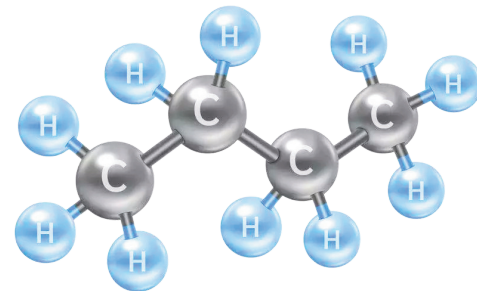


HYDROCARBON REFRIGERANT SAFETY

A3 REFRIGERANTS

PATRICK MURPHY, CM JASON OBRZUT, CMHE



Hydrocarbon Refrigerant Safety

A3 Refrigerants

Patrick Murphy, CM

Jason Obrzut, CMHE

esco institute



A3 Refrigerant Safety

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Ver 1: 100125

The safe use of refrigerants is one of the most critical responsibilities of today's HVACR technicians. As our industry transitions away from high-GWP refrigerants toward more sustainable alternatives, hydrocarbon refrigerants, classified as A3 refrigerants, are being reintroduced into a wide range of residential and commercial applications. While these refrigerants offer clear environmental advantages, their high flammability demands specialized training, awareness, and procedures.

This book was developed by the ESCO Institute to serve as both an instructional resource and a field reference for working with A3 hydrocarbon refrigerants such as propane (R-290) and isobutane (R-600a). It combines essential background knowledge with step-by-step safety practices, guided by the latest codes, standards, and regulatory requirements.

Technicians using this manual will gain:

- A clear understanding of hydrocarbon refrigerant properties, environmental considerations, and system applications.
- Knowledge of the governing codes and standards that define safe installation, servicing, transportation, and storage.
- Practical field procedures designed to minimize hazards and ensure compliance with best practices.
- Tools such as pressure-temperature charts and sample safety data sheets to support daily service activities.

Whether used in the classroom or on the job, this book and its accompanying certification are intended to protect technicians, customers, and the environment, while supporting a successful transition to next-generation refrigerants.

About This Book

Acknowledgements

ESCO Institute would like to extend our appreciation and gratitude to the following organizations who have contributed to this project.

Embraco
Leer
National Refrigerants
NAVAC
Pro Green Technologies, LLC
True Manufacturing

About the Authors



Patrick Murphy, CM has dedicated more than 50 years to the HVACR industry. He began his career in the commercial HVACR sector, specializing in supermarket systems, before transitioning into education as a classroom instructor. While teaching he was invited to assist with the development of the certification for vocational educators by the National Board of Professional Teaching in the late '90s. He eventually transitioned from just teaching to being a testing and certification specialists within the HVACR Industry.

In recent decades, Patrick has held leadership roles with several prominent trade associations, including NATE and RSES. Today, he continues to serve the HVACR Industry as a curriculum and testing consultant as well as a contract assessor for the ANSI National Accreditation Board (ANAB), conducting personnel certification accreditation assessments for Certified Food Protection (CFP) and ISO/IEC 17024:2012 Conformity Assessment.

Jason Obrzut, CMHE, is the Director of Industry Standards and Relations at ESCO Institute. In this role, he acts as the liaison to numerous government and industry organizations. He has taken on the following roles in the HVACR industry; technician, contractor, instructor, HVACR program chair, director of education, and author. Some of the publications authored and co-authored by Jason include Brazing & Soldering, Gas Heating, Low GWP Refrigerant Safety, Quick Guide to Refrigeration Cycle, System Recovery & Evacuation, Water Heaters by ESCO Institute, and Refrigeration & Air Conditioning Technology by Cengage. He presently serves on the AHRI Safe Refrigerant Transition Task Force (SRTTF). In 2016 he was recognized as one the ACHR News "Top 40 Under 40" and took first place in the Teachers-N-Trainers Competition hosted by HVAC Excellence.



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Introduction to Hydrocarbons (HCs)

Most refrigerants in use today started out as hydrocarbons such as methane (CH_4), propane (C_3H_8), propene (C_3H_6), or ethane (C_2H_6). Pure hydrocarbons (HCs) are natural organic compounds composed of only hydrogen and carbon. To produce the CFCs, HCFCs, HFCs, and HFOs that are widely used in the HVACR industry, hydrocarbons are subjected to a series of chemical processes that replace hydrogen atoms with halogens, such as chlorine and fluorine.

