Manufacturing Safety Conference

Managing Toxic Chemical Processes / Process Gases in Manufacturing

Pallas Athene Consulting Inc 26 Oct, 2010

Session Objectives

Purpose of this Session:

To familiarize participants with the hazards associated with Toxic Chemical Processes / Gases in Manufacturing

At the end of this Session you should be able to:

A. Identify hazards involved with typical Toxic Process Gases

B. Describe the Worksafe BC (WSBC) criteria related to Toxic Process Gases

C. Discuss safety requirements for Toxic Process Gases

Ω

Common Process Gases (*generalization*)

Food Grade Compressed / Process Gases

Nitrogen, CO2, Argon, Helium

Industrial Process Gases

ACETYLENE
AIR
ALIGAL™ - FOOD GRADE
AMMONIA
ARCAL™- PREMIUM SHIELDING GAS
BLUESHIELD™ - SHIELDING GAS
HYDROGEN
LASAL™ - LASER GAS
OXYGEN

Where / How do we get Process Gases to our site / facility?

Three most common ways to supply Ultra-High-Purity (UHP) Process Gases to a facility are:

1. **On site gas production plant**

2. **Bulk delivery to onsite storage tanks**

3. **Individual gas cylinders**

1. On site gas production plant

- Installed if you need large quantities of UHP Process Gas
  (ie: Nitrogen (N_2), Hydrogen (H_2), Oxygen (O_2))
- UHP product delivered at a much lower cost than alternatives

Advantages

: do not have to place orders / wait for delivery

: *NO* containers; cylinders; liquid gas to handle

Disadvantages

: real estate to install UHP gas generating equipment

: significant piping systems to distribute UHP gas

2. Bulk delivery to onsite storage tanks

- where certain industries (ie: semiconductors) require large quantities of specific types of UHP Process Gases
  (ie: Argon; CO_2; H_2; N_2; O_2)
- delivery of UHP process gas from a gas company's production facility to bulk storage tanks located at the end-user's facility

Advantages

: bulk storage tanks: can be rented or owned

: ability to have large quantities of UHP gases in high volumes

Disadvantages

: transfer of UHP Process gas during delivery

: significant piping systems to distribute UHP gas

3. Individual gas cylinders

- common where UHP gas volume requirements are small
- if consumption rate increases, can easily add multiple cylinders through a designed manifold delivery system

Advantages

: ability to have unlimited quantities and varieties of UHP Process Gases for different processes

Disadvantages

: *STORAGE* – may require several separate gas storage rooms depending on UHP Process Gas characteristics

: Cylinders – are *HIGH PRESSURE* storage containers

A – HAZARDS

Classes of Toxic Process Gases

Compressed gasses typically found in manufacturing processes are generally classified as:

i Oxidizers –	Air; Fluorine; Chlorine; Nitric Oxide, Oxygen
ii Inert –	Argon, Carbon Dioxide, Helium, Nitrogen, Xenon
iii Flammable –	Ammonia, Ethylene, Hydrogen, Methane, Propane, Butane

(WHMIS Classes: A, B, C, and D)

1 – HAZARDS

WHMIS Classes of Process Gases

Class A

Inert compressed gases: Argon; CO_2; Helium; N_2

Class B

Flammable / Combustibles (Divisions 1, 5): Butane; iso-Butane; Propane

Class C

Oxidizing Material – Contribute to combustion: Cl_2; Fl_2; O_2

Class D

Poisonous and Infectious Material (Division 1 – Materials causing immediate and serious toxic effects): Cl_2; Ethylene Oxide; O_3

Toxic Chemical Processes / Gases

Are there any health and safety consequences related to chemical processes / process gases?

