



RAGAGEP: Historical Variants and the Importance of IIAR Standards

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Session Outline

1. Define RAGAGEP
2. Discuss Historical Perspectives & IIAR Standards
3. Highlight RAGAGEP Variants



SECTION 1 – DEFINING RAGAGEP



Defining RAGAGEP

Process Safety Management – Process Safety Information

29 CFR § 1910.119 (d)(3)(i) information pertaining to the equipment in the process shall include:

- (F) Design Codes and Standards Employed

29 CFR § 1910.119 (d)(3)(ii) The employer shall document that equipment complies with **recognized and generally accepted good engineering practices**.



SECTION 2 – HISTORICAL PERSPECTIVES & IIAR STANDARDS

What Qualifies as RAGAGEP?



Ammonia
Refrigeration
Code &
Standard
Writing
Organizations



Ammonia
Refrigeration
Code &
Standard
Writing
Organizations



IIAR's
Vision for
the
Future

Guidelines for:
Identification of
Ammonia Refrigeration
Piping and
System Components

NOTICE

The information contained in these guidelines has been obtained from sources believed to be reliable. However, it should not be assumed that all acceptable methods or procedures are contained in this document, or that additional measures may not be required under certain circumstances or conditions.

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IIAR Bulletins



IIAR Standards

“This document is intended to serve as a standard for equipment, design and installation of closed circuit ammonia refrigerating systems. Additional requirements may be necessary because of particular circumstances, project specifications or other jurisdictional considerations. Note that this standard does not constitute a comprehensive detailed technical design manual and should not be used as such.”



IIAR Standards

- IIAR 1 – Definitions and Terminology (2012)
- IIAR 2 – Design (1974, 1984, 1999, 2008, 2014)
- IIAR 3 – Valves (2012)
- IIAR 4 – Installation (2015)
- IIAR 5 – Startup and Commissioning (2013)
- IIAR 6 – Inspection Testing and Maintenance (2019)
- IIAR 7 – Operating Procedures (2013)
- IIAR 8 – Decommissioning (2015)
- **IIAR 9 – Existing Systems (2019?)**



IIAR's
Vision for
the
Future





IIAR and Model Codes

2018 UMC §1102.1 General. Refrigeration systems using a refrigerant other than ammonia shall comply with this chapter and ASHRAE 15.

2018 UMC §1102.2 Ammonia Refrigeration Systems

Refrigeration systems using ammonia as the refrigerant shall comply with IIAR 2, IIAR 3, IIAR 4 and IIAR 5 and shall not be required to comply with this chapter



SECTION 3 – HISTORICAL RAGAGEP VARIANTS



EMERGENCY SHUTDOWN CONTROLS



Emergency Shutdown Controls

1967 UMC §1509 Equipment in a Machinery Room

A readily accessible single emergency refrigeration control switch shall be provided to shut off all electrically operated machinery in any machinery room, except the exhaust ventilation system complying with Section 1508. Such switch shall be controlled from a point outside of, and within ten feet (10') of the required opening to the machinery room....



Emergency Shutdown Controls

1982 UFC §63.108(a)(5)(iv) Control Valves

Emergency switches for deactivation of the system compressors shall be provided *within the emergency control box.*



Emergency Shutdown Controls

1994 UMC §1108.4 Emergency Control.

A clearly identified switch of the break-glass type providing off-only control of electrically energized equipment and devices within the refrigeration machinery room shall be provided immediately adjacent to and outside of each refrigeration machinery room exit. In addition, emergency shutoff shall also be automatically activated when the concentration of refrigerant vapor exceeds 25 percent of the LFL.



Emergency Shutdown Controls

2012 IFC §606.9.1 Refrigeration system emergency shutoff.

A clearly identified switch of the break-glass type or with an approved tamper-resistant cover shall provide off-only control of refrigerant compressors, refrigerant pumps and normally closed automatic refrigerant valves located in the machinery room.

Additionally, *this equipment shall be automatically shut off whenever the refrigerant vapor concentration in the machinery room exceeds the vapor detector's upper detection limit or 25 percent of the LEL, whichever is lower.*



EPCS VS ECB

Emergency Pressure Control System vs Emergency Control Box



Emergency Control Box (ECB)

1973 UMC §1518 Manual Discharge or Refrigerant

Every refrigerating system located in a building and containing... a Group 2 refrigerant shall be equipped with means for manual discharge of the refrigerant to the atmosphere.

