wash unit and / or emergency shower nearby (but not in the storage room)

Additional Safety Measures

Ensure adequate ventilation for:

- Chemical storage areas
- Chemical preparation areas
- For volatile compounds use a fume hood!
- Chemical use areas

Additional Safety Measures

- Emergency gas shut-off valve

Additional Safety Measures

- Retractable electrical outlets

Additional Safety Measures

- “Frequently used chemicals should be ordered in bulk.”
- “Ordering in bulk is the best deal for the money.”
- “Accept any donated chemicals…”
- “I’ll remember what I put in that jar.”

Remember these costly phrases:

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Label everything clearly

Appropriate containers in good condition

Be neat and orderly

Store only what you will use

Always wear protective clothing

Food allowed in eating areas only

Everything in its place on a shelf

Time to inventory & organize

Your safety is important

LAB SAFETY

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Section 2 Quiz

Section 3

Examples of Chemical Feed Systems

Sodium Hypochlorite

- The liquid form of chlorine
- Clear and has a slight yellow color
- Ordinary household bleach (~5% chlorine by solution) is the most common form
- Industrial strength: 12% and 15% solutions
- Can lose up to 4% of its available chlorine content per month; should not be stored for more than 60 to 90 days
- Very corrosive; should be stored and mixed away from equipment that can be damaged by corrosion

Diaphragm Pump/Tank for Chlorine

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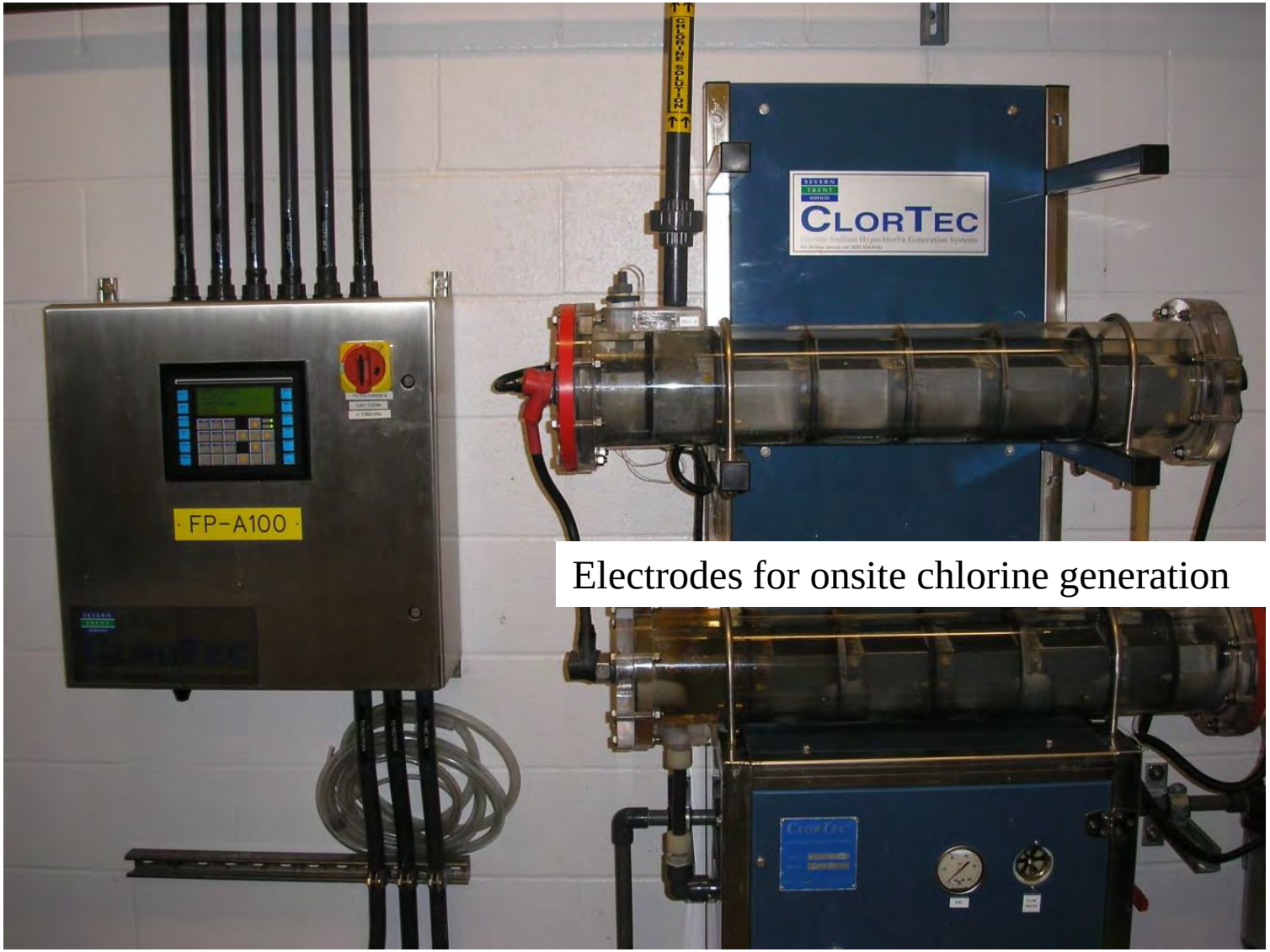
On-site generated sodium hypochlorite