Consequences:

Millard Refrigeration Services

Theodore, Alabama 23rd August, 2010 **(~ 130 seek medical attention)**

American Cold Storage

Louisville, Kentucky 14th May, 2009 **(2 fatalities)**

Mountaire Farms

Lumber Bridge, NC 20th June, 2009 **(1 fatality)**

Tanner Industries

Swansea, SC 15th July, 2009 **(1 fatality)**

CF Industries

Rosemount, MN 16th Nov, 2009 **(2 fatalities)**

CSB Conducting Assessment of Ammonia Release at Millard Refrigerated Services South of Mobile, Alabama

August 27, 2010

Washington DC, August 27, 2010 - A three-member assessment team led by Mr. Johnnie Banks from the U.S. Chemical Safety Board (CSB) is deploying to the scene of Monday's anhydrous ammonia release at the Millard Refrigerated Services, a warehouse and distribution center in Theodore, Alabama, 15 miles south of Mobile.
According to media reports, more than 130 members of the public sought medical attention and four people remain hospitalized as a result of the uncontrolled ammonia release.

CSB Chairperson Rafael Moure-Eraso said, "We are seeing too many ammonia releases in our daily incident reviews. Though many are "small" releases, a high consequence accident that causes multiple injuries to members of the public is a serious one that warrants our examination. Our team will be examining the events that led to the release and ways that the community can be better protected in the future."

Anhydrous ammonia is one of the most commonly used commercial refrigerants; it is a colorless, flammable, toxic gas. For humans, high exposure levels can result in suffocation as well as severe injuries to eyes, lungs and the digestive system.

Based on the CSB's monitoring of media reports there were four high consequence incidents involving the release of anhydrous ammonia which led to a total of six fatalities in 2009:

- May 14, 2009: American Cold Storage, Louisville, KY 2 fatalities
- June 20, 2009: Mountaire Farms, Lumber Bridge, NC 1 fatality
- July 15, 2009: Tanner Industries, Swansea, SC ? fatality
- November 16, 2009: CF Industries, Rosemount, MN 2 fatalities

NEWS ROOM
Request Speaker Form
Media Resources
News Releases

Injured worker transported after the NH_3 leak from Millard Refrigerated Services, Monday, Aug. 23rd, 2010

B - Worksafe BC (WSBC) criteria related to Toxic Process Gases

Worksafe BC (WSBC) OHS Regulation

Part 6: Substance Specific Requirements

Sections 6.116 to 6.132

(a total of 17 regulatory requirements)

Worksafe BC (WSBC) OHS *GUIDELINES*

(a total of 8 interpretive Guidelines)

B - Worksafe BC (WSBC) criteria (continued)

6.116 – *Definition:* WHMIS Class D, Division 1, Subdivision A: very toxic acute health effect material used as a:

- precursor

- refrigerant

- treatment of materials (disinfection)

6.117 – Application

B - Worksafe BC (WSBC) criteria (continued)

6.118 – Risk Assessment

- WSBC Guideline G-5.54 – 3

6.119 – Exposure Control Plan

- OHS Reg 5.54

6.120 – Procedures

6.121 – Education / Training

6.122 – Enclosure

6.123 – Testing

6.124 – Ventilation

B - Worksafe BC (WSBC) criteria (continued)

6.125 – Emergency Ventilation

6.126 – Shut down device

6.127 – Personal Protective Equipment

6.128 – Monitors / Alarms

6.129 – Pressure Relief Alarm Systems

6.130 – Identification of Controls

6.131 – Piping Systems

6.132 – Maintenance

B - Worksafe BC (WSBC) criteria (continued)

Guidelines:

G6.116-2:	Definition of “toxic process gas”
G6.118:	Risk Assessment
G6.122:	Exhaust Ventilation (122-2)
	Access and Egress (122-3)
	Authorized personnel (122-4)
G6.123:	Testing
G6.124:	Ventilation
G6.127:	Personal Protective Equipment

C - Safety requirements for Toxic Process Gases

US EPA:

"Accident Prevention and Response Manual

for

Anhydrous Ammonia Refrigeration System Operators"

(March, 2006)

http://www.epa.gov/region07/toxics/pdf/accident_prevention_ammonia_refrigeration.pdf

ACCIDENT PREVENTION AND RESPONSE MANUAL

for

Anhydrous Ammonia Refrigeration System Operators

U.S. Environmental Protection Agency Region 7

March 2006
(Third Edition)
EPA-907-B-06-001

C - Safety requirements for Toxic Process Gases (continued)

