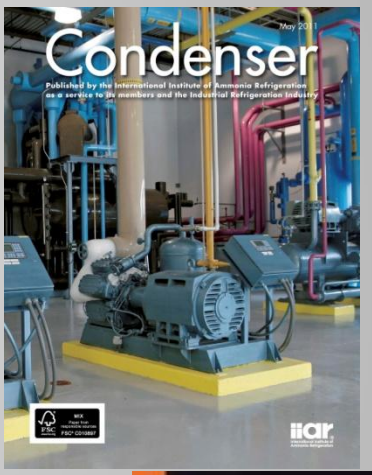
AMMONIA SAFETY & REGULATIONS

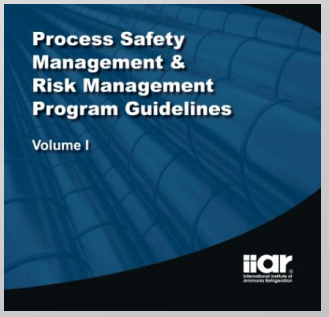
Dave Rule, President

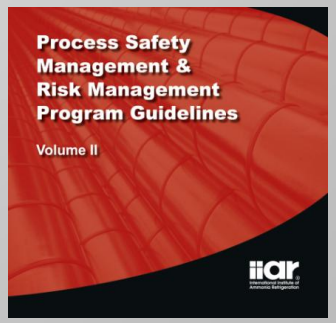
Eric Smith, Vice President and Technical Director

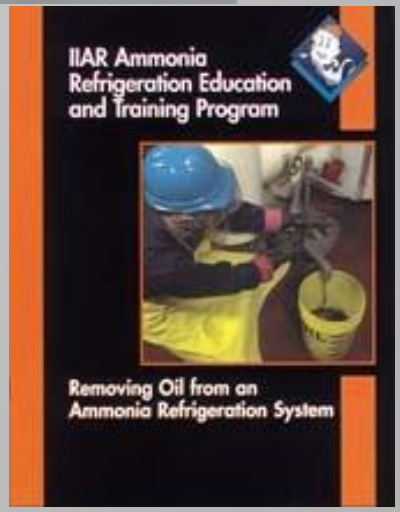
IIAR – Who We Are, What We Do



- Technical Society for Industrial Refrigeration
- ANSI Accredited Standards Writer
- Advocacy for Natural Refrigerants
- Educational Resource
- Work with ASHRAE, RETA, WFLO, IARW, IACSC, etc.
- 40 Year Anniversary







MISSION STATEMENT

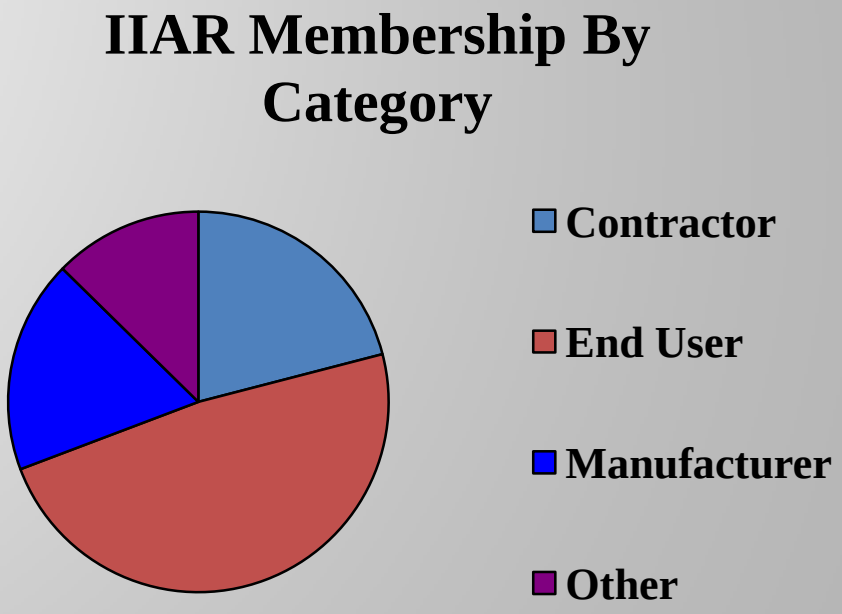
IIAR is an organization providing advocacy, education, standards and information for the benefit of the ammonia refrigeration industry worldwide

FOUNDED IN 1971

42nd Anniversary!

Membership

- 2,300+ Members
- Members in 80 countries
- 1,300+ members at Annual Conference and Heavy Equipment Show



Introduction

- An era of cooperation
- A focus on education (training) for everyone
- The IIAR and OSHA
  - Alliance with the GCCA
  - OSHA Institute
- The IIAR and EPA
  - Green Chill Program
  - E^3 Program
  - SNAP approved refrigerant
- Designing Engineered Solutions

Introduction

- Process Safety and Risk Management Programs
  - IIAR promotion as "Excellent Training Tools"
  - Updated IIAR "Compliance Library"
- Meeting expectations for today's session
  - Showing up is the first step
  - A safer workplace and community is the objective
  - Understanding what makes an industrial refrigeration system safe - dialogue
  - Focus on ammonia releases – prevention
    - Flammability
    - Toxicity

Introduction

- Releases – keeping ammonia in the system
  - Operator training
  - System Design
  - Personal Protective Equipment
  - Compliance – Codes and Regulations
- Releases –
  - When – over pressure, maintenance activities
  - Why – Equipment failure or Human Interface
  - Where – Piping, System Components

Refrigeration

The concept of refrigeration went unchanged for 2000+ years until mechanical refrigeration was invented 150+ years ago

Principles of Refrigeration and Refrigeration Systems

Mechanical Refrigeration

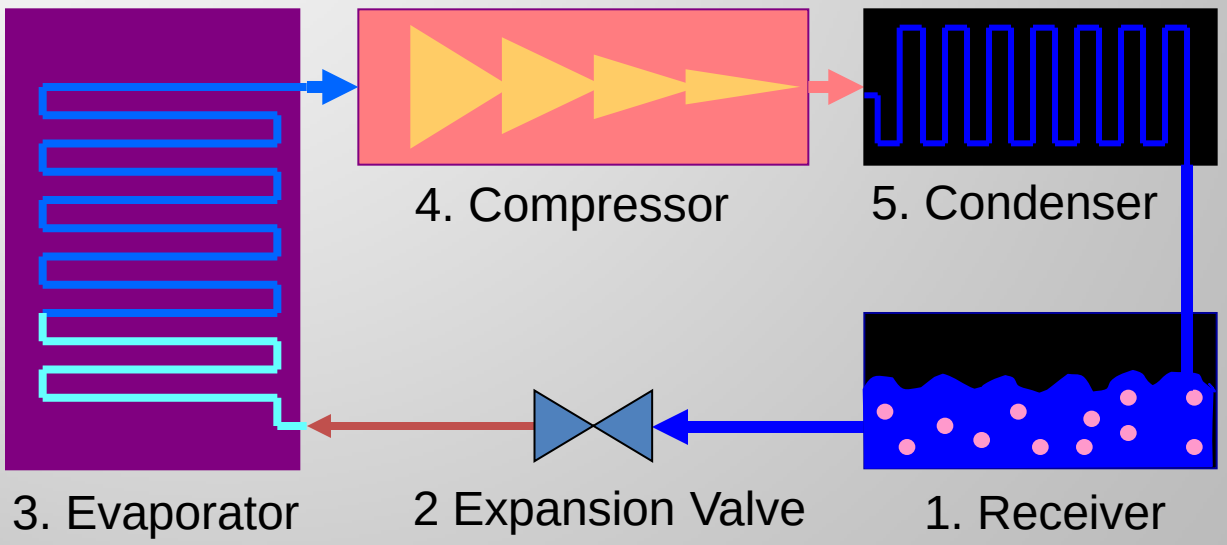
Since its invention, the process of mechanical refrigeration has remained relatively unchanged

Principles of Refrigeration and Refrigeration Systems

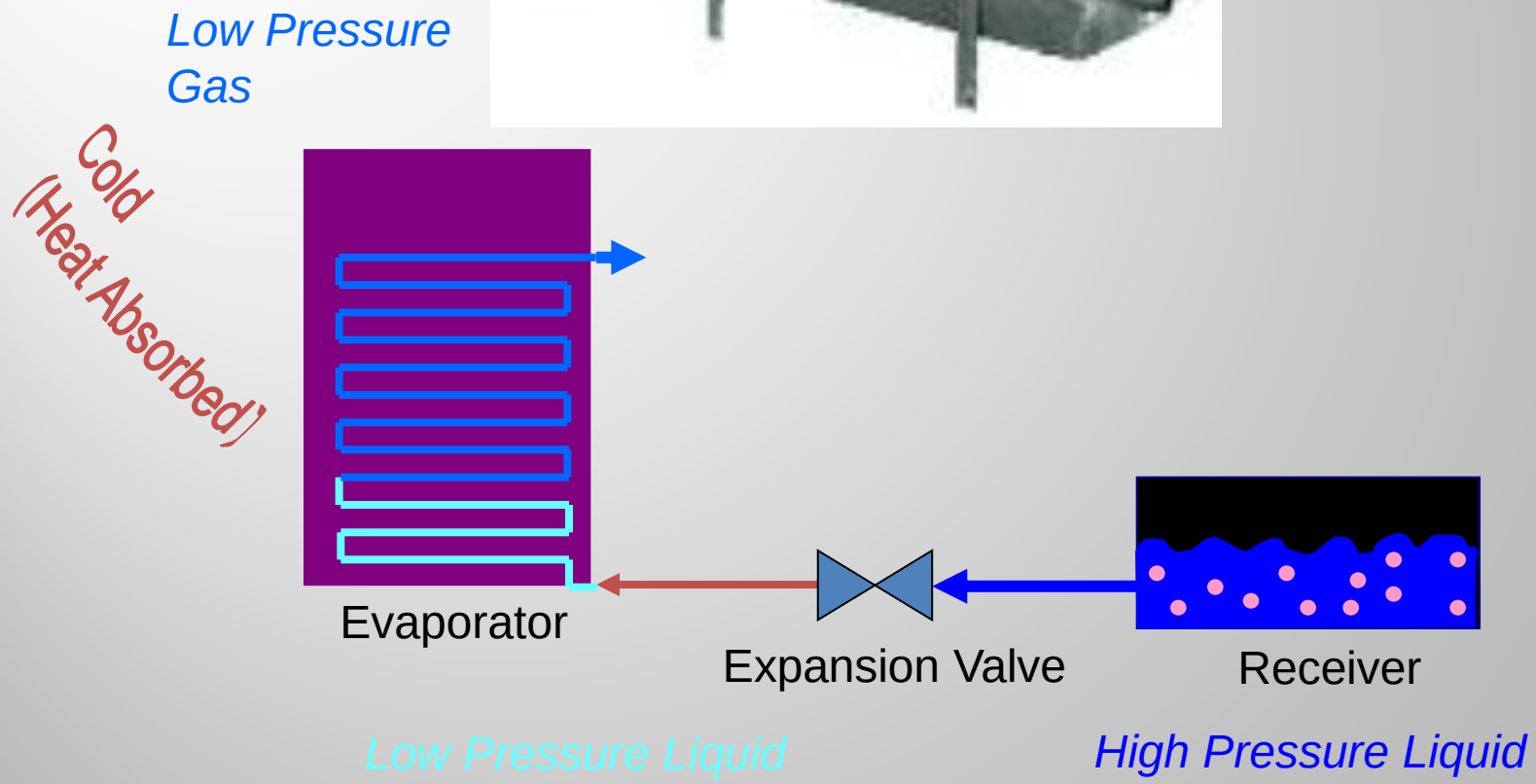
- Refrigeration systems do not add cold…they remove and relocate heat

