Introduction and Overview of HVAC Systems

Course 106

PARTICIPANT GUIDE

RAIL CAR TRAINING CONSORTIUM

HVAC Systems

Introduction and Overview

Course 106

Participant Guide

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Rail Car Training Consortium

How to Use the Participant Guide

Purpose of the Course

The purpose of the *Introduction and Overview of HVAC Systems* course is to provide participants with an orientation to rail car HVAC, basic principles and key components.

Approach of the Book

Each course module begins with an outline, a statement of purpose and objectives, and a list of key terms. The outline will discuss the main topics to be addressed in the module. A list of *key terms* identifies important terminology that will be introduced in this module. *Learning objectives* define the basic skills, knowledge, and abilities course participants should be able to demonstrate to show that they have learned the material presented in the module. *Exercises* are built in throughout the course materials to assist the participants in learning and reviewing key information.

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MODULE 1

Overview of Rail Car HVAC and General Safety Procedures

Outline

Purpose and Objectives

The purpose of this module is to provide participants with a basic understanding of the hazards and proper handling of refrigerant, Personal Protective Equipment (PPE) generally used by HVAC technicians, and safety rules and procedures related to HVAC maintenance.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Demonstrate knowledge of Clean Air Act of 1990, EPA 608 Certification, Refrigerant Hazards and Proper Handling Techniques
- Explain types and use of Personal Protective Equipment (PPE) when dealing with HVAC systems
- List safety rules related to HVAC maintenance

Key Terms

- Clean Air Act of 1990
- Environmental Protection Agency (EPA)
- Section 608 Certification
- Toxicity
- Exposure
- Heavier than Air
- Flammable Refrigerant
- Combustible Refrigerant
- Asphyxiation
- Decomposition
- Self-contained Breathing Apparatus (SCBA)
- Lockout/Tag out
- Pinch point
- Electrical Hazards

Classroom Activity 1 – Reading and Understanding a Safety Data Sheet
In small groups or pairs, pick one of the Safety Data Sheets (SDS) provided by the instructor. Discuss the key components of the MSDS. Using the worksheet below, note *key points* so that you can *share* these findings with the class.

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Table 1.2 Worksheet for Classroom Activity 1

Reading and Understanding a Safety Data Sheet	
Name of Material	
Emergency Overview	
Potential Health Hazards	
First Aid Measures	
Personal Protective Equipment	
Other	

Flammability/Combustion/Decomposition

Flammable refrigerants present an immediate danger when released into the air. The refrigerant can combine with air at atmospheric pressure and ignite, causing a flame and possibly an explosion to occur. Because of the obvious hazards, the use of flammable refrigerants is restricted to controlled environments that have monitors, proper ventilation, explosion-proof equipment and generally few people near the equipment.

is a good opportunity for HVAC technicians and their supervisor to work the JHR together, developing safe work practices for routine jobs.

Table 1.5 Job Hazard Review Example: Cutting the Refrigeration Line to Install a Retrofit Safety Valve

Task	Problem	Accident Prevention	PPE Required
1. pump out old refrigerant	Vacuum pump fittings leak Hose separates from quick connect	Inspect/Replace O-rings Push collar until fitting locks	Gloves, Safety Glasses Gloves, Safety Glasses
2. cut refrigeration tubing	Sharp edges on cut tubing	Use deburring tool	Gloves, Safety Glasses
3. install retrofit valve	Tight tubing fit, may leak	Sand off paint layer first	Safety Glasses

Some transit agencies have developed "Job Cards" for routine maintenance jobs. See Figure 1.15 for an example. Follow the safety instructions listed on the job card, including the identified hazards, required PPEs, and operating procedures.

250 HVAC EXTENSIVE

SAFETY INSTRUCTIONS

Identified Hazards: Exposure to electrical circuits. **Treat all circuits as if they were energized**. Whenever feasible, it is best to de-energize exposed electrical circuits when maintenance is necessary or the compartment is to remain open. Follow all electrical safety practices outlined at the beginning of this document, Trimet SOPs, Manufacturer Manuals, Maintenance Updates, and training instructions.

Require PPE's: LRV must be powered down and lockout/tag out must be applied prior to performing this work, Safety glasses with side shields or face shield/hearing protection (must be worn when using compressed air), mask/respirator (anytime you are using compressed air to clean.)

Tools: 9/16" socket, air nozzle, laptop, cables.

