# Engine Room Ventilation Design and Requirements

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# Introduction

- Codes and Standards
- Definition of machinery (engine) room
- Purpose of machinery room ventilation
- Code required ventilation amounts
- Example
- Other considerations

# Codes and Standards

- *ASHRAE 15-1994*
  Safety Code for Mechanical Refrigeration
- *IIAR 2-1999*
  Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems
- International Mechanical Code (2000)
- Uniform Mechanical Code (1997)

# Machinery Room Definitions

- *ASHRAE 15 - 1994*

Space that is designed to safely house compressors and pressure vessels

# Machinery Room Ventilation Functions

- Limit excessive temperature rise due to equipment-generated heat
- Provides fresh air for machinery room occupants
- Purges refrigerant vapor from the machinery room in emergency situations

# Halocarbon Refrigerants

- Considered non-toxic and non-flammable
  - Colorless and odorless
- Ventilation is still essential to purge vapor in leak scenarios
  - refrigerant is heavier than air
  - refrigerant displaces oxygen causing asphyxiation
    - keep oxygen >19.5% at atmospheric pressure
      - 20.9% of air is oxygen
      - approximately 7% of refrigerant by volume in air

# Ammonia as a Refrigerant

- Toxic and flammable
  - NIOSH IDLH 300 ppm
  - LFL ~ 16% (by volume), UFL ~ 25% (by volume)
  - Odor perceptible at very low concentrations (5-15 ppm)
- Ventilation is essential to purge vapor in leak scenario
  - ammonia vapor is lighter than air
  - attempts to prevent the concentration from reaching LFL to minimize the probability of a deflagration
    - NFPA requires sufficient ventilation to maintain concentrations below 25% of the LFL (or 4% for ammonia)

# Machinery Room Ventilation

- *ASHRAE 15 - 1994* Requirements
  - Emergency
    - Based on the single largest system charge of refrigerant

$$CFM_{emergency} = 100\sqrt{lb_{refrigerant}}$$

  - Non-Emergency
    - Intermittent
      - Maintain room temperature <18°F above ambient based on all of the heat-producing machinery in the room
    - Continuous
      - Greater of 0.5 cfm/ft$^2$ or 20 cfm/person when occupied

# Emergency Ventilation Requirements

- Other codes/standards:
  - *IMC* (2000), *UMC* (1997)
    - Same as *ASHRAE 15*
  - *IIAR 2-1999* (ammonia)
    - *ASHRAE 15* amount, or 12 ACH, whichever is greater
  - Other checks
    - local code requirement(s)
    - insurance carrier requirements (if applicable)

# Non-emergency Ventilation Requirements

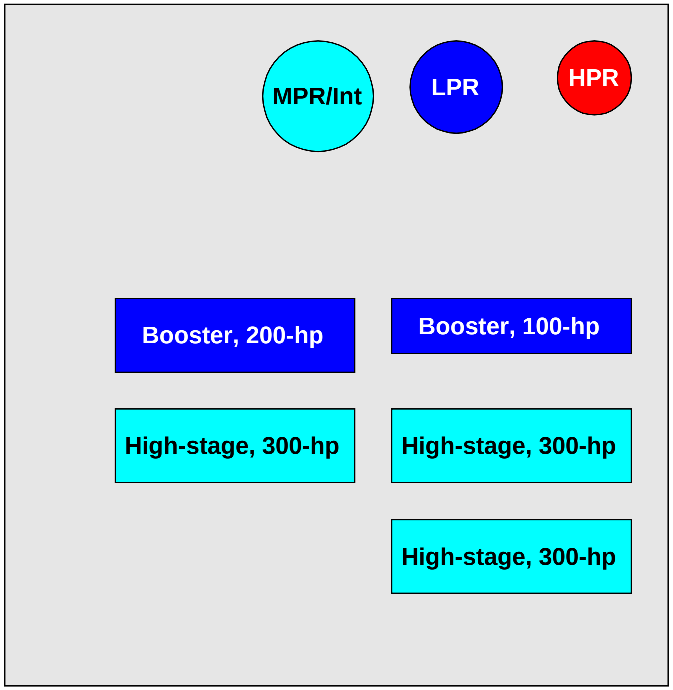
- Other codes/standards:
  - *IMC* (2000), *IIAR 2-1999*
    - Same as *ASHRAE 15*
  - *UMC* (1997)
    - Negative pressure of 0.05 in $H_2O$ relative to adjacent spaces
    - Room temperature must be less than 104$^{o}$F