1982 UFC §63.108 Emergency Ammonia Diffusion Systems

Ammonia refrigeration systems shall be provided with an approved system for promptly and safely removing the ammonia refrigerant in the event of an emergency.



Emergency Pressure Control Systems

2006 NFPA 1 §53.7

Refrigeration systems containing more than 6.6 pounds (3 kg) of flammable, toxic or highly toxic refrigerant or ammonia shall be provided with an emergency pressure control system.

2006 IMC §1105.9 Emergency pressure control system.

Refrigeration systems containing more than 6.6 pounds (3 kg) of flammable, toxic or highly toxic refrigerant or ammonia shall be provided with an emergency pressure control system in accordance with Section 606.10 of the International Fire Code.

2006 IFC §606.10 Emergency pressure control system

606.10 Emergency pressure control system. Refrigeration systems containing more than 6.6 pounds (3 kg) of flammable, toxic or highly toxic refrigerant or ammonia shall be provided with an emergency pressure control system in accordance with Sections 606.10.1 and 606.10.2.



ECB / EPCS - Big Ideas

- All refrigeration system should have an ECB or EPCS
- It is not necessary to update an ECB to an EPCS



NH₃ DISCHARGE TERMININATION

Atmospheric vs Diffusion Tanks



Diffusion Tanks

1971 UFC §63.106 Ammonia Diffusion

Ammonia refrigerating plants containing more than 30 pounds of refrigerant shall be equipped with facilities for diffusing the ammonia vapors. (a) Systems containing more than 30 pounds of refrigerant shall discharge to the outside of the building at least 2 feet above the roof and be so located that discharged refrigerants will not cause discomfort or harmful effects to persons **OR** such discharge shall be into a tank of fresh water having a capacity of one gallon for each pound of refrigerant and used for no other purpose than ammonia.

1982 UFC §63.108 Emergency Ammonia Diffusion Systems

Refrigeration systems shall be provided with an approved system for promptly and safely removing the ammonia refrigerant in the event of an emergency. Such emergency systems shall discharge into an approved water storage tank, water basin or diffuser having a capacity of 2 gallons of water for each pound of ammonia.



Diffusion Tanks

1994 UMC §1119 Ammonia Discharge

Ammonia systems shall be provided with an emergency discharge into a tank of water provided exclusively for ammonia absorption. At least 1 gallon (379 mL) of fresh water shall be provided for each pound (454 g) of ammonia in the system.

1994 UFC §6308.1.1

Refrigeration systems which are designed to discharge refrigerant vapor to atmosphere shall be provided with an approved treatment or flaring system....
EXCEPTIONS: Ammonia systems complying with Section 6309.

1994 UFC §6309 Ammonia Discharge

Ammonia systems shall be provided with an emergency discharge into a tank of water provided exclusively for ammonia absorption. At least 1 gallon (3.79 L) of fresh water shall be provided for each pound of ammonia in the system.



Diffusion Tanks

2000 IFC §606.11 Refrigerant Discharge

Refrigeration system containing more than 6.6 pounds of flammable, toxic or highly toxic refrigerants shall be provided with an approved discharge system as required by... 606.11.3 [Ammonia Refrigerant]. Systems containing ammonia refrigerant shall discharge vapor to the atmosphere through a flaring system... through an approved ammonia diffusion system... or by other approved means.

2000 IFC §606.11.6 Ammonia Diffusion System

Ammonia diffusion systems shall include a tank containing 1 gallon of water for each pound of ammonia that will be released in 1 hour from the largest relief device connected to the discharge pipe.



Diffusion Tanks

2003 NFPA 1 §53.9 Ammonia Diffusion Systems.

Ammonia diffusion systems shall include a tank containing 1 gal of water for each pound of ammonia that will be released in 1 hour from the largest relief device connected to the discharge pipe.

2009 UMC §1120.0 Ammonia Discharge.

Ammonia shall discharge into a tank of water that shall be used for no purpose except ammonia absorption. At least one (1) gallon (3.785 L) of fresh water shall be provided for each pound (454 g) of ammonia that will be released in one (1) hour from the largest relief device connected to the discharge pipe.



Diffusion Tanks Today – Mechanical Codes

2018 IMC §1105.8 Ammonia Discharge.

Pressure relief valves for ammonia systems shall discharge in accordance with ASHRAE 15.

2018 UMC §1102.2 Ammonia Refrigeration Systems Refrigeration systems using ammonia as the refrigerant shall comply with IIAR 2, IIAR 3, IIAR 4 and IIAR 5 and shall not be required to comply with this chapter.