1. Ensure that the catenary is locked out and the shop power is disconnected.
2. Thoroughly clean all fan impeller blades.
3. Check that condenser and evaporator fans rotate freely and without bearing noise.
4. Clean the compressor oil sight glasses.
5. Inspect the electrical compartment. Clean as required.
6. Inspect the compressor oil level. It must be visible in the sight glass. Fill as needed. Note: A droplight can be used to provide backlighting through the rear oil inspection sight glass. Oil Color and oil level can be seen easier. If there is clean oil in the sight glass and no external oil leaks are found, it is good. If it is low, add compressor oil halfway up the sight glass.

Figure 1.15 Job Card for HVAC Extensive (Courtesy of Tri-Met)

Lockout/Tagout

Lockout/tagout procedures have been implemented within the industry to prevent injury or death by requiring that certain precautions be taken before working on equipment. This includes de-energizing, locking, and tagging out the electrical power source of the equipment.

If any corrective or preventative procedures are required on the HVAC system, ensure that power to the HVAC unit is shut off and remains off until personnel are safely clear of moving parts.

Always follow lockout/tagout procedures as per your authority. It is the maintenance personnel's responsibility to read and understand the safety procedures and contact their supervisor/instructor with any questions. Always carry a personal lock and appropriate tag when starting a job. See Figure 1.16 for the lockout/tagout kit and Figure 1.17 for a lockout/tagout example.

Figure 1.16 Lockout/Tagout Kit

Figure 1.17 Electrical Cutout Box with Lock (Courtesy of MBTA)

3. Lockout and tagout the mainline electrical disconnect switch. **SAFETY CAUTION**: Stand to the side of the mainline electrical disconnect switch when energizing or de-energining the system to avoid injuries from arc flash. **Do not stand in front of the mainline electrical disconnect switch!**
4. All electrical circuits must always be treated as live.
5. Prior to working on any circuits, check for live voltage present. Current as small as fifty (50) milliampere can cause severe damage to the human nervous system, depending upon the body resistance. Contact with even low voltages can result in serious injury.
6. All safety circuits must be kept in normal operating condition.
7. After the work has been completed, the tag or tags must be removed by the same person whose name appears on the tag.
8. When using a temporary circuit jumper, follow agency procedure and make sure that you understand what effect it will have on the equipment. Always remove your jumper when the job is finished or before leaving the job site.
9. Turning the mainline electrical disconnect switch off will not necessarily disconnect all electrical power. Be aware of 115 VAC power in the controller when the mainline electrical disconnect switch is off.
10. Always use an insulated fuse puller when removing or reinstalling fuses to avoid electrocution and damage to the fuse and fuse holders.

Working with Mechanical Equipment

A **pinch point** is a place where it's possible for a body part to be caught between moving machine parts or between moving and stationary machine parts. To avoid possible injury when performing inspection of maintenance on HVAC systems, keep hands and tools away from pinch points (Figure 1.19: Pinch Point), for example, motors or fan assemblies.

Figure 1.19 Pinch Point

Rotating equipment can damage body and property. Jewelry, especially rings and dangling necklaces, can cause serious injury if it gets caught in rotating equipment, on nails or screws, ladder rungs, scaffolding or various types of building materials, therefore, rings and dangling jewelry must be removed prior to working where they can get caught. Jewelry made of conductive metal also presents electrocution hazards while technicians work around powered equipment.

Chemicals and Cleaning

Chemicals are often used to clean equipment such as air-cooled condensers and evaporators. The chemicals are normally simple and mild. However, some cleaning products used for evaporator and condenser coil cleaning, especially for condenser coils (see Figure 1.20), can be harsh and