- Think of a train on a circular track with two stations.
  - "Heat passengers" are loaded at one station and unloaded at the other

Refrigeration Systems
–How do they work–



- By removing heat, evaporation is a cooling process



The Refrigeration Process

Low Pressure Gas

High Pressure Gas

Cold (Heat Absorbed)

Hot (Heat Rejected)

Compressor

Condenser

Evaporator

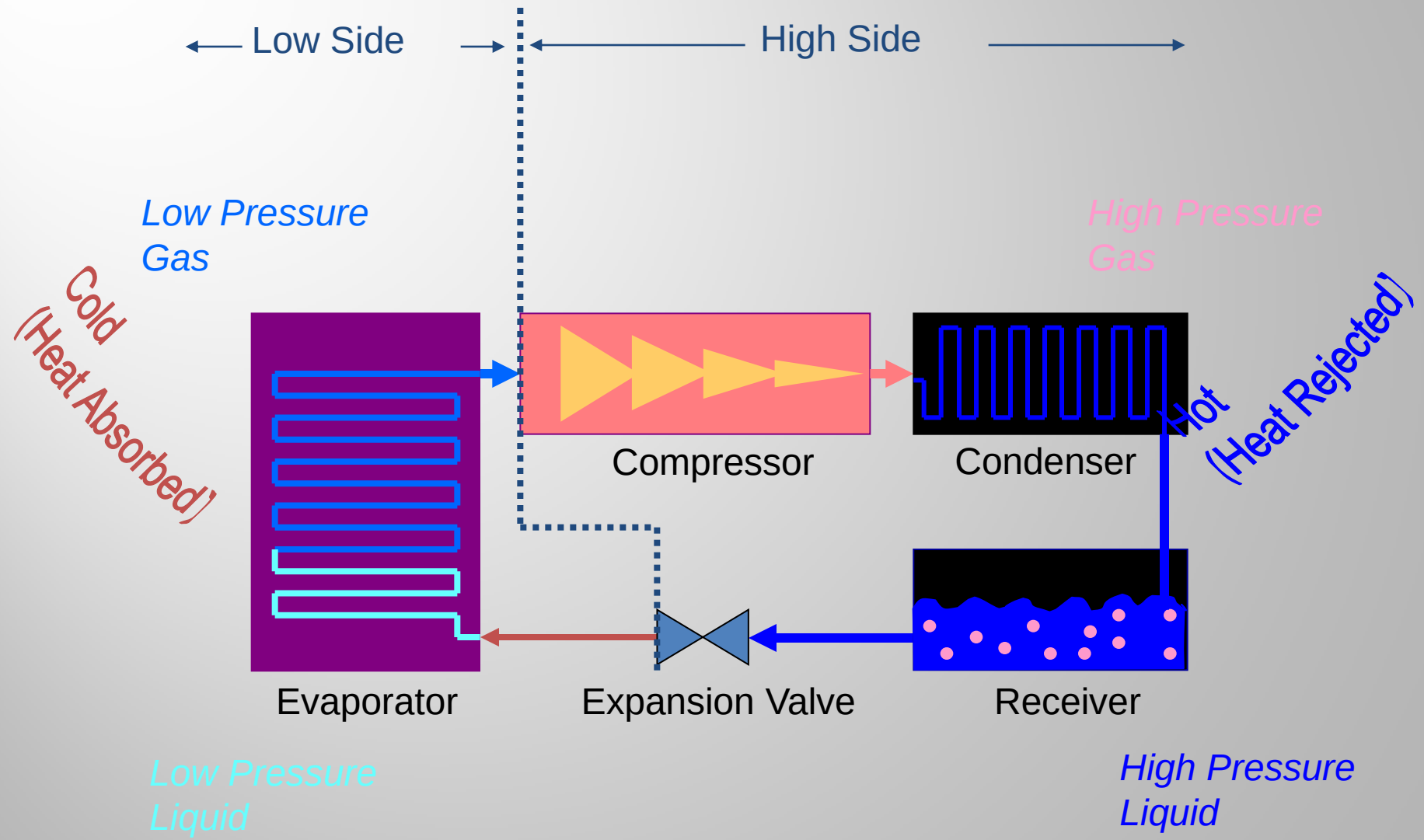
Expansion Valve

Receiver

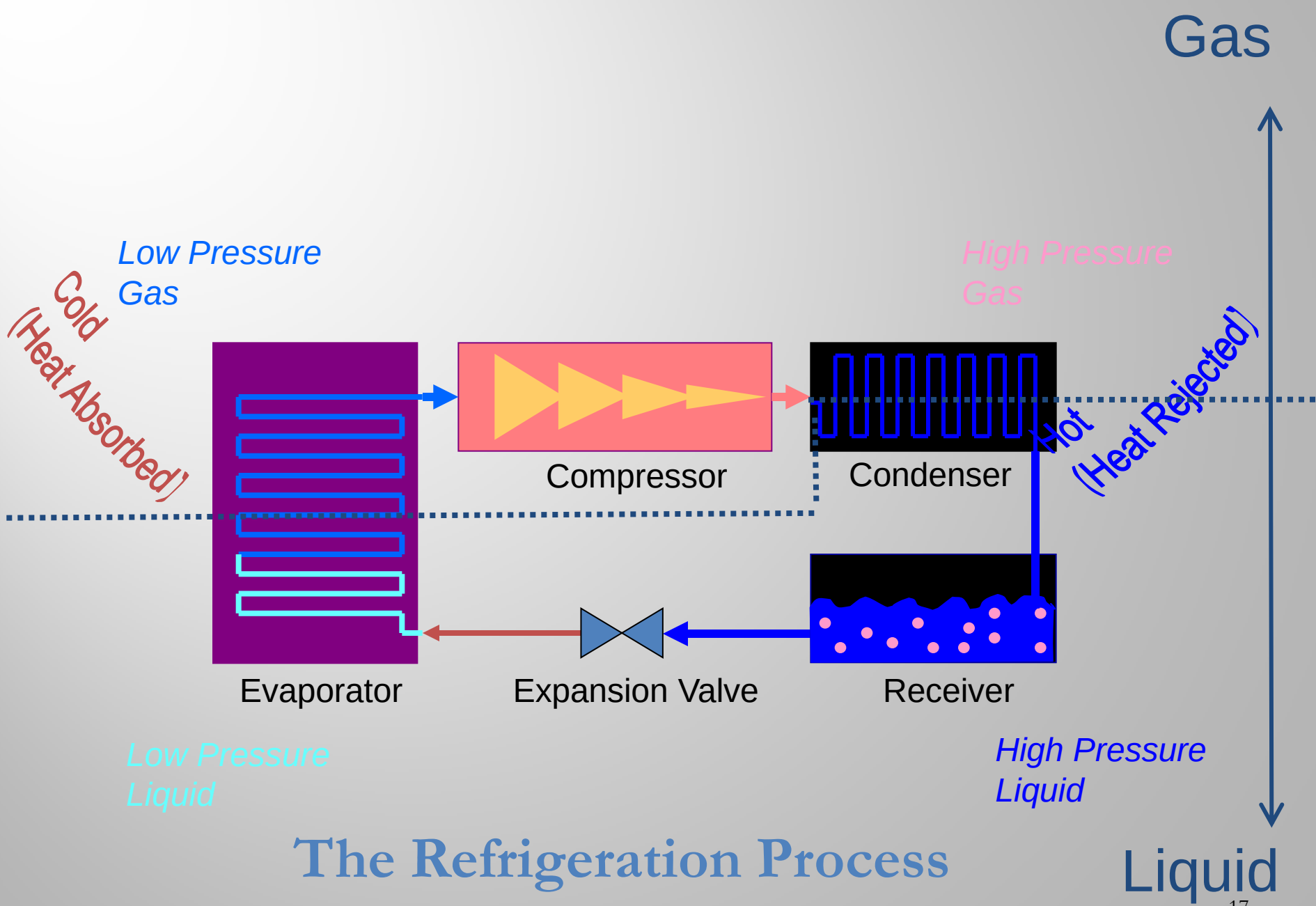
Low Pressure Liquid

High Pressure Liquid

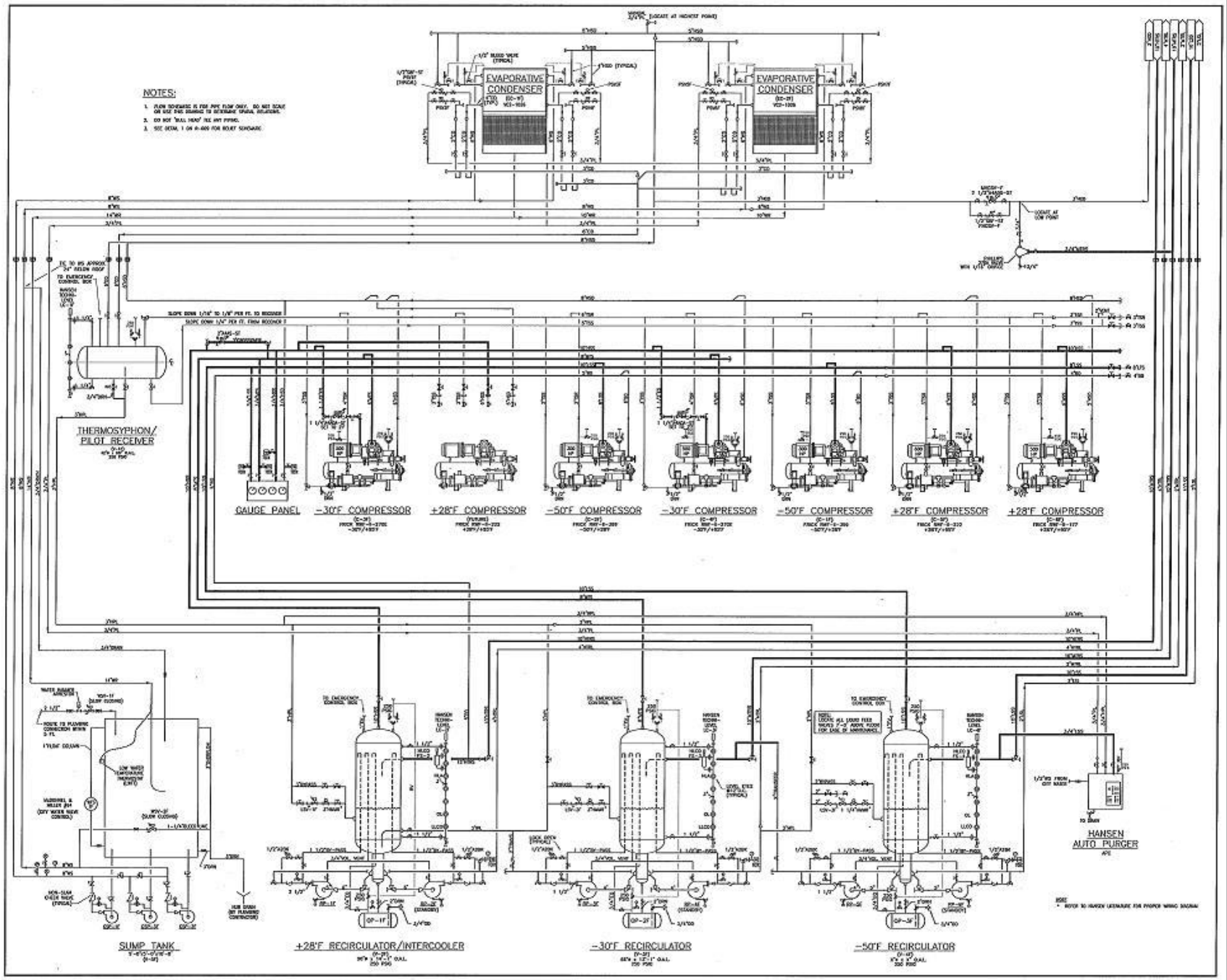
The Refrigeration Process



The Refrigeration Process



The Refrigeration Process


NOTES:
EVAPORATIVE CONDENSER
EVAPORATIVE CONDENSER
THERMOSYPHON/ PILOT RECEIVER
GAUGE PANEL
-30°F COMPRESSOR