- 0.8% sodium hypochlorite is produced on demand by combining salt, water & electricity
- Electrolysis of brine solution produces sodium hydroxide and chlorine gas, which then mix to form sodium hypochlorite
- Hydrogen gas byproduct; vented to atmosphere
- Alleviates safety concerns associated w/ hauling and storing bulk chlorine
- Higher initial cost, high power cost
- Mixed oxidants (proprietary)



Electrodes for onsite chlorine generation

Calcium Hypochlorite

- The solid form of chlorine
- Usually tablet or powder form
- Contains ~65% chlorine by weight
- White or yellowish-white granular material and is fairly soluble in water
- Important to keep in a dry, cool place
- More stable than liquid
- Used by small systems w/ low flows or no power

Calcium hypochlorite erosion feeder

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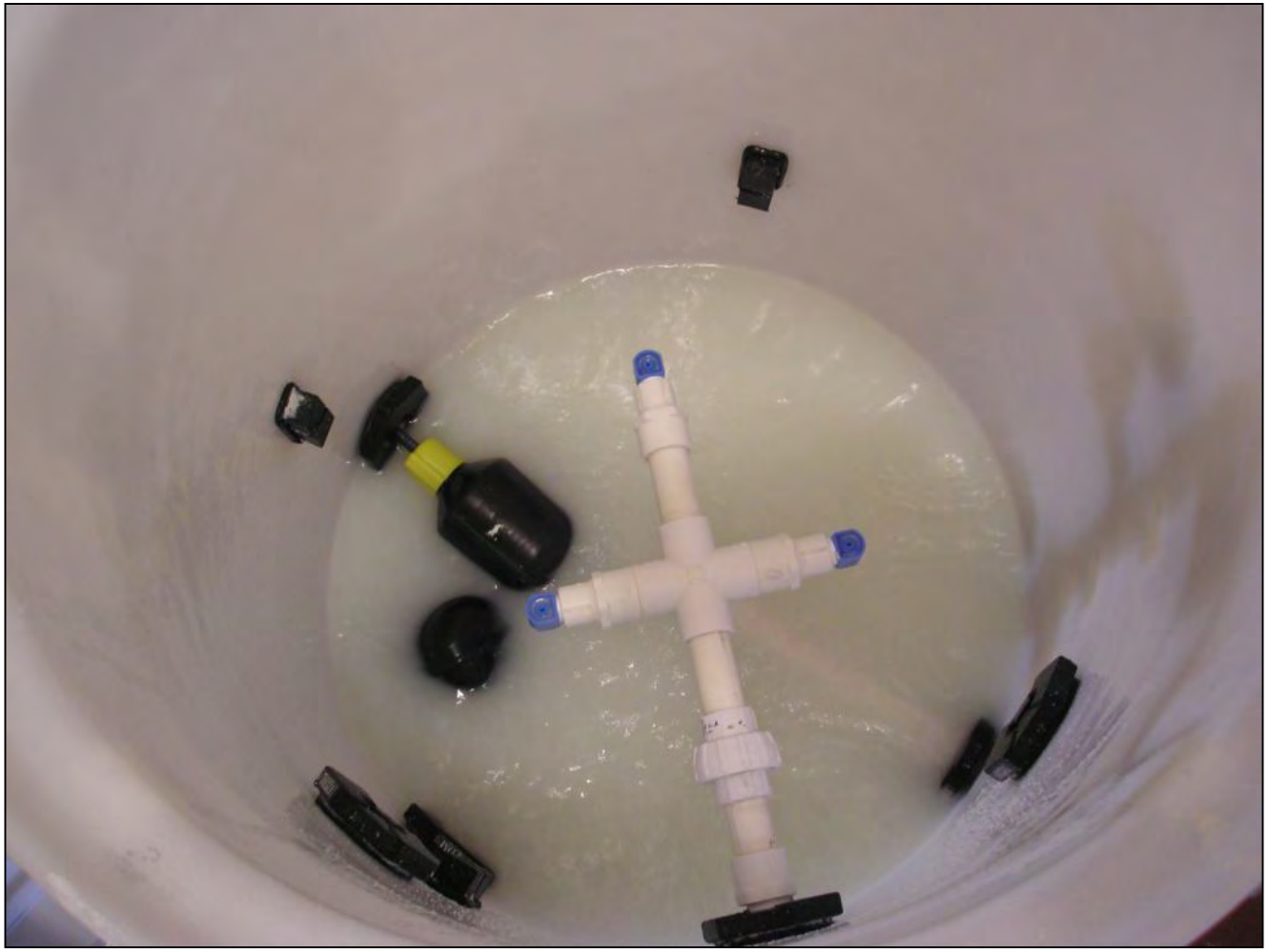