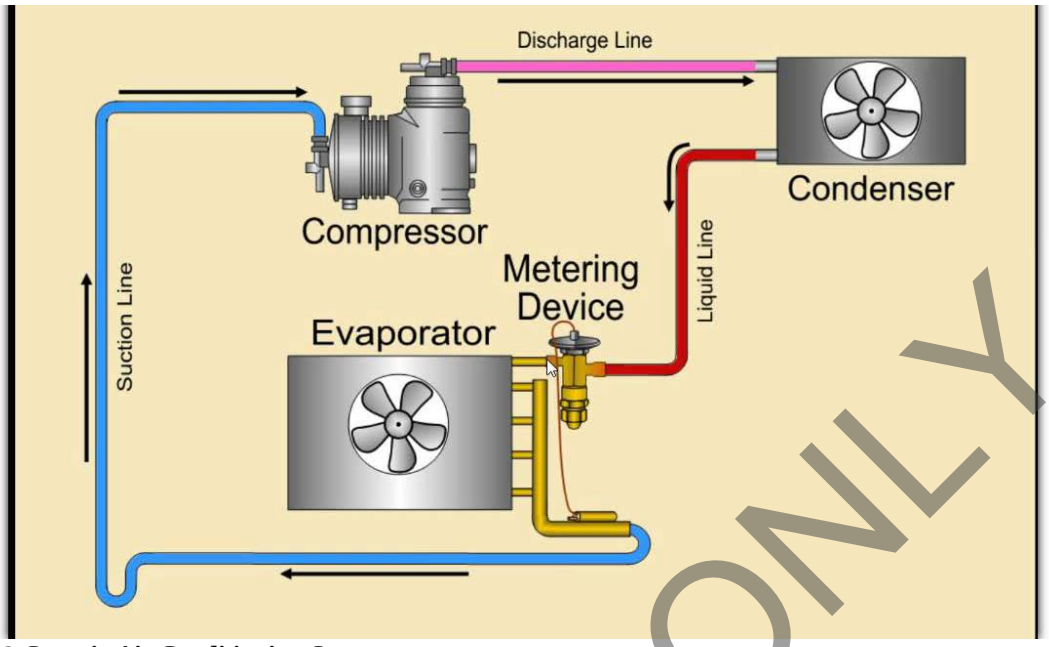


Figure 2.2 Generic Air Conditioning System

Source: http://www.frankpolimeda.com/perth-business-tips-why-is-commercial-refrigeration-an-specialists-area/

Refrigeration Process

A diagram of the AC refrigeration cycle (Figure 2.3) shows the refrigeration process and key AC unit components. There are four (4) major AC components which are split into two (2) sections:

- Indoors - indicated in blue and includes AC parts numbered one (1) and two (2)
- Outdoors - indicated in red and includes AC parts numbered three (3) and four (4).

These four components are divided into two different pressures: high pressure and low pressure. The high-pressure side is the condenser unit (outdoor/red) and the low-pressure side is the air conditioning evaporator (indoor/blue).

It's important to note that the dividing point between high and low pressure cuts through the compressor and the expansion valve.

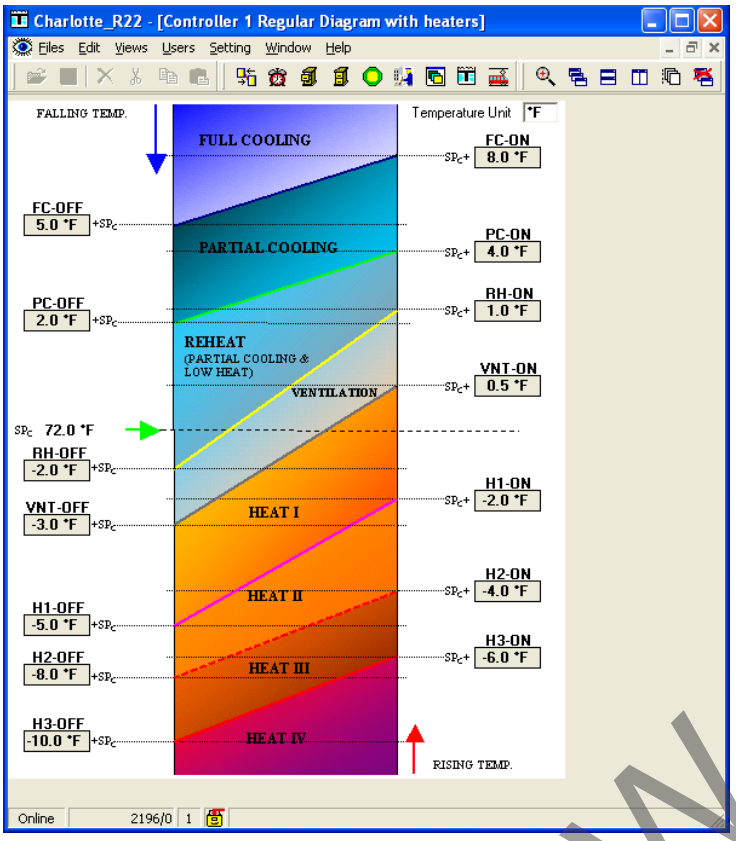


Figure 2.6 HVAC Controller Regular Diagram with Heaters (Courtesy of CATS)