Hydrocarbons must be purified before they can be used as a refrigerant. Standard propane, for example, is commonly used for cooking, and heating but contains many impurities. Refrigerant-grade propane is a purer chemical formulation designed specifically for use in modern refrigeration and air conditioning systems. When propane is purified to refrigerant-grade standards, it becomes R-290. The level of purity that must be achieved is set by AHRI Standard 700, which ensures that minimal contaminants like water, sulfur, and other hydrocarbons are not present.

Propane is available in different grades such as fuel-grade, chemical-grade, refrigerant-grade, and aerosol-grade. The difference is in the purity levels, which can range from 80% to 99.9%. For example, aerosol-grade propane, which is used for some spray paint applications, has a lower purity requirement than refrigerant-grade propane.

Like most hydrocarbons, propane is odorless. For safety, standard propane has an odorant which is considered to be a contaminant in a refrigeration system. The stenching agent, called mercaptan or ethyl mercaptan, is added to propane to give it a "rotten egg" smell. This is an important safety feature to alert people when a gas leak is present. These additives can cause damage and premature failure of system components if used in a refrigeration system. When purchasing refrigerant-grade propane (R-290), it is important to ensure that its purity has been certified by AHRI, Underwriter's Laboratory (UL), or both.

Re-introduction to Hydrocarbon as Refrigerants

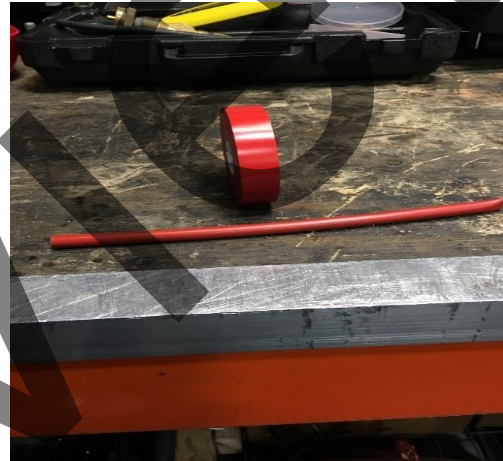
The use of hydrocarbon refrigerants is not new. Propane and other types of flammable refrigerants have been in use since the mid 1800's. The development of non-flammable refrigerants, like R-12, reduced the use of flammable refrigerants for close to 100 years. However, environmental concerns such as Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) have caused these flammable refrigerants to be reintroduced as alternatives.

HCs have zero ozone depletion potential and very low global warming potential, which makes them a sustainable alternative. They are starting to see expanded use across many applications. While there are charge size restrictions in place, refrigerants such as R-290 (propane) and R-600a (isobutane) have become commonplace in many corded refrigeration appliances. However, they are highly flammable and require special safety precautions and training to handle.

Section 1: Introduction to Hydrocarbons



EPA Section 608 regulations require that if a system is charged with a flammable refrigerant, the equipment must have red (Pantone® Matching System (PMS) #185) markings on the service valves and tubing through which a flammable refrigerant will flow. This color will be present on all service valves and/or process tubes. The color mark must extend at least 1 inch, in each direction, from the refrigerant service valve and must be replaced if removed.



Electrical Requirements

Flammable refrigerant systems require sealed/gas-tight or fire/explosion-proof electrical components and connectors as specified by UL 60335-2-89. The system controls and connecting accessories must meet the requirements for use in equipment charged with a flammable refrigerant. The controls are designed and located to minimize the refrigerant/air mixture near electrical contacts to prevent ignition should a leak occur. Additionally, some commonly used industry components are no longer allowed to be used per UL standards. Wire-nuts do not meet the UL-required pull test as they can be pulled off the wires and could potentially provide an ignition source from the bare wire to the cabinet. Therefore, wire-nuts are no longer allowed to be used in systems with A3 flammable refrigerants.



Standards and Codes for Hydrocarbon Refrigerants

Standards and codes are two distinct documents. A standard is developed by an organization through a comprehensive review process that is open, transparent and consensus based. The standard, depending on its use, is approved for accuracy and safety of the general public or a specific subset within an industry. The standards of the various organizations help to inform and develop model building codes.