+28°F COMPRESSOR
-50°F COMPRESSOR
-30°F COMPRESSOR
-50°F COMPRESSOR
+28°F COMPRESSOR
+28°F COMPRESSOR
SUMP TANK
+28°F RECIRCULATOR/INTERCOOLER
-30°F RECIRCULATOR
-50°F RECIRCULATOR
HANSEN AUTO PURGER

Five Key Refrigeration System Components

Receiver - A reservoir for high-pressure liquid refrigerant

Five Key Refrigeration System Components

Expansion Valve – A device used to reduce refrigerant pressure and the control flow rate

Five Key Refrigeration System Components

Ammonia Recirculator Package

Five Key Refrigeration System Components

Evaporator – Allows refrigerant to absorb heat

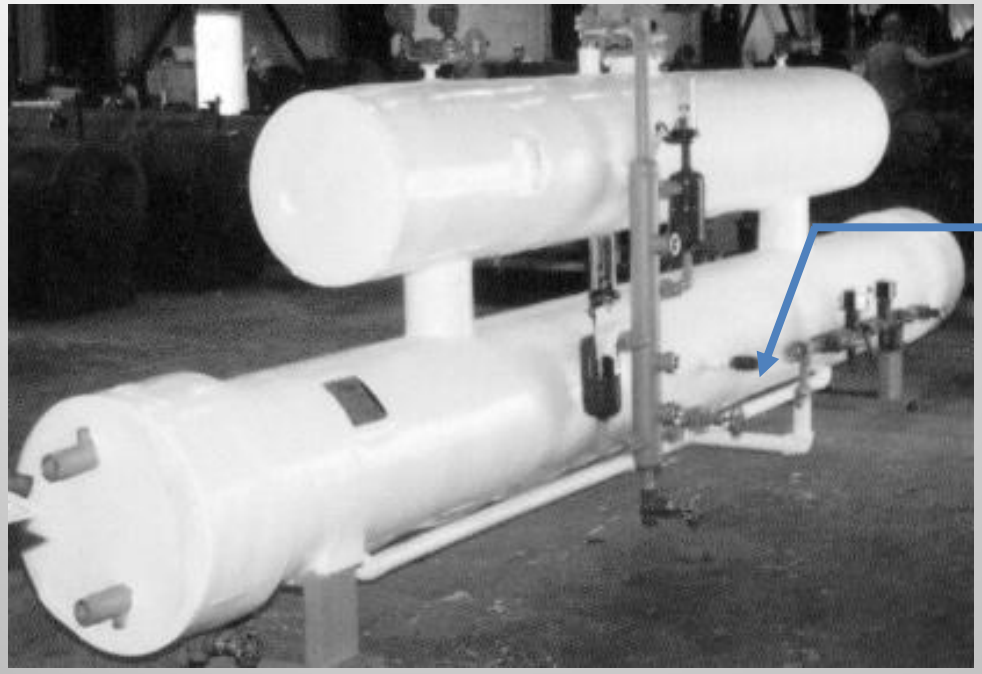
Evaporator – Allows refrigerant to absorb heat

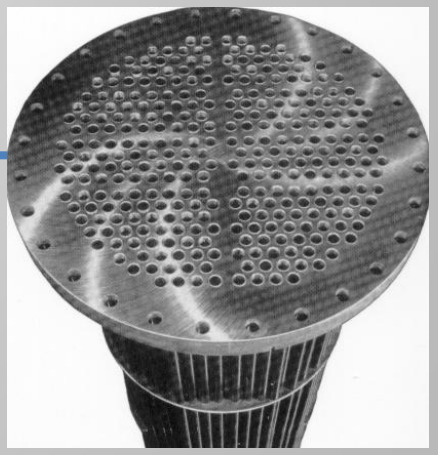
Rooftop Air Unit for Cooling and Make-up Air