Diffusion Tanks Today – Refrigeration Industry Groups

ANSI/IIAR 2-2014 §15.5.1 Atmospheric Discharge.

Pressure relief devices shall discharge vapor directly to the atmosphere outdoors in accordance with this section. EXCEPTION: In lieu of relieving directly to atmosphere, the following methods of discharging ammonia from pressure relief devices shall be permitted where approved by the AHJ: (1) Discharge through a treatment system. (2) Discharge through a flaring system (3) Discharge through a water diffusion system. (4) Discharge using other approved means

ANSI/ASHRAE 15-2016 §9.7.8.4.2 Ammonia (R-717).

Pressure relief valves serving systems using ammonia as a refrigerant shall discharge in accordance with one of the following: (a) To atmosphere (b) Internally (c) To a treatment system approved by the authority having jurisdiction



Diffusion Tanks Today – Fire Codes

2018 NFPA 1 §53.2.2.1 Required Systems.

Unless the AHJ determines, upon review of an engineering analysis prepared at the expense of the owner, that a significant fire, health, or environmental hazard would not result from an atmospheric release, refrigeration systems that are designed to discharge refrigerant vapor to the atmosphere shall be provided with an approved treatment, flaring, or diffusion system...

2018 NFPA 1 §53.2.2.1.3 Ammonia Refrigerant.

Systems containing ammonia refrigerant shall discharge vapor to the atmosphere through a treatment system in accordance with 53.2.2.1, through a flaring system in accordance with 53.2.2.2, through an approved ammonia diffusion system in accordance with 53.2.2.3, or by other approved means....

2018 NFPA 1 §53.2.2.3 Design of Ammonia Diffusion Systems.

Ammonia diffusion systems shall include a tank containing 1 gal of water for each pound of ammonia... that will be released in 1 hour from the largest relief device connected to the discharge pipe.



Relief Valve Termination - Big Ideas

- Jurisdictional authority may require a facility to install a diffusion tank if there is reasonable precedent, or during years which specifically required them.
- Industry prioritizes atmospheric diffusion