Chapter 3: Preventing Accidents

System design, modification and protection

- Identify locations for installing "self-closing" valves
- NH_3 – spring-loaded ¼ turn ball or globe valve (self-closing valve) with an oil drain container is considered a best practice
- However maintenance staff must ***NEVER*** leave such valves unattended

C - Safety requirements for Toxic Process Gases (continued)

Protect Equipment, Tanks, Piping

- warning signs; bang plates
- installing horizontal / vertical structural components to prevent products (pallets or stacked material) from falling against equipment
- blocking access to storage bins / vessels / containers
- installing: concrete curbs, barriers, bollards to prevent impact against piping systems storage vessels

C - Safety requirements for Toxic Process Gases (continued)

Install, Maintain and Inspect Detector Systems

- Operation of sensors and alarms should be checked and calibrated regularly to ensure alarm integrity
- Example alarm problems:
  - calibrated to incorrect alarm levels *(EL, STEL, CEILING, IDLH)*
  - detectors do not function properly
  - not properly calibrated

"BEST Practice (NH_3)": calibrated every 6 months

Alarm = 50 PPM outside mechanical room

= 300 PPM inside mechanical room

C - Safety requirements for Toxic Process Gases (continued)

Install Emergency Ventilation Switches

- Manually – remotely activate system at a time of need

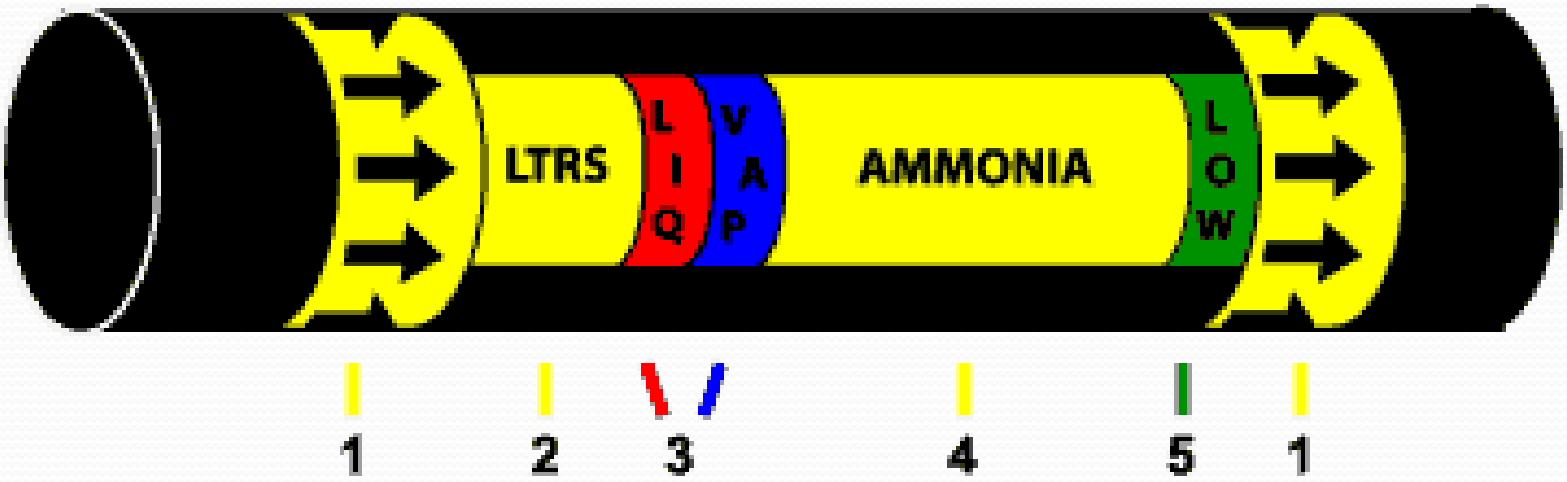
- Automatically – activate the ventilation system from the alarm / detection system

C - Safety requirements for Toxic Process Gases (continued)

Color Coding / Labeling

- ensure facilities engineering drawings or Piping and Instrumentation diagrams (P&IDs) are up to date
- arrows to indicate direction of flow
- abbreviations to identify system components
- identify the “phase” of the material (liquid; vapor; gas)
- identify internal pipe pressures (High vs Low)
- write on the piping (appropriately)