Food Production Room Air Unit During Clean-up Operations

Five Key Refrigeration System Components

Evaporator – Allows refrigerant to absorb heat

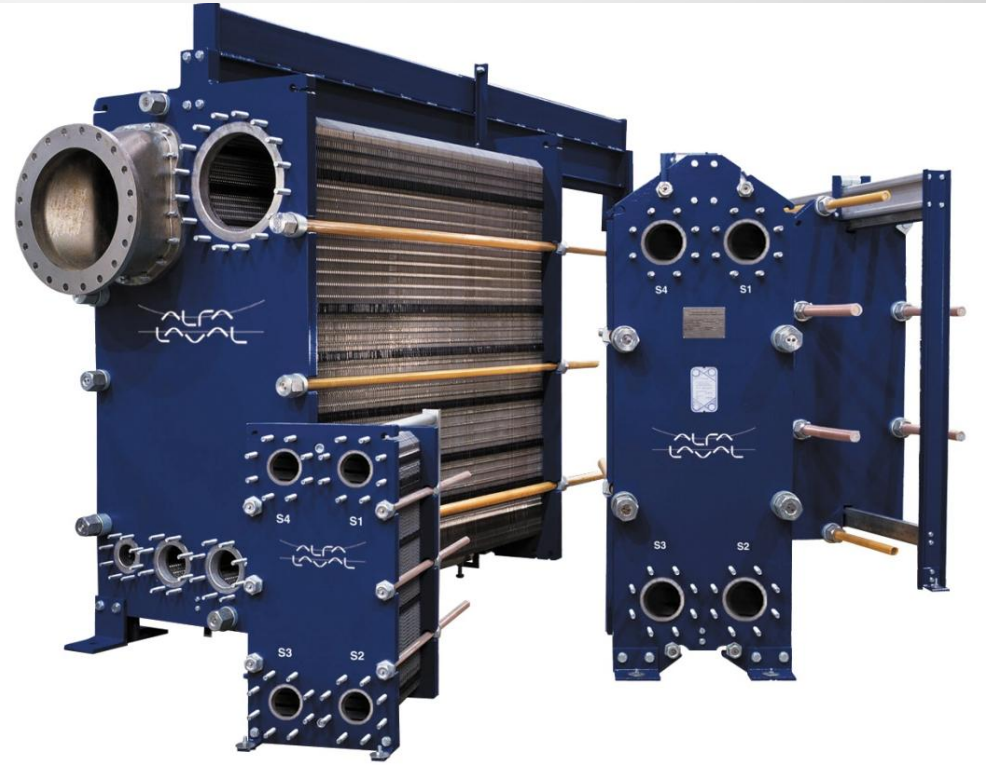




Liquid Chiller Shell & Tube

Five Key Refrigeration System Components

Evaporator – Allows refrigerant to absorb heat

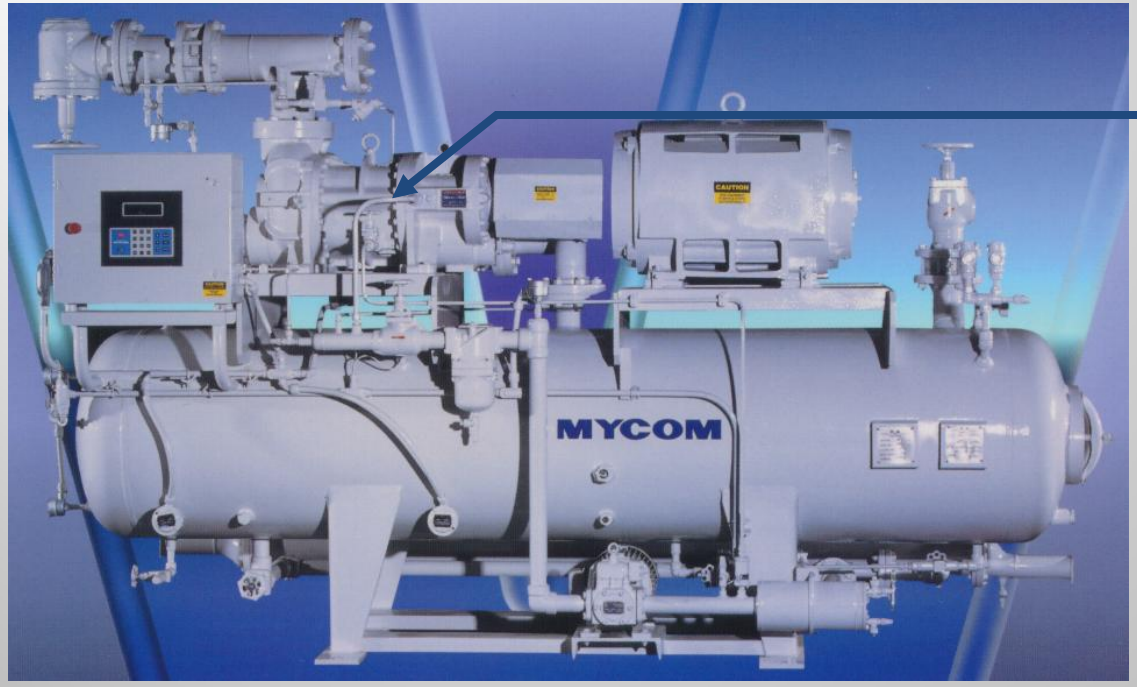


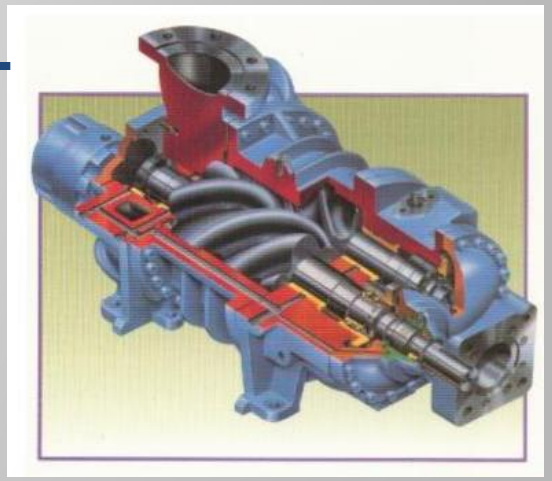
Liquid Chiller
Plate & Frame

Five Key Refrigeration System Components

Compressor - Increases system pressure and "pushes" refrigerant through the circuit

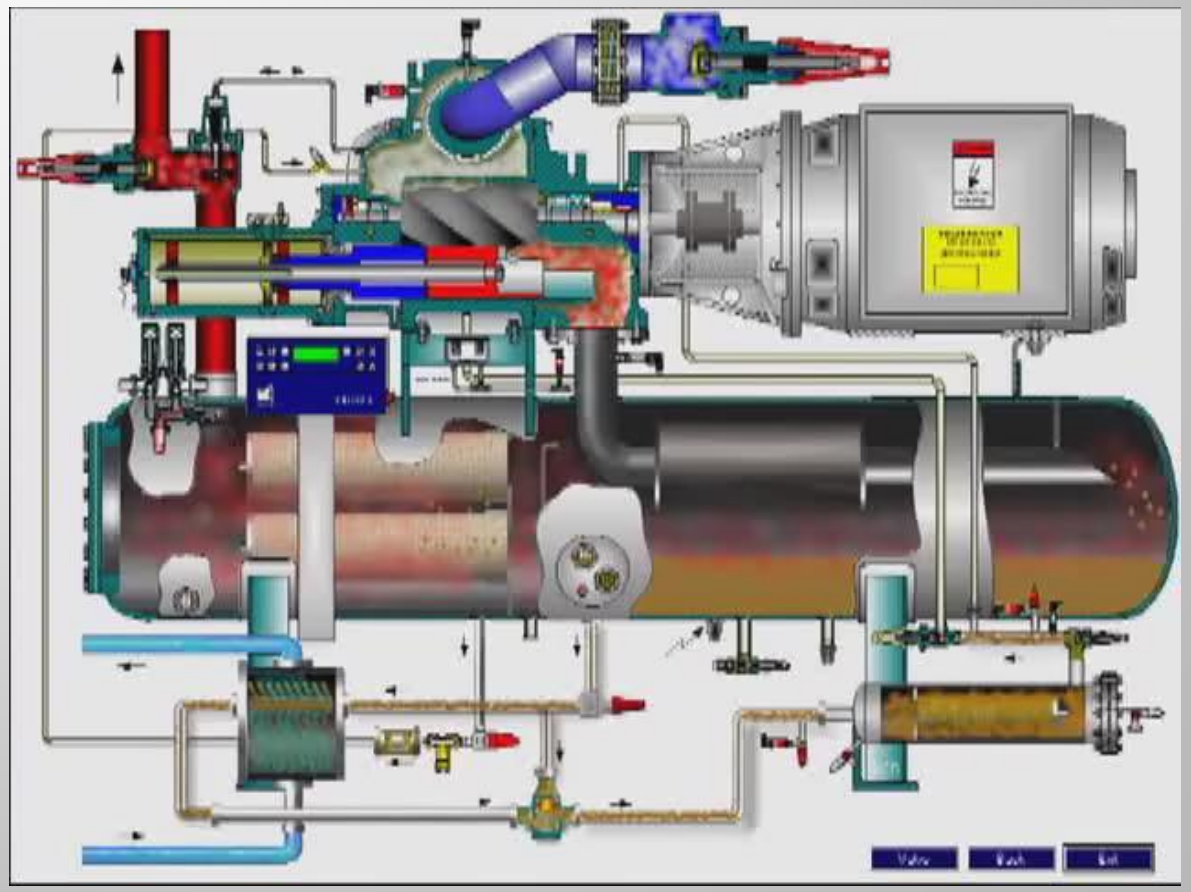
Five Key Refrigeration System Components



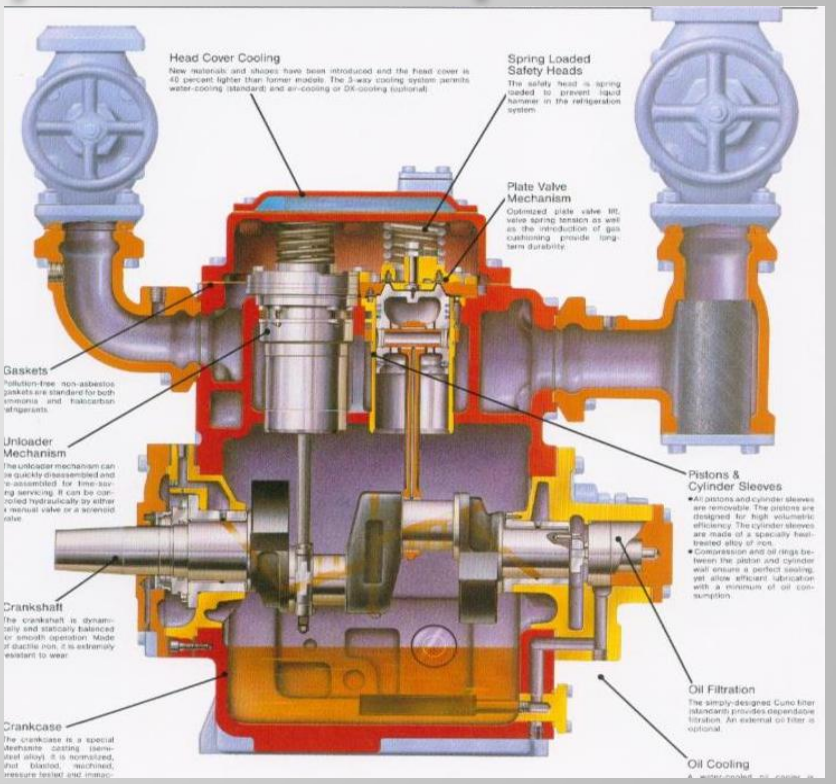


Screw Compressor

Five Key Refrigeration System Components



Five Key Refrigeration System Components



Reciprocating (piston) Compressor

Five Key Refrigeration System Components

Condenser - allows refrigerant to reject heat

Refrigerants

- Liquid or gas used to absorb and reject heat
- Ammonia
  - A gas that is quite easily changed to a liquid at a low temperature with a favorable latent heat of vaporization
  - Naturally occurring and biodegradable
- Freon gases
  - Manufactured
  - Many have damaging side effects on the environment
- Others

Ammonia Properties
Noxious: Odor is a GOOD thing!

You'll smell ammonia well below a dangerous concentration

- Odor threshold (ANSI K61.1) — 5ppm (.0005% in air)
- PEL (OSHA) — 50 ppm
  - Household ammonia (1-4% aqueous solution, ½ inch from top ~200+ ppm)
- IDLH (NIOSH 95) — 300 ppm
  - Ammonia smelling capsule (600 ppm)
- Immediate throat irritation (ANSI K61.1) — 400 ppm
- Serious eye irritation (ANSI K61.1) — 700 ppm
- Acute toxicity — 1,000 ppm
- Rapidly fatal — 5,000 ppm

A 1-pound leak yields 22.4 cubic feet of gas

- 22.4/0.000005 (odor threshold) yields 4,480,000 cf "smelly air"

Why the Fuss Over Ammonia Refrigeration ?

Ammonia STINKS !

- Refrigeration is a complex subject
- A history of releases
  - Ammonia releases don't set well with the public…dangerous or not

Ammonia Has an Image Problem

- Largely because of odor and noxious effects, ammonia has an image problem
- Freon gases were regarded as the "safe" refrigerants for years until environmental issues of global warming and ozone depletion took the forefront
- Fatality rates of ammonia and Freon are equal – by law, ammonia is reported, thus adding to the image problem

There is No Perfect Refrigerant

- From 860 chemicals evaluated for refrigeration in the space program, ammonia scored highest
  - It's as natural as water…simple molecule of nitrogen and hydrogen
  - Superior physical properties
  - Stability
  - Relative toxicity
  - Relative flammability
  - Compatibility with materials, gaskets, etc.
  - Price

Let's look at the numbers

- Fatalities (average per year during the past 12 years for air conditioning and refrigeration applications only) –
  - Halocarbons ~ 2 per year
  - Ammonia ~ 2 per year
- Nitrogen is used for industrial pressure testing and inerting processes with a fatality rate of 8 per year. (ref. Chemical Safety Board)