AMMONIA DETECTION

The Most Confusing of them All



Year	1974 - 1984	July 24, 1985 - 1999	August 5, 1999 - 2008	June 3, 2008 - 2010	Aug 4, 2010 - 2012	Dec 3, 2012 - 2014	2014 - Present
General	ANSI / IAR 1974-78 No "General" Section	ANSI / IAR 1984 No "General" Section	ANSI IAR 2-1999 No "General" Section	ANSI IAR 2-2008 §13.1.1.2 All machinery rooms shall be equipped with at least ONE ammonia detector connected to a supervised alarm.	ANSI IAR 2-2008 Addendum A §13.2 Each refrigerating machinery room shall contain at least TWO refrigerant detectors that actuate an alarm and mechanical ventilation	ANSI IAR 2-2008 Addendum B §13.2 Each refrigerating machinery room shall contain at least TWO refrigerant detectors that actuate an alarm and mechanical ventilation	ANSI IAR 2014 §6.13.1 Machinery rooms shall be provided with ammonia detection and alarm in accordance with Sections 17.2-17.6 and the following features: 1. AT LEAST ONE ammonia detector shall be provided in the room or area. 2. The detector shall activate an alarm that reports to a monitored location so that corrective action can be taken at an indicated concentration of 25 ppm or higher. 3. Audible and visual alarms shall be provided inside the room to warn that access to the room is restricted to authorized personnel and emergency responders when the alarm has activated. Additional audible and visual alarms shall be located outside of each entrance to the machinery room.
Alarms - Machinery Rooms	ANSI / IAR 1974-78 §4.3.2.2 The vapor detector(s) shall also initiate a supervised alarm so corrective action can be initiated	ANSI / IAR 1984 §4.3.2.2 The vapor detector(s) shall also initiate a supervised alarm so corrective action can be initiated	ANSI IAR 2-1999 §6.2.1.3 A supervised alarm system shall be activated when the ammonia leak detector is activated or when the mechanical ventilation system fails so that corrective action can be taken.	ANSI IAR 2-2008 §13.2.1.3 A supervised alarm system shall be activated when the ammonia leak detector is activated or when the mechanical ventilation system fails so that corrective action can be taken	ANSI IAR 2008 Addendum A §13.2.1.1 A monitored location shall be notified when the ammonia leak detector is activated so that corrective action can be taken. ANSI IAR 2008 Addendum A 13.2.1.2 The detectors shall activate VISUAL and AUDIBLE alarms INSIDE the refrigerating machinery room and OUTSIDE each entrance to the refrigerating machinery room	ANSI IAR 2-2008 Addendum B §13.2.1.1 A monitored location shall be notified when the ammonia leak detector is activated so that corrective action can be taken. ANSI IAR 2-2008 Addendum B §13.2.1.2 The detectors shall activate visual and audible alarms inside the refrigerating machinery room and outside each entrance to the refrigerating machinery room.	ANSI IAR 2-2014 §6.13.2.2 Detection of ammonia concentrations equal to or exceeding 25 ppm shall activate visual indicators and audible alarms as specified in Section 6.13.1. The visual indicator and audible alarm shall be permitted to automatically reset if the ammonia concentration drops below 25 ppm
Year	1974 - 1984	July 24, 1985 - 1999	August 5, 1999 - 2008	June 3, 2008 - 2010	Aug 4, 2010 - 2012	Dec 3, 2012 - 2014	2014 - Present
Alarms - Refrigerated Spaces	ANSI / IAR 1974 No Reference	ANSI / IAR 1984 No Reference	ANSI IAR 2-1999 No Reference	ANSI IAR 2008 No Reference	ANSI IAR 2008 Addendum A No Reference	ANSI IAR 2008 Addendum B No Reference	ANSI IAR 2014 §7.2 Where an ammonia refrigeration system or equipment is installed outside of a machinery room, the area containing the system or equipment shall comply with this section. 7.2.3 *Detection and Alarms. Level 1 detection and alarm shall be provided in accordance with Section 17.7.1.
Ventilation Control	ANSI / IAR 1974-78 §4.3.2.2 The room shall be provided with an independent mechanical ventilation system actuated automatically by a vapor detector(s) when the concentration of ammonia in the room exceeds 40,000 parts per million	ANSI / IAR 1984 §4.3.2.2 The room shall be provided with an independent mechanical ventilation system actuated automatically by a vapor detector(s) when the concentration of ammonia in the room exceeds 40,000 parts per million	ANSI IAR 2-1999 §6.2.3 Equipment 6.2.3.1 The machinery room shall be provided with an independent mechanical ventilation system actuated automatically by vapor detector(s) and also operable manually. 6.2.3.1.1 The typical recommended actuation level of the detection device is a setting less than 400 ppm ; however, activation levels shall be set as required by the jurisdictional authority. 6.2.3.1.2 Where one or more alarm levels are used, the level actuating the ventilation system shall not exceed 1000 ppm .	ANSI IAR 2008 §13.2.3.1 The machinery room shall be provided with an independent mechanical ventilation system actuated automatically by vapor detector(s) and also operable manually 13.2.3.1.1 The typical recommended actuation level of the detection device is a setting less than 400 ppm; however, activation levels shall be set as required by the jurisdictional authority. 13.2.3.1.2 Where one or more alarm levels are used, the level actuating the ventilation system shall not exceed 1000 ppm.	ANSI IAR 2008 Addendum A §13.2.3.1 One detector shall be utilized to activate an alarm and actuate the normal mechanical ventilation system (at its maximum design capacity) at a value not greater than the corresponding TLV-TWA . ANSI IAR 2008 Addendum A §13.2.3.2 The second detector shall be utilized to activate an alarm and actuate the emergency mechanical ventilation system at a level not exceeding 1000 ppm	ANSI IAR 2008 Addendum B §13.2. Shall contain at least two refrigerant detectors that actuate an alarm and mechanical ventilation. ANSI IAR 2-2008 Addendum B §13.2.3.1 One detector shall be utilized to activate an alarm and actuate the normal mechanical ventilation system (at its maximum design capacity) at a value not greater than the corresponding TLV-TWA ANSI IAR 2-2008 Addendum B ANSI IAR 2008 Addendum B §13.2.3.2 The second detector shall be utilized to activate an alarm and actuate the emergency mechanical ventilation system at a level not exceeding 1000 ppm	ANSI IAR 2014 §6.13.2.3 Detection of ammonia concentrations equal to or exceeding 150 ppm (1/2 IDLH) shall activate visual indicators and an audible alarm and shall activate emergency ventilation, where required, in accordance with Section 6.14.7. Once activated, emergency ventilation shall continue to operate until manually reset by a switch located in the machinery room