A code is an industry organization's developed standard adopted in part or whole by a governing body. Standards are used as guidance by a code authority for adoption for the safety of the public, structure and/or systems within. Local building codes can vary from state to state or city to city. If compliance questions arise, always defer to the local code authority for guidance.

There are many standards and codes governing the use of flammable refrigerants. Some of the applicable standards have been referenced in EPA SNAP (Significant New Alternative Program) approvals for use applications and limitations.

Due to environmental concerns and regulatory changes, alternative refrigerants may become necessary across a variety of applications. Refrigerant and equipment manufacturers will identify a substitute refrigerant through research, testing, and development. Safety standards for design, installation, maintenance, and disposal must then be updated to provide guidance for use. Once the appropriate safety standards for design (UL), installation, maintenance, and disposal (ASHRAE) have been updated, the final step in the refrigerant approval process is EPA SNAP approval. Model building codes, which are typically updated every three years, can then adopt the new standards. Many of the substitute refrigerants that are now being approved have some level of flammability, either A2L or A3.

The following are some of the codes and standards that govern the safe use, storage, and transportation of flammable refrigerants. Always refer to the most recent version of these codes and/or standards.



EPA Significant New Alternatives Policy (SNAP)

Section 612 of the Clean Air Act (CAA) requires EPA to evaluate substitutes for ozone-depleting substances to reduce overall risk to human health and the environment. Through these evaluations, SNAP generates lists of acceptable and unacceptable substitutes for each of the major industrial use sectors. SNAP rulings may reference safety standards for use limitations or applications. The intended effect of the SNAP program is to promote a smooth transition to safer alternatives.

Approved Hydrocarbon Refrigerants and Applications

At the time of this writing, the hydrocarbon refrigerants R-290 and R-600a are approved for use in a variety of applications, with more being tested for use regularly. The following are some current examples of these systems and are not meant to be an exhaustive list.

Residential Refrigeration

Some residential refrigerator and freezer manufacturers started HC refrigerants around 2012. All systems are now mandated to use low GWP refrigerants. The current GWP limit for refrigerants used in domestic refrigeration systems is 150. Most manufacturers use R-600a, which has a GWP of 3, to meet these requirements. The HC charge size is restricted to 150 grams (5.3 ounces) or less for this application.



	HOUSEHOLD REFRIGERATOR / RÉFRIGÉRATEUR MÉNAGÈRE
MODEL/MODÈLE :	LF29H8330S /00
PRODUCT CODE / CODE DE PRODUIT :	GR-L29BFSRH.ASTCNA0
SER.No. / NO. DE SÉRIE :	308KBMKKQ587
RATING / CAPACITÉ NOMINALE	115 V ~ 60 Hz 4.0 A
DEFROSTING INPUT / PUISSANCE ABSORBÉE EN DÉGIVRAGE	380 W
POWER INPUT OF ICEMAKER HEATER / PUISSANCE ABSORBÉE DE LA RÉSISTANCE DE LA FABRIQUE DE GLACE	— W
REFRIGERANT / RÉFRIGÉRANT	R600a 2.96 oz (84 g)
DIMENSIONS (W x H x D)	35 3/4" x 70 1/4" x 34 3/8"
PRODUCTION DATE / DATE DE PRODUCTION	2023.08
Contains FCC ID : BEJ-LCW8001	
Contains IC / Contient IC : 2703N-LCW8001	
MADE IN KOREA / FABRIQUÉ EN CORÉE	

	DANGER - Risk of fire or explosion.	R600a
	AVERTISSEMENT - Risque d'explosion.	
	ADVERTENCIA - Riesgo de explosión.	
Flammable Refrigerant Used.		
This product is only to be repaired by trained service personnel.		
- Use only manufacturer-authorized service parts.		
- Any repair equipment used must be designed for flammable refrigerants.		
- Follow any manufacturer repair instructions.		
Do not damage or puncture refrigerant tubing.		
Dispose of refrigerator properly in accordance with federal or local regulations.		