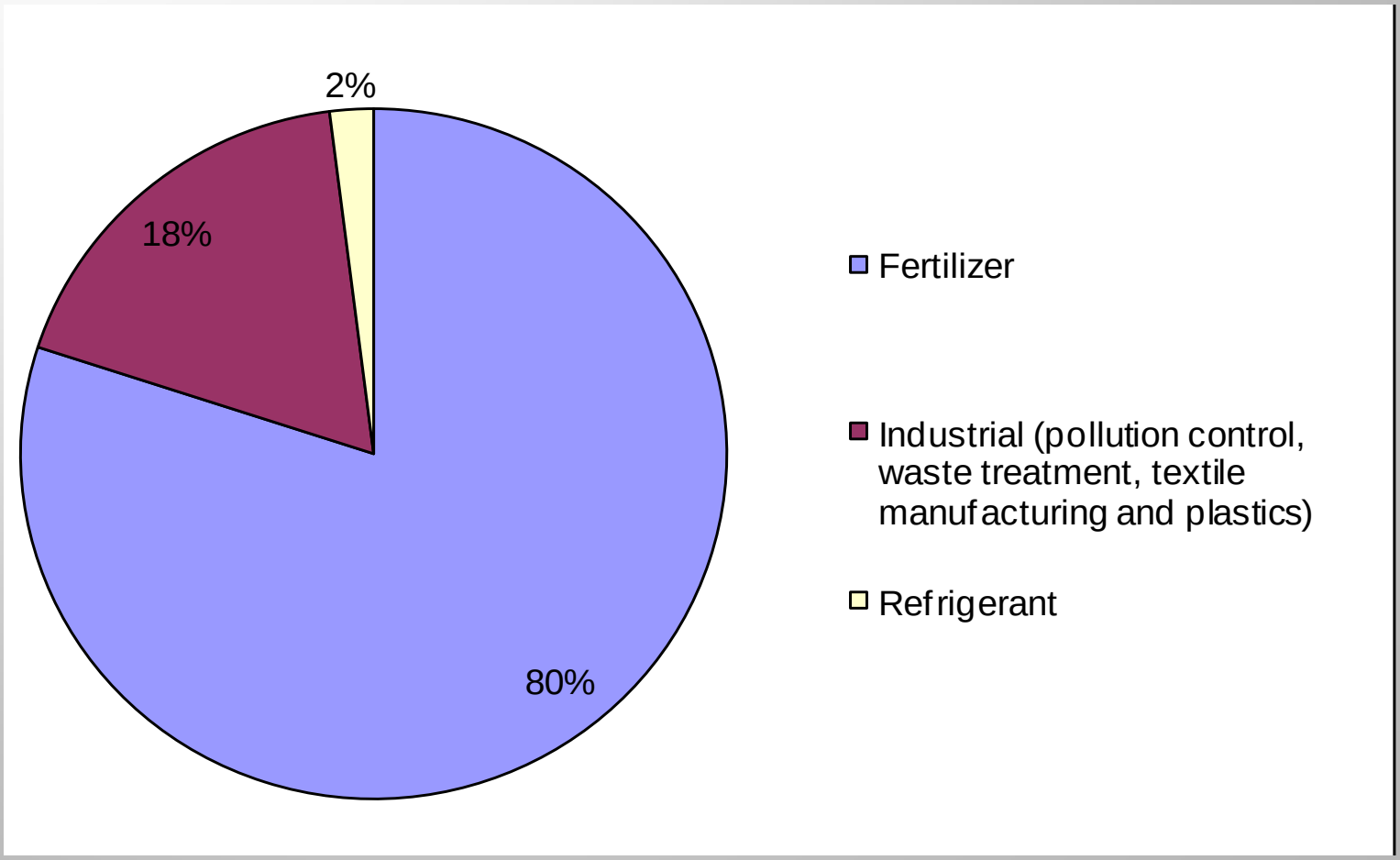
Natural Gas Overcame an Image Problem

- A relatively short time ago, many believed natural gas was too dangerous for widespread use
- They added odorant to natural gas !

Natural Gas Overcame an Image Problem

- Nevertheless, natural gas continues to have safety issues…
- And don't forget propane…

North American Use of Ammonia

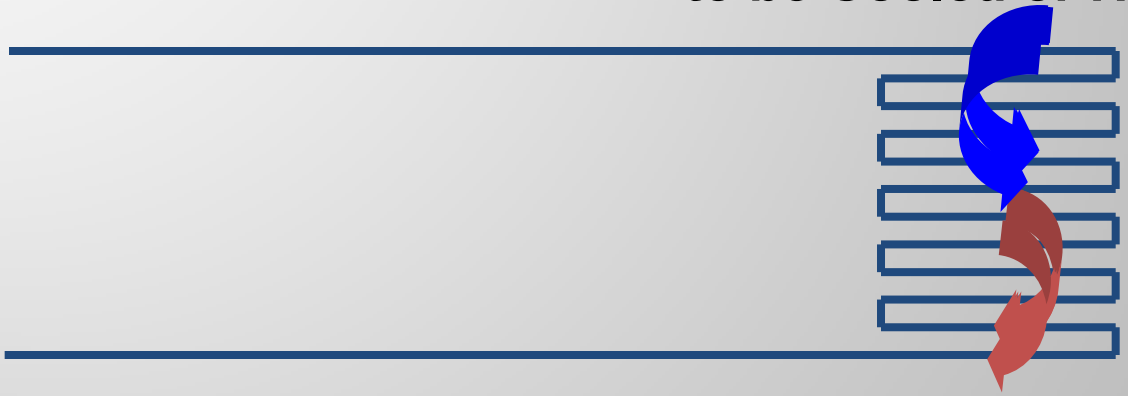


Morning Break

Direct Systems

Cooling or Heating Source

Air or Substance to be Cooled or Heated

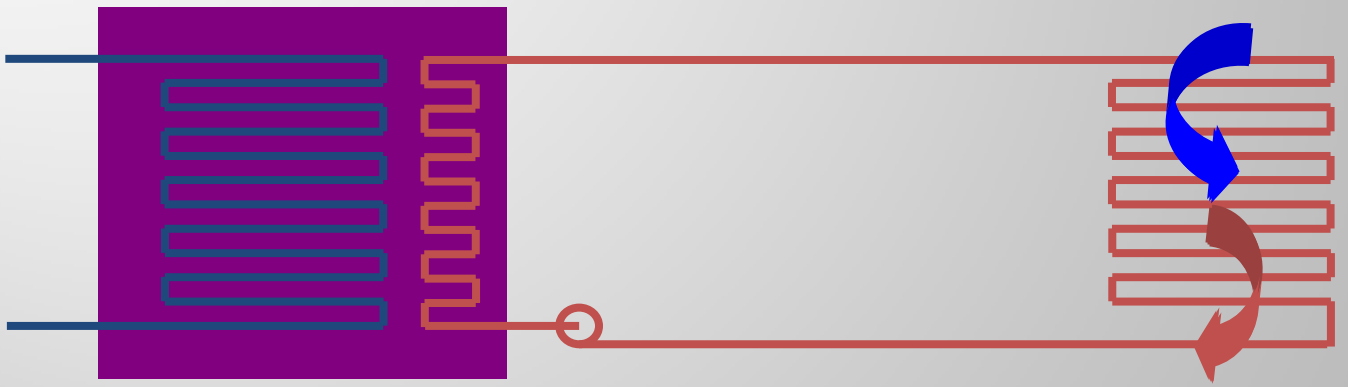


- A system having the evaporator or condenser in direct contact with the air or other substances to be heated or cooled

Indirect Closed System

Cooling or Heating Source

Air or Substance to be Cooled or Heated



- A system having a secondary coolant which passes through a closed circuit that is in direct contact with the air or other substance to be cooled or heated

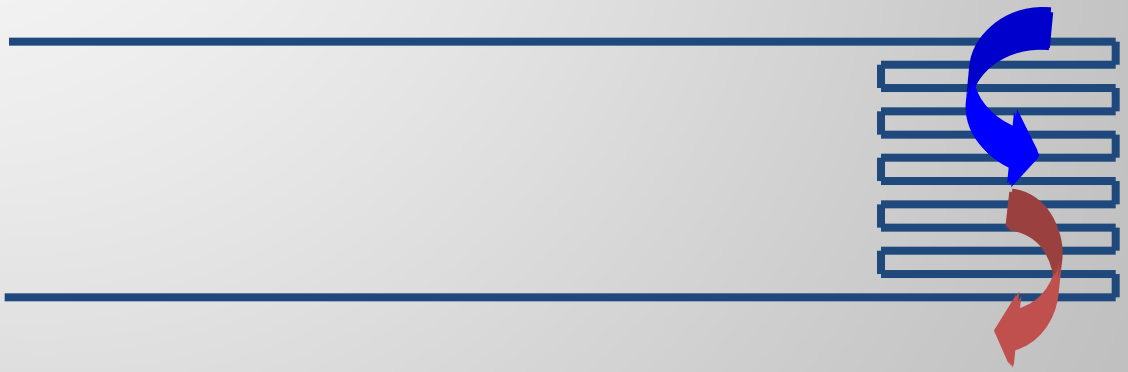
System "Probability"

- Refrigerating systems are assigned probability ratings to indicate the degree of probability that leakage of refrigerant will enter an occupancy-classified area
  - "High" probability – less safe
  - "Low" probability – more safe