Year	1974 - 1984	July 24, 1985 - 1999	August 5, 1999 - 2008	June 3, 2008 - 2010	Aug 4, 2010 - 2012	Dec 3, 2012 - 2014	2014 - Present
Emergency Shut off	ANSI / IAR 1974 No Reference	ANSI / IAR 1984 No Reference	ANSI IAR 2-1999 No Reference	ANSI IAR 2008 No Reference	ANSI IAR 2008 Addendum A No Reference	ANSI IAR 2008 Addendum B No Reference	ANSI IAR 2014 §6.13.2.4 Detection of ammonia concentrations that exceed a detector's upper detection limit or 40,000 ppm (25% LFL) , whichever is lower, shall activate visual indicators and an audible alarm and shall activate emergency ventilation, where required, in accordance with Section 6.14.7. Once activated, emergency ventilation shall continue to operate until manually reset by a switch located in the machinery room. In addition, the following equipment in the machinery room shall be automatically de-energized: 1. Refrigerant compressors. 2. Refrigerant pumps. 3. Normally closed automatic refrigerant valves that are not part of an emergency control system
Testing	ANSI / IAR 1974-78 §4.3.2.2 Periodic tests of the detector(s) / alarm / mechanical ventilation system shall be performed	ANSI / IAR 1984 §4.3.2.2 Periodic tests of the detector(s) / alarm / mechanical ventilation system shall be performed	ANSI IAR 2-1999 §6.2.2 The machinery room design shall establish a time schedule for testing of the mechanical ventilation system, the ammonia detectors, and the alarm system. The manufacturer's recommendations shall be followed. Where no recommendations are provided, these devices shall be scheduled for exercising on an annual basis	ANSI IAR 2-2008 §13.2.2 The machinery room design shall establish a time schedule for testing of the mechanical ventilation system, the ammonia detectors, and the alarm system. The manufacturer's recommendations shall be followed. Where no recommendations are provided, these devices shall be scheduled for exercising on an annual basis	ANSI IAR 2008 Addendum A §13.2.5.1 The facility shall establish a time schedule for testing of the ammonia detectors and the alarm system. The manufacturer's recommendations shall be followed or modified based on documented experience ANSI IAR 2008 Addendum A §13.2.5.2 Where no recommendations are provided, these devices shall be functionally tested on an annual basis	ANSI IAR 2-2008 Addendum B §13.2.5.1 The facility shall establish a time schedule for testing of the ammonia detectors and the alarm system. The manufacturer's recommendations shall be followed or modified based on documented experience ANSI IAR 2-2008 Addendum B §13.2.5.2 Where no recommendations are provided, these devices shall be functionally tested on an annual basis.	ANSI IAR 2-2014 §17.3.1 A schedule for testing ammonia detectors and alarms shall be established based on manufacturers' recommendations, unless modified based on documented experience. ANSI IAR 2-2014 §17.3.2 Where manufacturers' recommendations are not provided, ammonia detectors and alarms shall be tested at least annually

Ammonia Detection & Ventilation

Year	Ventilation Control						
	Strictest Requirement	IMC	IFC	UMC	UFC / NFPA 1	IIAR	ASHRAE
1974 - 1989	Ventilation automatically actuated by detection @ 40,000 PPM	No	No	No	No	Yes	No
1989 - 1992	Ventilation automatically actuated by detection @ Lowest Practical Level	No	No	No	No	*40,000 PPM	Yes
1992 - 1994	Ventilation automatically actuated by detection @ Lowest Practical Level	No	No	No	No	*40,000 PPM	Yes
1994 - 1998	Ventilation automatically actuated by detection @ 150 PPM (1/2 IDLH)	No	No	Yes	Yes	*40,000 PPM	*1,000 PPM
1999	Ventilation automatically actuated by detection @ 150 PPM (1/2 IDLH)	No	No	Yes	Yes	*1,000 PPM	*1,000 PPM
2000 - 2009	Ventilation automatically actuated by detection @ 150 PPM (1/2 IDLH)	*1,000 PPM	No	Yes	*1,000 PPM (2003)	*1,000 PPM	*1,000 PPM
2009	Ventilation automatically actuated by detection @ 1,000 PPM	Yes	No	Yes	Yes	Yes	Yes
2010 - 2012	Ventilation automatically actuated by detection @ TLW-TWA (25 PPM)	*1,000 PPM	No	*1,000 PPM	*1,000 PPM	Yes	*1,000 PPM
2012 - 2014	Ventilation automatically actuated by detection @ TLW-TWA (25 PPM)	*1,000 PPM	No	*1,000 PPM	*1,000 PPM	Yes	*1,000 PPM
2014 - Present	Ventilation automatically actuated by detection @ 150 PPM	*1,000 PPM	No	*1,000 PPM	*1,000 PPM	Yes	*1,000 PPM