A3 System Field Procedures

There are several procedures required to complete the servicing/repair of a refrigeration system. When working on an A3 system, these procedures have added layers of safety, require special tools, or additional steps. They can include:

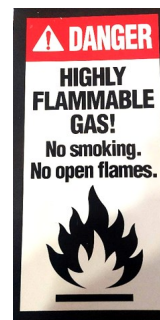
- Recovery/Venting
- Component Removal
- System repairs
- Brazing
- Evacuation
- Pressure Testing
- Charging

Jobsite Safety

When working with refrigerants on a jobsite, safety should always be a priority. A proper lockout/tagout procedure should be used when the equipment is de-energized. The person performing the work should carry the only key. A multimeter should be used to verify that there is no voltage present before beginning work. The area should be well ventilated to prevent oxygen displacement and suffocation in the event of a refrigerant leak. With proper jobsite ventilation, flammable refrigerants can be kept below their lower flammability limit (LFL) should a leak occur. Accumulation of a flammable refrigerant in a confined space can lead to a severe ignition event, resulting in a fire or explosion. The jobsite should be evaluated for safety hazards, such as possible ignition sources or the presence of flammable vapors, *prior to beginning the work*.

When installing and servicing equipment with flammable refrigerants, conduct the following procedures:

- Always conduct a risk assessment to determine whether it is appropriate and allowed by code to use a flammable refrigerant in that particular workplace.
- Always wear appropriate safety glasses and gloves when working with HCs and while brazing tubing.
- The work area must be free from sources of ignition such as open flames and sparking electrical devices, like light switches. Typically, an area with a radius of 10 feet around the equipment being serviced, should have no source of ignition. If there is any source of ignition the area must be fan ventilated.
- This safe zone also applies around a vacuum pump because it could discharge some residual HC gas during evacuation.
- Hydrocarbon refrigerants do not have an odorant, so leaks can't be identified by smell. A quality combustible gas leak detector is mandatory for HC service work.
- The combustible gas detector must be located at a low level as HCs are heavier than air.
- Good ventilation is essential to reduce the potential of a flammable mix.
- Do not smoke while working with A3 refrigeration systems.
- Assure the presence of a functioning Class B fire extinguisher or bring one.



easier to braze closed. Before brazing, perform a leak test with a digital leak detector or bubble solution. Braze the pinched end of the process stub closed and repeat the leak test. If the red identifying process tube cover has been removed for the repair, it must be replaced after the tube has cooled down.



Note: In some jurisdictions or occupancy classifications, such as institutional structures, there may be a requirement to transport equipment charged with a hydrocarbon off-site to perform service. After the equipment has been serviced, it can be returned to site. Always check with the local code authority for guidance when servicing hydrocarbon equipment.



Charging

One way to help ensure that an air conditioning or refrigeration system will operate at its rated capacity and efficiency is to make certain that the system contains the appropriate refrigerant charge. The charge specified by the manufacturer is the exact amount of refrigerant required for optimal performance of the equipment under specified conditions and temperature ranges. Refrigerant charge, airflow, ambient temperatures, refrigerant line set length, and load conditions all affect the system's performance. A slight overcharge or undercharge can result in significant losses in cooling capacity. A slight overcharge will increase the amount of liquid subcooling in the condenser, and a slight undercharge will starve the evaporator, increasing superheat.

In a critically charged system, the refrigerant must be weighed into the exact amount listed on the manufacturer's label. Always use a scale capable of charging a hydrocarbon along with the proper adaptors for the refrigerant tank. Always use hoses rated for flammable refrigerants. The following is an example of a charging procedure using a programmable digital hydrocarbon scale with a built-in isolation solenoid. *Always follow manufacturer's instruction for the tools and equipment being used.*

- Connect the refrigerant tank to the scale, either directly or using an approved charging hose.
- Connect the charging hose from the scale to the system being charged.
- Purge the air from any hoses being used, then zero the scale.
- Program the required charge into the digital scale.
- Open the low loss fitting to allow the refrigerant to enter the system.