Direct Systems

Cooling or Heating Source

Air or Substance to be Cooled or Heated

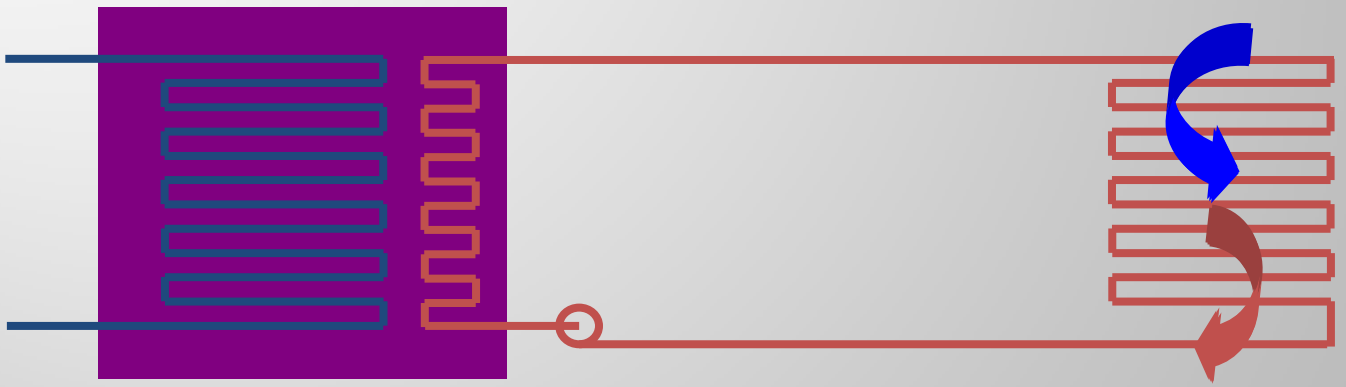


High Probability

Indirect Closed System

Cooling or Heating Source

Air or Substance to be Cooled or Heated



Low Probability

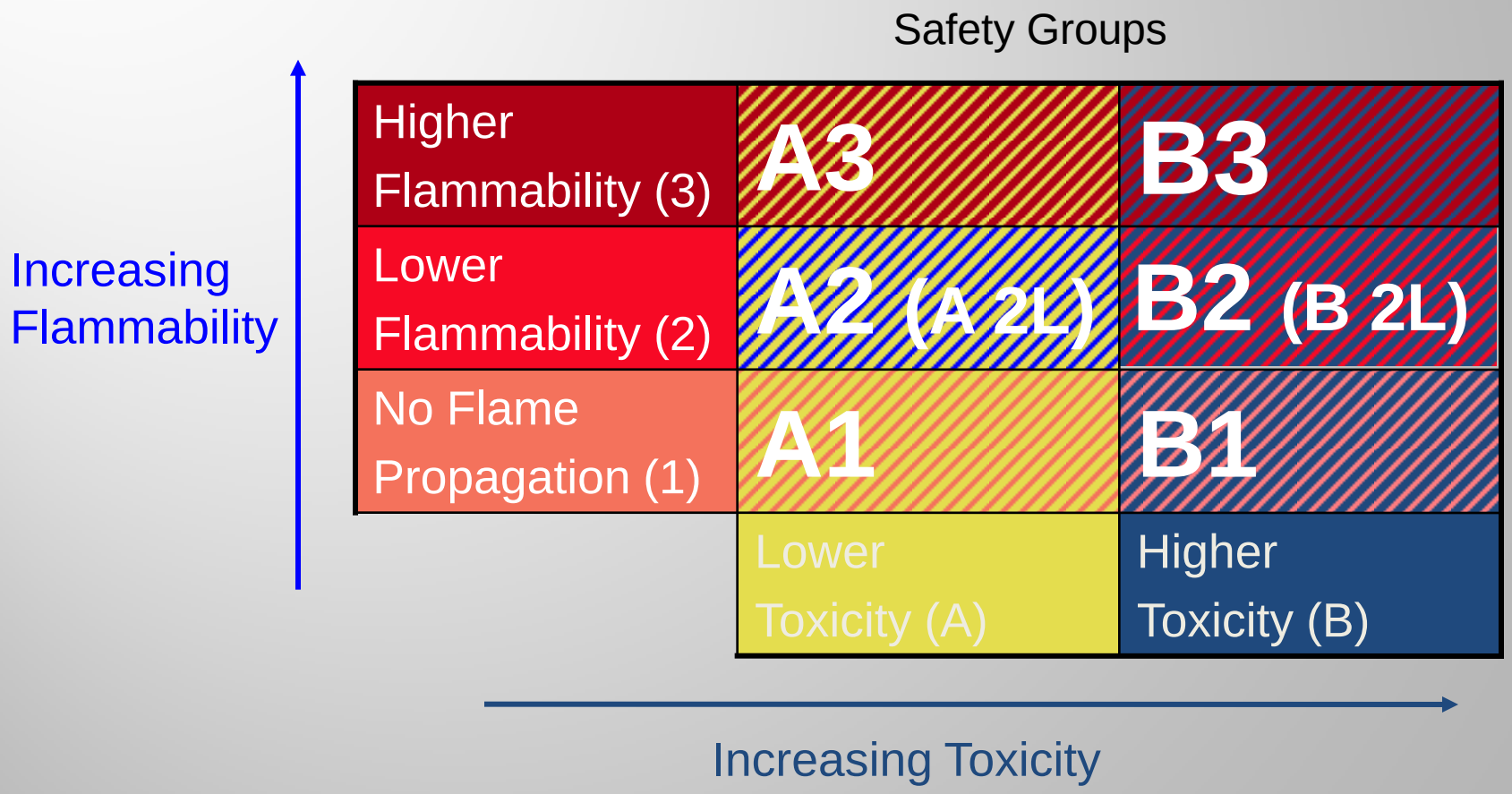
Probability Based Regulations

1. The IMC permits refrigerants in any safety group to be used
   - In low-probability systems
   - In high-probability system equipment located within refrigeration machinery rooms
2. Use of refrigerants in high-probability systems outside of refrigeration machinery rooms is limited based on
   - The occupancy classification of the space
   - The safety group of the selected refrigerant
   - The quantity of refrigerant

   Except for certain refrigerated storage or processing areas

Hazard Classification of Refrigerants

ASHRAE 34 Safety Groups



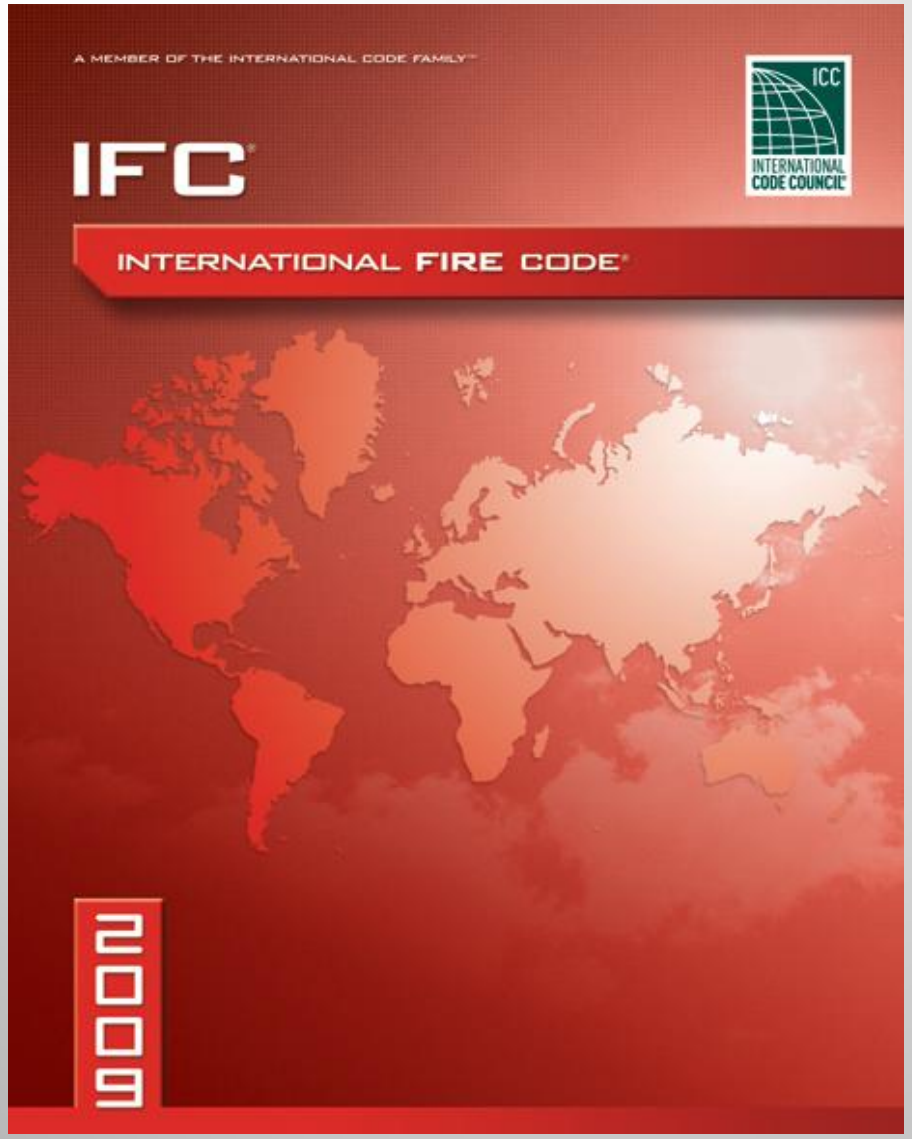
Why Are Codes Concerned With Refrigeration Systems ?

- Personal injury and property damage
  - Release of refrigerant from a fracture, leaking seal or incorrect operation can damage property and cause injures
  - Fire or deflagration hazard associated with escaping lubricant or refrigerant can damage property and cause injures

Code Development Relationships

OSHA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



IFC SECTION 606
MECHANICAL REFRIGERATION

Fire Code Requirement for Ammonia Refrigeration Systems

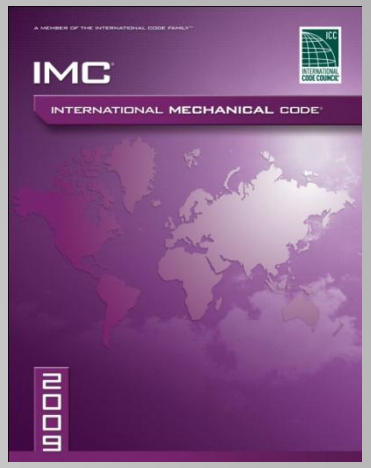
- In the case of ammonia discharge, the fire code has traditionally had two concerns of interest
  - Discharge of overpressure relief vents, which operate automatically if needed to maintain a limit on system pressure
  - Manual discharge to diffusion systems, which must be operated by someone who is knowledgeable regarding system design pressures and safe operating limits

IFC Regulations For Refrigeration Systems

Fire Codes

- IFC Section 606 is the primary IFC section regulating ammonia refrigeration systems
- Provisions in the fire code primarily focus on issues involving emergency control and alarm systems and emergency response

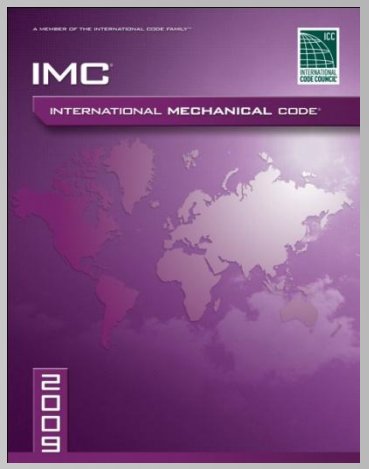
Codes and Standards Regulating Ammonia Refrigeration Systems



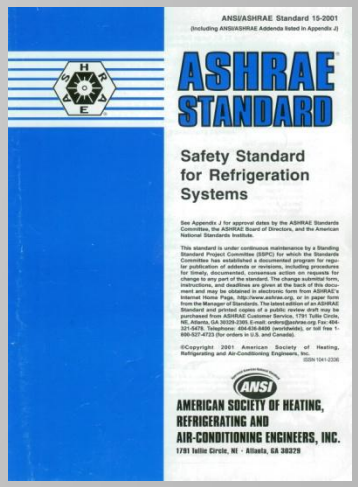
Mechanical Codes

- Chapter 11 of the IMC regulates the design and installation of mechanical refrigeration systems
- The IMC focuses on protecting occupants, the environment and the local community

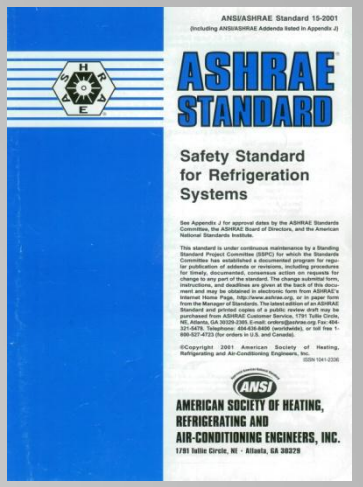
IMC Regulations For Refrigeration Systems