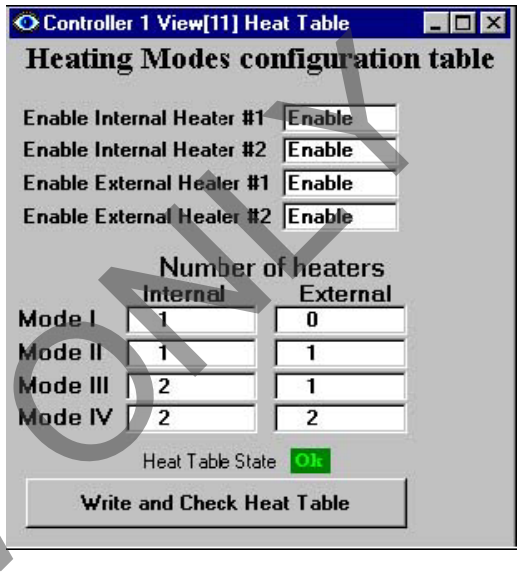


Figure 2.7 Heater Modes Configuration Table (Courtesy of CATS)

Electrical Heating Elements

Electric heat is produced by converting electrical energy to heat. This is done by placing a known resistance of a particular material in an electric circuit. The resistance has relatively few free electrons and does not conduct electricity easily. The resistance to electron flow produces heat at the point of resistance. One type of material commonly used in electric heating is nichrome, which is short for nickel chromium. Wire made from nichrome is used in the majority of electric heaters. For example, 80% nickel and 20% chromium are used for some rail car HVAC heater coils. Electric heat is very efficient but can be more expensive to operate compared to other sources of heat. It is efficient because very little electrical energy is lost from the meter to the heating element and there are no chimney losses as in the case of fossil-fuel heating systems. It is expensive because it takes large amounts of electrical energy to produce the heat, and the cost of electrical energy in most areas of the country can be expensive compared to fossil fuels (coal, oil, and gas). Although other types of heating elements can be used, such as hydronic (heated water), most current rail car HVAC systems are designed with electrical heating.

Flux is a chemical compound, usually made in the form of a liquid or paste which is applied to the joint surface prior to brazing. Its purpose is to protect the joint surface from the oxides that form during heating. Flux melts and becomes active during brazing, absorbing oxides and assisting in the flow of the brazing alloy. Although fluxing is generally an important part of the brazing process, it plays only a minor role in brazing HVAC components because most of these joints are copper-to-copper. When brazing copper-to-copper you can eliminate the flux by using a phosphorus bearing filler metal like Sil-Fos® or Fos Flo® because the phosphorus acts as a fluxing agent.

However, when brazing copper to steel (in compressor or valve assemblies) you can't use phosphorus bearing filler metals as they form brittle phosphides and the joint could fail. Instead use a phosphorus-free filler metal, but then you will have to use a flux. When brazing brass, you could use a phosphorus bearing alloy, but you will have to apply flux here as well. Refer to Figure 2.22 for a list of fluxes for base metals to be joined

The chart below shows recommended brazing filler metals and fluxes for various base metal combinations that can be joined.

SOLDER	95-5 Tin Antimony Solder	C-Flux	Copper Pipe Brass Steel
	95-5 Tin Antimony Solder	Rosin	Copper Pipe Copper Wiring Brass
	95-5 Tin Antimony Solder	Acid	Copper Pipe Brass Steel Galvanized Sheet Metal
	98-2 Tin Silver Solder	Mineral Based Flux	Copper Pipe Brass Steel
	40-60 Cadmium Zinc Solder	Specific Flux from Solder Manufacturer	Aluminum
BRAZING	Copper Phosphorus Silver Brazing BCuP	1% to 15% Silver No Flux required	Copper Pipe
	Copper Phosphorus Silver Brazing BcuP	1% to 15% Silver Mineral Based Flux	Copper Pipe to Brass Brass Steel
	Copper Silver Brazing BCuP	45% Silver Mineral Flux	Copper Pipe to Steel Brass Steel