Appendix Pressure-Temperature Charts and SDS Sheets

In this section:

- R-290 P/T Chart
- R-600a P/T Chart
- R-290 SDS Sheet
- R-600a SDS Sheet

NATIONAL REFRIGERANTS, INC. **R-290**

Safety Data Sheet

R290 PROPANE

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: PROPANE
 OTHER NAME: Liquefied Petroleum Gas (LPG)
 USE: Refrigerant Gas
 DISTRIBUTOR: National Refrigerants, Inc.
 661 Keyway Avenue
 Bridgeton, New Jersey 08302

FOR MORE INFORMATION CALL:
 (Monday-Friday, 8:00am-5:00pm)
 1-800-262-0912

IN CASE OF EMERGENCY CALL:
 CHEMTREC: 1-800-224-9500

2. HAZARDS IDENTIFICATION

CLASSIFICATION: Flammable Gas, Gas under pressure, Compressed Gas
 SIGNAL WORD: DANGER
 HAZARD STATEMENT(S): Extremely flammable gas. Contains gas under pressure, may explode if heated
 SYMBOLS: Flames, Gas Cylinder

PRECAUTIONARY STATEMENT(S):
 Prevention: Keep away from heat, sparks, open flame, and hot surfaces. No smoking
 Response: Leaking gas fire: Do not extinguish unless leak can be stopped immediately. Eliminate all ignition sources to 40 ft.
 Storage: Protect from sunlight, store in a well ventilated place.

EMERGENCY OVERVIEW:
 Flammable gas. Liquid under high pressure.

POTENTIAL HEALTH EFFECTS:
 Effects of Overexposure:
 Eye Contact: No known significant effects or critical hazards.
 Skin Contact: No known significant effects or critical hazards.

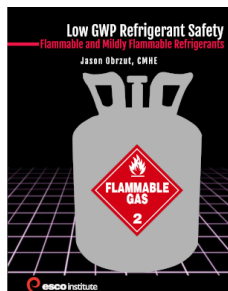
SDS: PROPANE
 Current Issue Date: January, 2024
SDS courtesy of National Refrigerants. For education purposes only. Please refer to the refrigerant manufacturer's website for current data.

°F	PSIG	°F	PSIG
60	93	110	199.6
65	101.4	115	213.4
70	110.2	120	227.8
75	119.5	125	242.9
80	129.3	130	258.7
85	139.7	135	275.1
90	150.5	140	292.3
95	161.9	145	310.2
100	173.9	150	328.9
105	186.5	155	348.4
110	199.6		
115	213.4		
120	227.8		
125	242.9		
130	258.7		
135	275.1		
140	292.3		
145	310.2		
150	328.9		
155	348.4		

Did You Enjoy This Training Program?



If you enjoyed this training program, here are some additional training programs from ESCO Institute you may enjoy:



Low GWP Refrigerant Safety: Flammable and Mildly Flammable Refrigerants

Item #: LGRSPM
Retail Price: \$48.95

Description:

The EPA began the phasedown of HFC refrigerants, including R-410A, on January 1, 2022. As a result, the HVACR industry is transitioning to Low GWP Refrigerants including R-32, R-454B, and equipment that runs on them. HVACR professionals need to know the codes and standards for safe handling, storage, and transportation of these mildly flammable refrigerants (A2L).

Did You Know?

- A2L cylinders will be equipped with a spring-loaded pressure relief valve instead of a rupture disc.
- A2L cylinders will be color-coded red.
- Most A2L equipment will require refrigerant detection systems.
- There are new National Fire Protection Association (NFPA) fire safety storage requirements for Low GWP Refrigerants.
- These are some of the things you **NEED TO KNOW** to work on new equipment!

Certification & Instructor Resources also available!



Introduction to R-744 (CO₂) Refrigeration

Item #: R744PM
Retail Price: \$69.95

Description:

As you work through this book, you'll navigate the principles, practices, and procedures that define R-744 refrigeration. You'll also take the first step to learning how to safely and properly handle, install, and maintain these systems with confidence.

Covered in the Book:

- Carbon Dioxide (CO₂) Refrigeration Introduction
- R-744 Safety, Handling, and Storage
- The Vapor-Compression Refrigeration Cycle and the Pressure Enthalpy Chart
- R-744 System Types, Equipment Applications and High-Pressure Controls
- R-744 Refrigeration System Components
- R-744 Refrigeration System Installation
- R-744 Refrigeration System Leak Testing, Evacuation, and Start-Up
- R-744 Refrigeration System Service and Maintenance Procedures

Certification & Instructor Resources also available!