- The IMC and ASHRAE 15 are generally coordinated



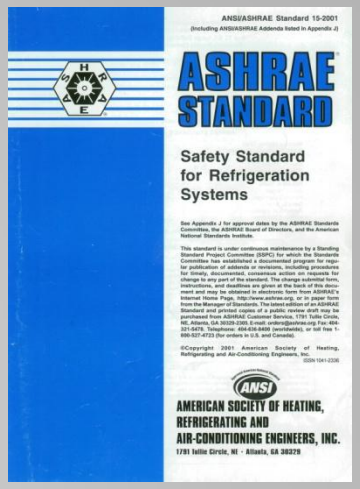
ASHRAE Regulations For Refrigeration Systems



ASHRAE 15

- ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
- ASHRAE 15 - *Safety Code for Mechanical Refrigeration, is* an American National Standards Institute (ANSI) accredited standard
- Regulations in ASHRAE 15 are generally consistent with the IMC and IFC, but are more detailed

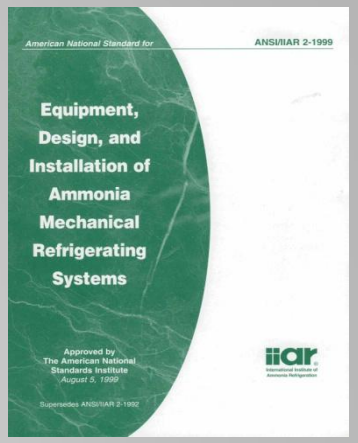
ASHRAE Regulations For Refrigeration Systems



ASHRAE 15

- Specifies safe design, construction, installation and operation of refrigerating systems
- Establishes safeguards for life, health and property and prescribes safety standards
- Applies to new installations and modifications of existing installations

IIAR Regulations For Refrigeration Systems



IIAR 2

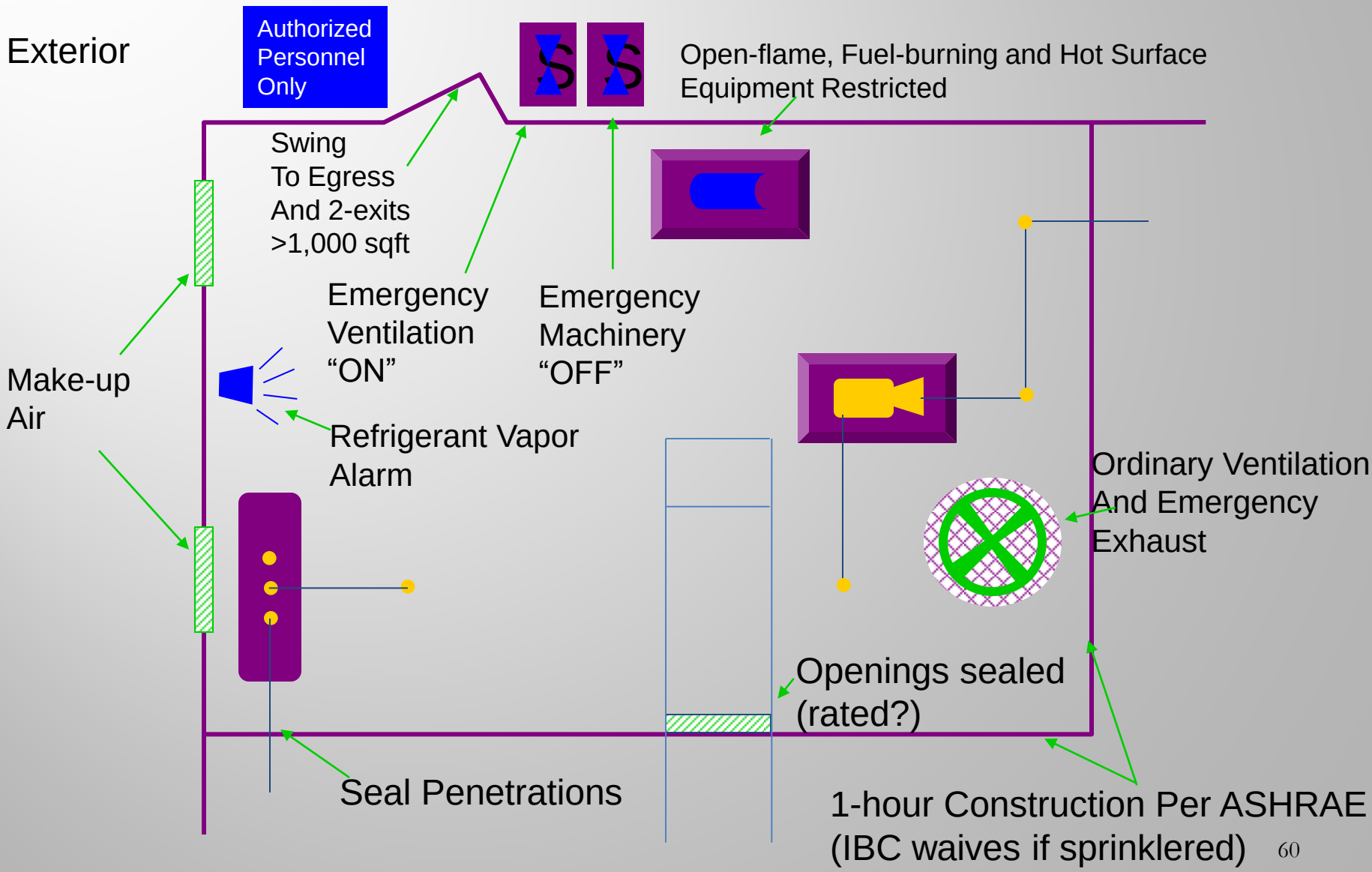
- IIAR - International Institute of Ammonia Refrigeration
- IIAR 2, *Equipment, Design and Installation of Ammonia Mechanical Refrigerating Systems,* is an American National Standards Institute (ANSI) accredited standard
- This document is specific to ammonia systems and provides detailed design and installation information not typically referenced during inspection

Lunch Break

Machinery Rooms

- Codes specify two levels of machinery room protection for refrigeration equipment
  - Basic machinery room (Section 1105)
  - Special machinery room (Section 1106)
- Except for small installations, such as listed, factory assembled units, ammonia refrigeration systems will require a special machinery room

Refrigeration Machinery Rooms



What Happens in a Release?

- Like any liquefied compressed gas, the release of liquefied ammonia to atmosphere causes the remaining liquid to cool
- Once the system pressure has been released and the liquid cools to its boiling point temperature, evaporation slows dramatically, and the liquid essentially sits there

We'll demonstrate...

System will sit at -28 °F and 0 psi

Initial fill

After 2-hours plus manually draining 2 cups

Changes in New Codes

- IIAR has been successful with proposed changes to model fire codes that deal with ammonia discharge to promote design flexibility.

New Alternatives to Water Tanks

Water diffusion tanks, pros/cons:

Do you really want your last line of defense before an release from the system to be located 30 feet under water?

2003 IFC:

Systems containing ammonia refrigerant shall discharge vapor to the atmosphere through an approved treatment system, a flaring system, an approved ammonia diffusion system or by other approved means.

Exception

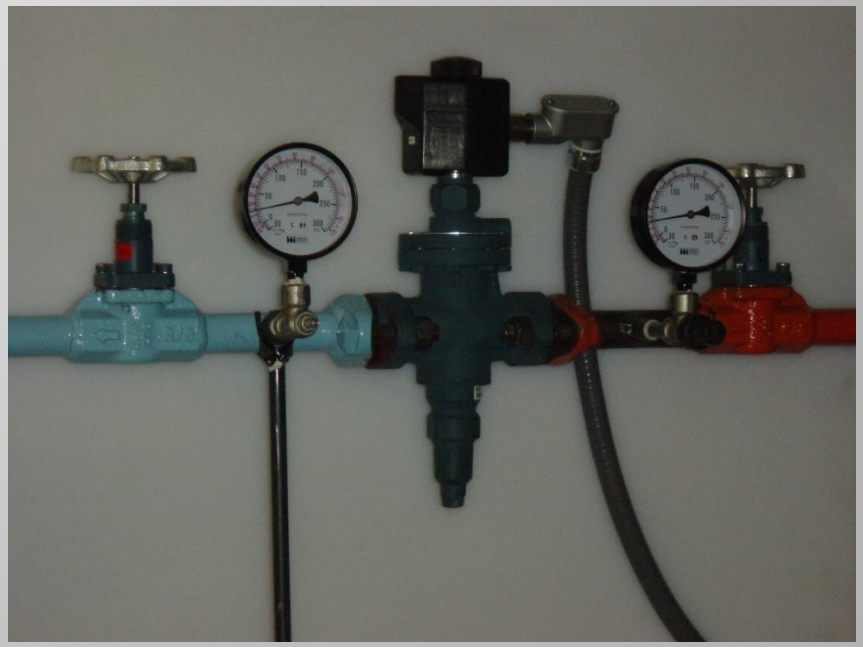
When the fire code official determines, on review of an engineering analysis, that a fire, health or environmental hazard would not result from discharging ammonia directly to the atmosphere.