Figure 2.22 Soldering and Brazing Metal and Fluxes Chart

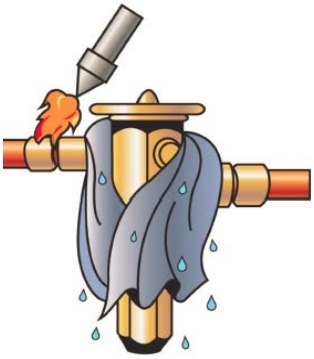


Figure 2.27 Wet Rag Wrapped Around TXV to Avoid Overheating

Figure 2.28 LA-Co Cool Gel

Figure 2.29 Heat Sink Compound

Safety Precaution

The following section provides some safety precautions when technicians perform HVAC piping and tubing tasks:

- Torches are used for soldering or brazing and have a high concentration of heat. Many combustible materials may be in the area where soldering or brazing is required. For this reason, it is important to know the proper procedures for extinguishing fires. See “Fire Safety and Fire Extinguisher Use” in Course 106 Module 1 for more information.

- When cutting the tubing to the required length, make sure that you use a proper tool such as the tube cutter. The burr on the inside of the tube that resulted from the cutting must be removed from the tube as these contaminants will affect the flow of refrigerant as well as affecting the performance of the system.

- When bending is required, take note that only the soft copper type can be bent. Use a proper tube bending spring setto prevent flattening the tube or kinks.

- When soldering or brazing is required, make sure that you have being trained to do this and adhere strictly to the instructions of the manufacturers.

- Wear eye protection when particles are being released in the air as a result of your action. Also, OSHA standard 1910.252(b)(2)(ii)(H) recommends using shaded lenses of Shade Number 3 or 4 when torch brazing, to protect the eyes from the bright light generated by the torch (Table 2.2).

- When you are doing annealing process where you heat up the tube and allow it to cool slowly, make sure that you use a flared flame over a distance of 1 foot at a time and not concentrating the heat on one location.

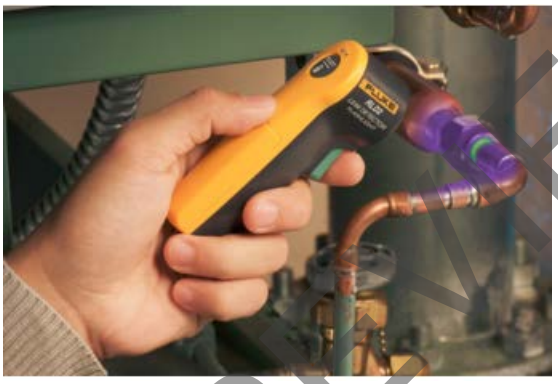
For example, if you repaired a leak, replaced a component, know that a system has a leak somewhere and/or you observe an area of the system that is oil coated, you would probably use a soap solution in the area to test and pinpoint a leak. It is the second simplest method after the visual method and it's inexpensive.

Soap solutions are available in many different types. Some have a brush applicator and others have a dabber (an absorbent ball attached to a stiff wire inside of the cap). Some brands may even have a spray applicator to quickly cover large areas of tubing in a short amount of time. This is an advantage, but it's also messy and time consuming to clean up.

Some soap solutions even have an antifreeze base to prevent them from freezing in the wintertime. Others may have a lower density to make them even more sensitive to very tiny leaks.

Figure 3.13 Big Blu Leak Detection Solution (Courtesy of CATS)

High-Intensity Ultraviolet Lamp



The ultraviolet system, Figure 3.14, induces an additive into the refrigerant system. The additive shows up as a bright yellow-green glow under the ultraviolet lamp at the source of the leak. The additive can remain in the system to test for a new suspected leak at a later date.

Figure 3.14 High-intensity Ultraviolet Lamp

Ultrasound Leak Detector

Ultrasound detectors use the sound from the escaping refrigerant to detect a leak (Figure 3.15 and Figure 3.16). This type of leak detector is relatively new and not commonly used in the transit rail HVAC maintenance environment. It consists of a device that is capable of amplifying noise so it can be heard. Most detectors will allow a technician to hear minute sounds indicating a small leak in a sealed system. Newer ultrasonic leak detectors now come with individual headphones to allow the technician to hear the leak even in noisy compressor rooms.

As usual, the higher the pressure in the system, the greater the chance of finding or, in this case, hearing, the leak. It can be used in the same manner as an electronic leak detector with one exception: It's more effective using dry nitrogen as a pressure medium than refrigerant because