Find out more at www.escogroup.org

Appendix A: Pressure-Temperature Charts

Refrigerant:	R-290
ASHRAE Standard 34 Safety Rating:	A3
Global Warming Potential:	3

°F	PSIG		°F	PSIG
-40	1.4		60	93
-35	3.4		65	101.4
-30	5.7		70	110.2
-25	8.1		75	119.5
-20	10.7		80	129.3
-15	13.6		85	139.7
-10	16.7		90	150.5
-5	20.1		95	161.9
0	23.7		100	173.9
5	27.6	R-290	105	186.5
10	31.8		110	199.6
15	36.3		115	213.4
20	41.1		120	227.8
25	46.3		125	242.9
30	51.8		130	258.7
35	57.7		135	275.1
40	63.9		140	292.3
45	70.6		145	310.2
50	77.6		150	328.9
55	85.1		155	348.4



Important Information Regarding Safety Data Sheets

The safety data sheets (SDS) provided here are for sample/review purposes only, and are current as of the date of publication of this manual. SDS sheets are updated by the refrigerant manufacturer, as necessary, and it is the responsibility of the technician to ensure the most up to date information on the refrigerant being used is reviewed.

Preview



Safety Data Sheet

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1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

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USE: Refrigerant Gas
DISTRIBUTOR: National Refrigerants, Inc.
661 Kenyon Avenue
Bridgeton, New Jersey 08302

FOR MORE INFORMATION CALL:
(Monday-Friday, 8:00am-5:00pm)
1-800-262-0012

IN CASE OF EMERGENCY CALL:
CHEMTREC: 1-800-424-9300

2. HAZARDS IDENTIFICATION

CLASSIFICATION: Flammable Gas, Gas under pressure, Compressed Gas
SIGNAL WORD: DANGER
HAZARD STATEMENT(S): Extremely flammable gas, Contains gas under pressure, may explode if heated
SYMBOL(S): Flames, Gas Cylinder



PRECAUTIONARY STATEMENT(S):

Prevention: Keep away from heat, sparks, open flame, and hot surfaces. No Smoking

Response: Leaking gas fire: Do not extinguish unless leak can be stopped immediately. Eliminate all ignition sources if safe to do so.

Storage: Protect from sunlight, store in a well ventilated place.

EMERGENCY OVERVIEW:

Flammable gas. Liquid under high pressure.

POTENTIAL HEALTH EFFECTS:

Effects of Overexposure:

Eye Contact

No known significant effects or critical hazards.

Skin Contact

No known significant effects or critical hazards.



Safety Data Sheet

R600a ISOBUTANE

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: ISOBUTANE
OTHER NAME: 2-methylpropane
USE: Refrigerant Gas
DISTRIBUTOR: National Refrigerants, Inc.
661 Kenyon Avenue
Bridgeton, New Jersey 08302

FOR MORE INFORMATION CALL:
(Monday-Friday, 8:00am-5:00pm)
1-800-262-0012

IN CASE OF TRANSPORTATION EMERGENCY CALL:
CHEMTREC: 1-800-424-9300

EMERGENCY OVERVIEW:
Flammable gas. Liquid under high pressure.

2. HAZARDS IDENTIFICATION

CLASSIFICATION: Flammable Gas, Gas under pressure, Compressed Gas
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Storage: Protect from sunlight, store in a well ventilated place.

EMERGENCY OVERVIEW:
Flammable gas. Liquid under high pressure.

POTENTIAL HEALTH EFFECTS

Effects of Overexposure:

Eye Contact

Liquid can cause severe irritation, redness, tearing, blurred vision, and possible freeze burns.

Skin Contact

Contact with evaporating liquid can cause frostbite.

HYDROCARBON REFRIGERANT SAFETY

A3 REFRIGERANTS

PATRICK MURPHY, CM JASON OBRZUT, CMHE

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- Knowledge of the governing codes and standards that define safe installation, servicing, transportation, and storage.
- Practical field procedures designed to minimize hazards and ensure compliance with best practices.
- Tools such as pressure-temperature charts and sample safety data sheets to support daily service activities.

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