These Changes Are Recognized By

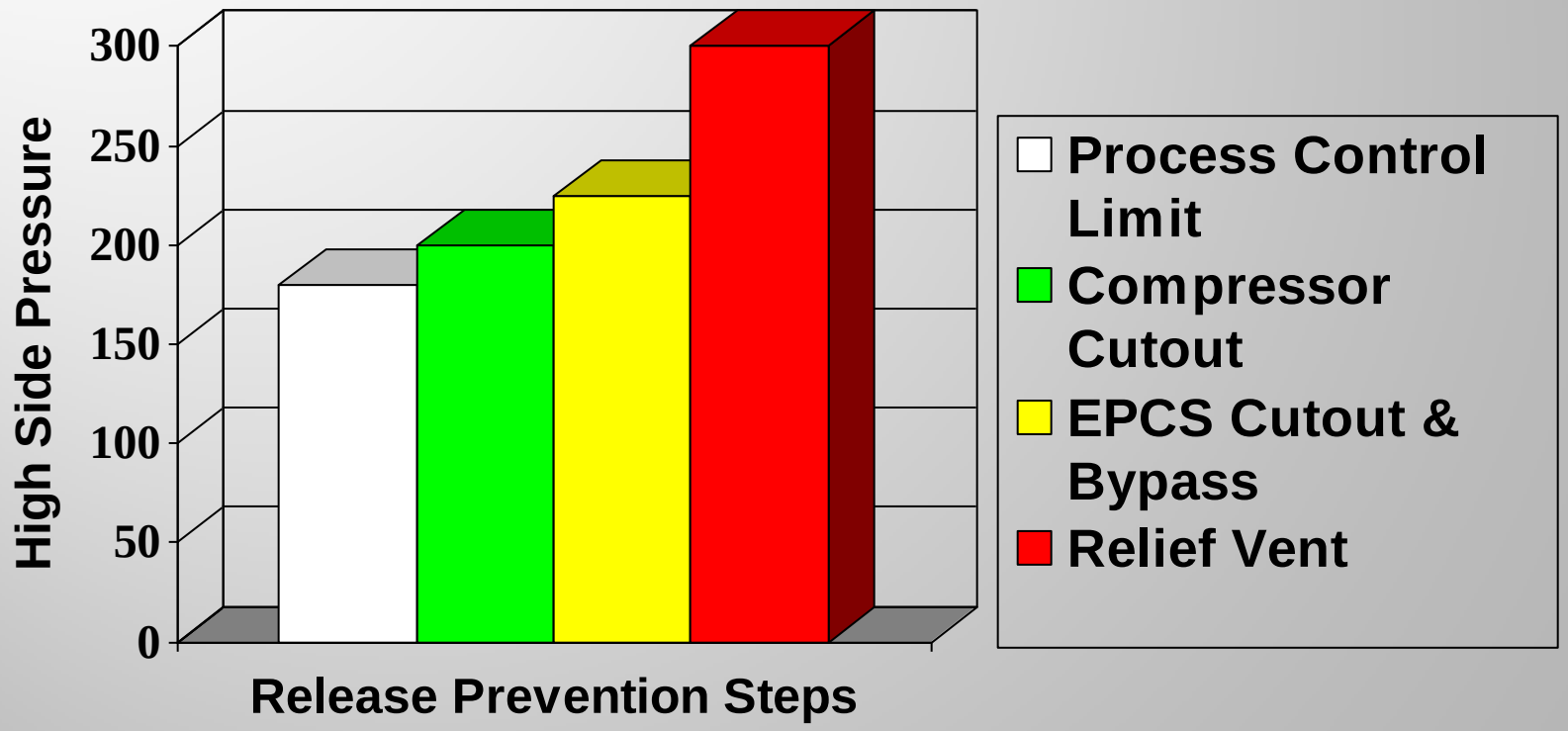
- 2003 International Fire Code
- 2003 IMC defers to ASHRAE 15, which permits atmospheric discharge

Emergency Pressure Control System

- Automatic Emergency Pressure Control Systems are now required in lieu of emergency control boxes.
- Automatic hi-low crossover valve
- Redundant overpressure cutouts



Release Prevention Steps



IIAR Standards and OSHA

- IIAR-2 is considered the benchmark for industrial refrigeration systems using ammonia
- However…….
  - *Bulletins are used as guidance documents and industry best practice by inspectors*
  - *The informative sections of IIAR Standards are also used as best practice guidance by inspectors*

Using IIAR Standards, Bulletins and Handbooks

- What is IIAR doing?
  - *Creating Standards intended for Codes*
  - *Creating Handbooks intended for guidance*
  - *Eliminating Bulletins*
  - *Re-writing existing Standards based upon the new understanding that inspectors will use the entire document as the basis for inspections*

The IIAR / OSHA Alliance

- Official Alliance created July 31, 2010
- First Alliance program under the Obama Administration
- Committee of End Users, Contractors, Manufactures and our Government Affairs Director, Lowell Randel

Mission of the Alliance

- The Alliance is the centerpiece of the new IIAR program to create cooperation between OSHA and the Industrial Refrigeration community
  - Improve worker safety
  - Increase compliance
  - Improve communications
  - Provide Education for OSHA
  - Help reduce citations and fines

Challenges

- Desire for “Engineered Solutions”
- Employee involvement during inspections
- Promoting exterior piping and valve stations
- Resolving requirements associated with roof access, body and eye wash stations

Solutions?

- Higher pressure rated vessels 300psig
- Smaller Ammonia charges (direct expansion, electric defrost, penthouse location for cold storage and process evaporators)
- Over pressure relief to lower pressure side (EPCS)
- Secondary coolants in process and storage areas CO_2, Glycol, Brine

Solutions?

- Personnel Training
- Emergency Responder Training
- Regulatory Enforcement Training
- “Engineered Solutions” are certainly a part of the solution

Afternoon Break

Recent Discussions, Situations, and Dialogue Concerning OSHA and PSM

- January Meeting Between OSHA and the SRC: Best for the industry to develop RAGAGEP or else OSHA will apply other standards
- Two systems, each under 10k lbs, on one property. Total over 10k. This is a case by case analysis. If a situation can reasonably affect both systems, PSM required.
- Repetitive SOPs for like equipment and applications– good or bad? Are we ensuring that a "whole system approach" is being emphasized?
- Technical Operating Specifications: Good, but not required in SOPs – must be readily available to personnel

Recent Discussions, Situations, and Dialogue Concerning OSHA and PSM

- Penthouses with air units should not be considered machinery rooms. Problems and effectiveness of machinery room provisions – will not provide the protection that is assumed. Companies are encouraged to take a strong stance. Compromises can be made, such as personal wash units.

Recent Discussions, Situations, and Dialogue Concerning OSHA and PSM

- Industrial Refrigeration systems are thought to be overly inspected by comparison to other industries…Systems are simplistic, easier chore for inspectors…likely not to see much change in this any time soon.

- IIAR is encouraging the concept of OSHA looking for safety issues, but not administrative "needling". Documentation is the common ground, but the real goal of safety should be at the forefront.

- "Good players" are not the problem – they are the ones who realize the benefits of safety, energy efficiency, reduced costs and higher production. We don't want OSHA to alienate them.

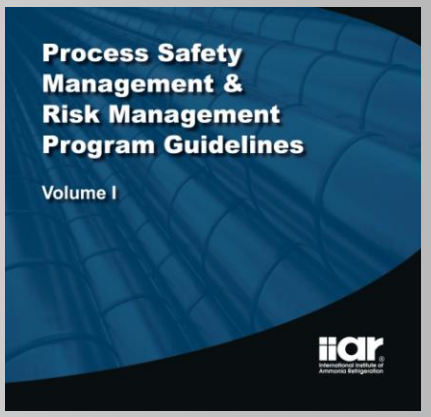
BACKGROUND On IIAR PSM/RMP Compliance Guidelines

- In 1992 OSHA published its PSM Standard
- The IIAR published *Guide to the Implementation of Process Safety Management for Ammonia Refrigeration* in 1994 to provide comprehensive advice for compliance

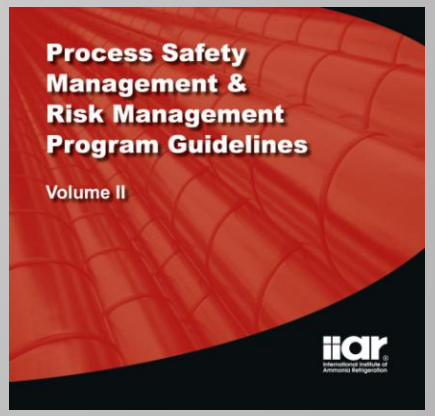
CONTENTS OF THE IIAR PSM GUIDE

- One chapter for each of the 14 PSM elements
  - The first part of each chapter contained the relevant text of the PSM Standard and a description of the employer's compliance obligations
  - The second part consisted of a general series of work practices that may assist the employer in developing a PSM Program

RISK MANAGEMENT PROGRAM RULE



- In 1996 EPA published its Risk Management (RM) Program Rule



- The IIAR updated the *Process Safety Management Guidelines* in 1998

UPDATED PSM GUIDELINES

- Included lessons learned from the first five years of PSM implementation and enforcement
- Added new material related to the RM Program Rule in a companion *Risk Management Guidelines*

CRITIQUE OF THE GUIDELINES

- Work practices have been an excellent source of relevant information
- Guidelines and related training have attracted end-users to the IIAR
- Implementation practices have changed over the last 10+ years

IIAR GUIDELINES – REV 3

- IIAR established a Task Force in 2010 to update the IIAR *Process Safety Management Guidelines* and the *Risk Management Program Guidelines*

- New Guidelines were completed in 2012

TASK FORCE OBJECTIVES

- Put Guidelines in "user friendly" format
- Update the Guidelines to reflect OSHA and EPA clarifications
- Update the Guidelines to reflect current PSM and RM Program practices
- Update the Guidelines to reflect OSHA's NEP

SCOPE OF WORK (Cont'd)

- Additional information added:
  - How to prepare for and participate in an OSHA/EPA inspection
  - Summary of recent OSHA/EPA citations
  - How to respond to an OSHA/EPA citation

ISSUES RELATED TO INTERPRETATIONS

- All OSHA and EPA interpretations are listed
- If Task Force "agrees" with the interpretation guidance includes steps to comply
- If Task Force "disagrees" with the interpretation (e.g., hydrostatic relief valves) information has been provided to "address" the interpretation
- If Task Force feels OSHA or EPA interpretation can not be enforced but agrees with their "suggestions", TIPS are given to help each facility to decide what is best for their operation

MANAGEMENT SYSTEM

- Task force wrote a management system guide to help companies keep up with their program documentation.

- Revised guidelines have simpler format
  - Organizational chart
  - List of PSM and RM Program activities with space to assign responsibilities
  - Provisions for a document plan

HAZARD ASSESSMENT

- Increased emphasis on EPA Guidance
- Description of how to use engine room as a containment device
- Current population programs to be references
- Plan to be in “Report Format”

RMP

- Guidance is provided on the changes in the regulation including use of RMP*eSubmit
- Guidance is provided on the difference between:
  - Accidents which should be investigated as part of PSM/RM Program
  - Accidents which need to be reported to the NRC
  - Accidents to include on five-year accident history

EMPLOYEE PARTICIPATION

- Additional "TIPS" provided on how to encourage participation
- References to the EPA RM Program added

PROCESS SAFETY INFORMATION

- Several OSHA clarifications addressed
- Additional options provided for
  - Estimating ammonia inventory
  - Documenting relief system design basis

PROCESS HAZARD ANALYSIS

- Ensure questions reflect current industry standards and guidelines
- Ensure all operations addressed (e.g. oil draining)
- Reflect OSHA citations
- Address facility siting, human factor and site security issues
- Consistent with the ARM Program

OPERATING PROCEDURES

- Ensure guidelines are consistent with IIAR-7
- Ensure sample operating procedures are still relevant and accurate

TRAINING

- Document updated to reflect current training options available:
  - IIAR videos
  - Publications
  - Outside training resources

MOC and PSSR

- Updated, stream-lined forms provided
- Recent OSHA clarifications are addressed

MECHANICAL INTEGRITY

- Guidelines were updated to ensure they reflect current industry standards and guidelines, especially IIAR-5 and IIAR-6
- References to non-applicable standards were deleted

INCIDENT INVESTIGATION

- Forms were updated
- “Odor compliant” procedures added

COMPLIANCE AUDIT

- Procedures were streamlined
- Updated checklist has been provided

EMERGENCY RESPONSE

- Additional clarification was provided on response options
- Guidelines have beenupdated to reflect current suggested response procedures

Thank you