Color Coding / Labeling



***NOTE*: Some Industry-based Specifications may apply –**

IIAR – International Institute of Ammonia Refrigeration
ASHRAE
ANSI
NFPA


VACUUM
SUPPLY

System Operation & Maintenance

Develop Operating Procedures (NH_3)

ANSI: Safety Code for Mechanical Refrigeration

IIAR Guidelines for:

Suggested Safety and Operating Procedures When Making Refrigeration Plant Tie-Ins

Minimum Safety Criteria for Safe Ammonia Refrigeration System

Start-Up, Inspection and Maintenance of Ammonia Mechanical Refrigeration Systems

System Operation & Maintenance

Develop and Maintain: Preventive Maintenance Program

- **In the US specific legislation (*40 CFR 68.73 Mechanical Integrity*) requires:**

"procedures must be written and implemented to maintain the ongoing integrity of process equipment"

- **Preventive maintenance program – based on manufacturer's recommendations**

System Operation & Maintenance

Other requirements:

- Monitor system operating parameters
- Track UHP Process Gas purchases, leakage, consumption
- Schedule replacement of Pressure Relief Valves (PRV's)

EVERY 5 years – ANSI Standard 2: *Equipment Design and Installation of Ammonia Mechanical Refrigerating Systems*

- Conduct a periodic Process Hazard Analysis *(PHA) – HAZOP*

EVERY 5 years – 40 CFR 68.50(d); and 29 CFR 1910.119 – OSHA Process Safety Management Standard

- PHA should identify ***"ALL FAILURE SCENARIOS"***

System Inspections

Purpose: **identify any parameters that could contribute to, or result in equipment failure**

Conduct:

Visual Inspections **– corrosion to piping, valves, critical equipment**

- keep a log of: findings, photographs

Leak Testing **– all piping, valves, seals, flanges**

- Recommended practice: 4 times per year

- investigate ALL leaks, regardless of size (large or small)

Vibration testing **– on rotating equipment (compressors, pumps)**

- supplements maintenance program (Id when equipment overhauls should be performed)

System Operators

Training

- fully trained, qualified operators permitted to operate systems

- *WSBG 6.122 (d)* enclosure designated as a "restricted work area" limited to *authorized personnel*…

Authorized Personnel – *"are workers who are qualified to perform the work, have been designated by the employer as being permitted to do so, and are required to be present within the designated work area…"*

System Operators

Value of training:

Factors Causing Ammonia Releases	(4 states, 10 year history)
Equipment failure	70 %
Human error	26 %
Unusual weather	2 %
Other (vehicle impacts, etc)	2 %

96 % of all anhydrous ammonia accidents
were preventable through:

increased operator training
improved procedures
communication of lessons learned

System Operators

Awareness training to *OTHER* facility personnel

- **Awareness in recognizing the basic hazards associated with the process gas (gases)**

- **Actions to take in the event of an Emergency**

Resources

Worksafe BC – OHS Regulations / Guidelines

Chemical Safety Board - http://www.csb.gov/

Canadian Society for Chemical Engineers – Process Safety Management Division - http://psm.chemeng.ca/

Canadian Society for Chemical Engineers – PSM Tools - http://psm.chemeng.ca/help/index.htm

Canadian Environmental Protection Act (CEPA)

Centre for Chemical Process Safety – www.aiche.org/ccps

Resources

US – EPA Accident Prevention and Response Manual
(Anhydrous Ammonia Refrigeration System Operators. March, 2006) –
www.epa.gov/region07/toxics/arpp.htm

Factory Mutual Data Sheet – 12-61: Mechanical Refrigeration

International Institute of Ammonia Refrigeration (IIAR)
Standards and Bulletins

***Other Industry – Specific Associatons*:**

Compressed Gas Association

Summary

Process gases **– are a fundamental and necessary part of our lives (food production, manufacturing, etc)**

Danger **- they can be extremely dangerous, if handled incorrectly or managed inappropriately**

Safety requirements **- WSBC Regulations place specific requirements on employers who have toxic process gases present in their workplace**

Resources **- there are sufficient resources to ensure that process gases are managed in a safe manner**