Ammonia Detection – Big Ideas

- All refrigeration facilities should have ammonia detection in the machinery room and refrigerated spaces
- Detection systems should be tested according to the manufacturer recommendations; at least annually where no recommendation exists.
- Initial alarm level should be set at 25 ppm for both the machinery room and refrigerated spaces.
- Detection systems should be interlocked with the machinery room ventilation system



Machinery Room Ventilation

ANSI/IIAR 2 1974-1978 §4.3

“The room shall be provided with an independent mechanical ventilation system actuated automatically by vapor detector(s)....”



Sizing Ventilation Fans

1970 Uniform Mechanical Code (UMC) §1508

“An exhaust system of ventilation arranged to provide a complete change of air in such a room at least once every five minutes and discharge to the outside air at a location not less than 20 feet from any exterior door, window or ventilation inlet in any building.”

Note: “once every 5 min.” = 12 air changes per hour



Sizing Ventilation Fans

ANSI/ASHRAE 15-1989 § 10.13.6.2

...The mechanical ventilation required to exhaust a potential accumulation of refrigerant due to leaks or a rupture of the system shall be capable of removing air from the machinery room in the following quantity:

$$Q = 100 \times G^{0.5}$$

where:

Q = the air flow in cubic feet per minute

G = the mass of refrigerant in pounds in the largest system, any part of which is located in the machinery room



Sizing Ventilation Fans

ANSI/IIAR 2-2008 §13.3.9.1 Addendum A

Emergency mechanical ventilation systems shall be capable of providing at least one air change every two minutes, which is 30 air changes per hour (30 ACH) based on the gross machinery room volume.

Up or Down Blast?





Up or Down Blast?

IIAR Bulletin 111 §3.3.1 Fan Type

Published June 2002

“Consider specifying up-blast, high velocity discharge non-sparking fans since they tend to be effective at dispersing ammonia exhaust vapors more effectively.”

Bulletin No. 111 06/02

Guidelines for:

Ammonia Machinery
Room Ventilation

International Institute of
Ammonia Refrigeration





Up or Down Blast?

ANSI/IIAR 2-2008

Addendum A §13.3.7.1

Published August 2010

“All exhaust fans shall discharge up vertically with a minimum discharge velocity of 2500 FPM”





Machinery Room Ventilation – Big Ideas

- All machinery rooms should have mechanical ventilation
- Documentation should describe what the ventilation system is capable of and what codes were used to design / select the fan.



LABELING

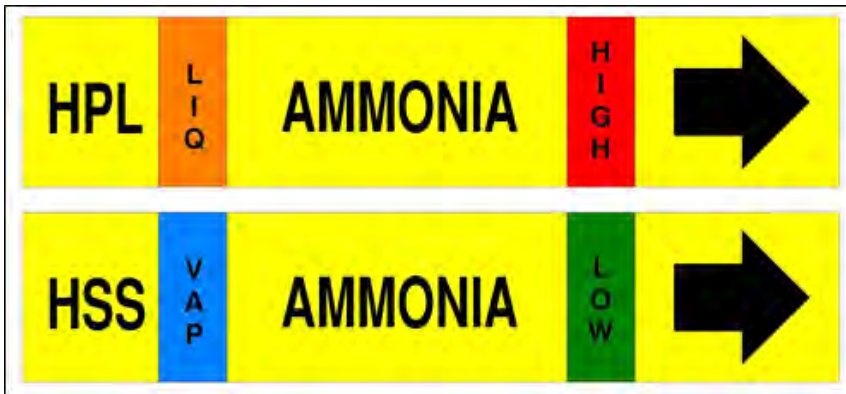
Yellow vs Orange



Pipe Labeling

- “AMMONIA”
- Physical state of ammonia
- Relative pressure (high or low)
- Pipe service (HPL, CD, HSS)
- Direction of flow





Bulletin No. 114 9/91

Guidelines for:

Identification of
Ammonia Refrigeration
Piping and
System Components

International Institute of
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Bulletin No. 114 March 2014

Guidelines for:

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IIAR STANDARD 9

An Important Contribution



QUESTIONS?

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