# Other guidance

- *IIAR Bulletin 111-1991* (ammonia)
  - Recommends
    - Emergency
      - Recommends 10 cfm/ft$^2$ with a minimum of 20,000 cfm
    - Continuous
      - 1-2 cfm/ft$^2$
  - Considered industry best practice for ammonia

# Example

- 50' x 50' x 25' Machinery room
- Two-stage ammonia system with five screw compressors
  - Boosters: (1) 200-hp, (1) 100-hp
  - High-stage: (3) 300-hp
- Three vessels
  - LPR @ -20°F (3.5 psig)
  - MPR/Intercooler @ 18°F (31 psig)
  - HPR @ 95°F (181 psig)
- 20,000 lb charge (1 system)



# ASHRAE 15 Design Ventilation Rates

- Emergency $CFM_{emergency} = 100\sqrt{20,000} = 14,200\text{ cfm}$
- Non-emergency
  - Intermittent
    - 1,095 hp of 93% efficient motors = 195,000 Btu/hr
    - High-stage oil separators and discharge gas piping heat gain estimate = 10,000 Btu/hr
    - Miscellaneous = 20,000 Btu/hr

$$CFM_{non-emergency} = \frac{q_{equipment}}{1.08 \cdot (\Delta T_{ER})} = \frac{225,000}{1.08 \cdot (18)} = 11,800\text{ cfm}$$

  - Continuous†
    - 0.5 cfm/ft$^2$ = 1,250 cfm

† May require heat depending on location.

# Other Checks

- Emergency
  - *IIAR 2-1999:* Check 12 ACH
    12,500 cfm
  - *IIAR Bulletin 111-1991*: (10 $cfm/ft^2$)
    25,000 cfm
- Non-emergency (continuous)
  - *IIAR Bulletin 111-1991*: 1-2 $cfm/ft^2$
    2,500-5,000 cfm

# Ventilation Placement

- Inlet location for exhaust fans should consider where vapors will concentrate
- Exhaust fan location should consider prevailing weather conditions and surrounding buildings
- Avoid recirculation between inlets and outlets

# Ventilation Control

- Refrigerant detectors
  - Set to initiate emergency ventilation at:
    - 50% of IDLH (*UMC*)
      - 150 ppm ammonia
    - 80% of cardiac sensitization level (*ASHRAE 15*†)
      - 42,000 ppm R-22
      - 60,000 ppm R-134a

† From Table 1 of allowable refrigerant quantities.

# Recap

- *ASHRAE 15* is widely referenced by code authorities and local jurisdictions
- Keep in mind that code values for emergency ventilation are minimums
- Always double check proposed design for
  - compliance with local code requirement(s)
  - insurance underwriter

# Ammonia Ventilation Rule-of-thumb

- Ventilating ammonia to keep concentration below 4% (25% of LFL) requires:
  - 24 volumes of fresh air for each volume of ammonia vapor generated in the engine room
  - total exhaust volume is 25

$$CFM_{exhaust} = 25 \cdot CFM_{ammonia\ vapor\ generated}$$

Source: IIAR Bulletin 111, 1991

# Halocarbon Ventilation Rule-of-thumb

- Ventilating halocarbon to keep concentration below 7% (19.5% oxygen) requires:
  - 13 volumes of fresh air for each volume of ammonia vapor generated in the engine room
  - total exhaust volume is 14

$$CFM_{exhaust} = 14 \cdot CFM_{halocarbon\ vapor\ generated}$$