Calcium hypochlorite hopper interior

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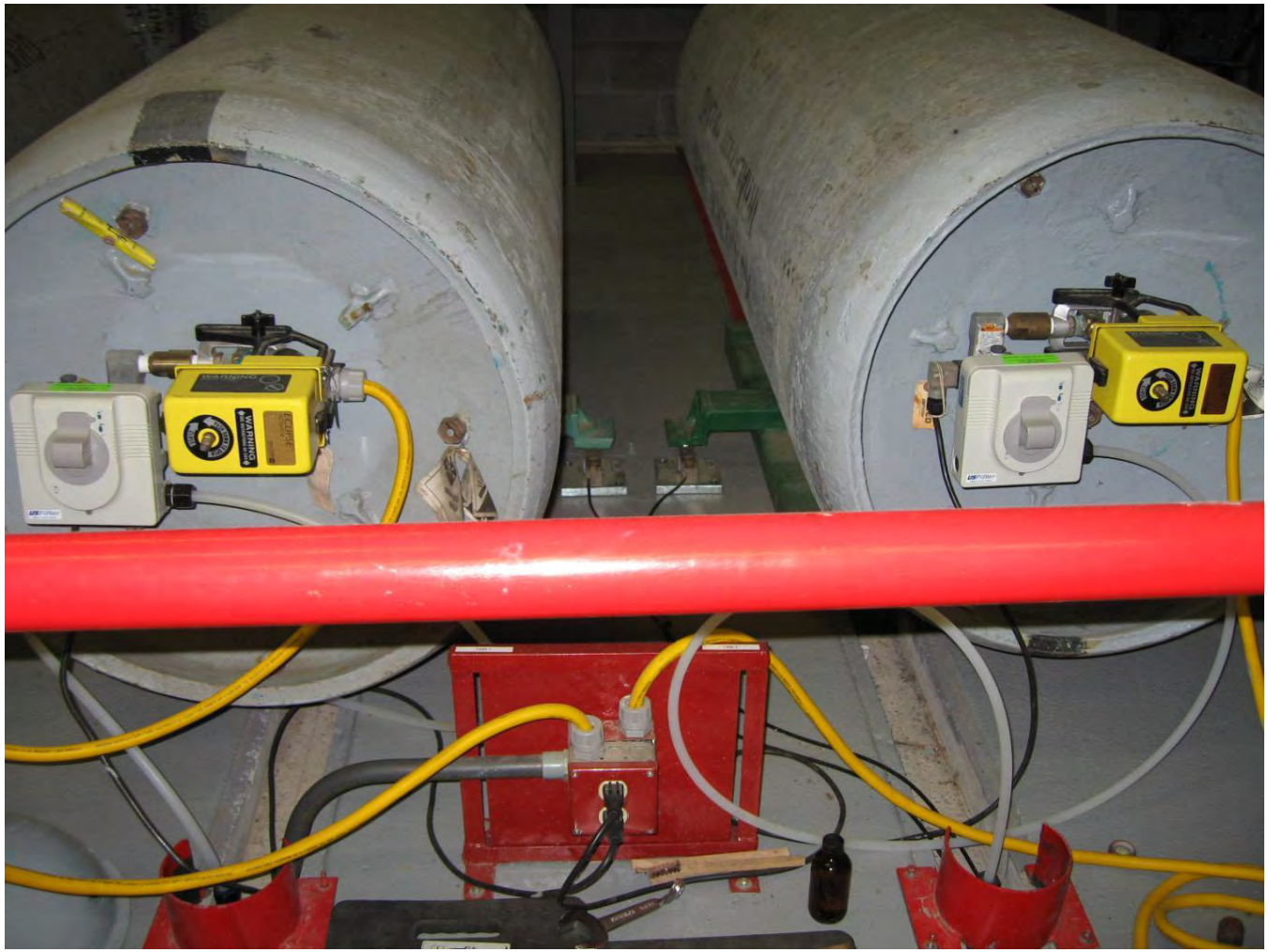
Chlorine Gas (Cl2)

- 99.5% pure chlorine
- Yellow-green color 2.5x heavier than air
- Liquefied at room temperature at ~107 psi – hence the pressurized cylinders actually contain liquefied chlorine gas
- Liquefied Cl2 is released from tanks as chlorine gas, which is then injected into the water stream
- Usually used only by large water systems
- Smaller systems may find initial cost of operation prohibitive



1-ton chlorine gas cylinders

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Note: scales used to weigh cylinders (to tell when they are empty)

1-ton chlorine gas cylinders

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Chain to secure tank in place

Spare tank on hand

Tanks clearly marked

150-lbs chlorine gas cylinders

Chloramines

- Chlorine + ammonia = chloramination
- Two advantages to regular chlorination:
  - Produces a longer lasting chlorine residual (helpful to systems with extensive distribution systems)
  - May produce fewer by-products depending on the application
- Disadvantage:
  - Needs a lot of contact time to achieve CTs compared to free chlorine (300 times more) which is why not used for primary disinfection
  - Requires specific ratio of chlorine to ammonia or else potential water quality problems

Ammonia for making chloramines

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Ozone

- Colorless gas (O_3)
- Strongest of the common disinfecting agents
- Also used for control of taste and odor
- Extremely unstable; Must be generated on-site
- Manufactured by passing air or oxygen through two electrodes with high, alternating potential difference

Large water system ozone

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Large water system ozone

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Ozone Contactors

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- Ozone is too reactive to store, so liquid oxygen is used for making ozone

Ozone & Liquid Oxygen

Storage Tanks and Containment

Example Storage Tanks (Containers)

- Single-wall Aboveground Storage Tank (AST)
  - Has one wall to contain the contents of the tank, typically older fuel and oil tanks were single-wall construction. Some form of containment is required when storing oil.
  - Typically admixture tanks are single-wall polyethylene tanks.
  - Industrial Bulk Containers (IBC) totes and drums are typically single-wall.
- Double-wall AST
  - The primary tank is wrapped by an exterior tank that may be in contact with the primary tank (a tank within a tank). The outer tank has the capacity to capture the inner tank contents should a leak develop. This interstitial space between the tanks can be checked for signs of leakage during regular inspections.

Storage Tanks and Containment

Example: storage tanks (containers)

- Industrial Bulk Containers (IBC) Totes
  - Typically these totes are single-wall and range in size from 275 to 330 gallons. Many chemicals such as admixtures and form oils are shipped in totes. Containment would also be required if storing oil.
- Drums
  - 55 gallon drums are an industry favorite for a variety of chemicals. They come in a multitude of materials and sizes ranging from 10 gallons all the way to 95 gallons. Some form of containment is required when storing oil.

Single-Wall Steel AST in Plastic Containment

Steel Oil ASTs not in Containment

10,000 Gallon Diesel Double-Wall Steel AST

55 Gallon “Oil” or Larger Drums

Plastic Admix Tanks in Containment

Industrial Bulk Containers (IBC Totes)

Storage Tank Examples

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- Variety of shapes and sizes
- EPA uses the term "bulk storage container".
  - 55 gallons or larger
  - Everything from a drum to the 10,000 gallon or larger diesel Aboveground Storage Tank (AST) at your facility is a bulk storage container.

What is a Storage Tank?

- Chemicals stored in bulk should be provided with secondary containment.
- With multiple tanks, the secondary containment should cover the tank with the largest volume.

Storage Tanks

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Section 3 Quiz

Wrap Up/Evaluation