CAMT Training:
Air Conditioning Maintenance and Repair Course

Refrigeration System | Electrical System | Air Distribution System | Unit Replacement

INSTRUCTOR RESOURCE GUIDE
CAMT Online Training

Don’t Forget…Take the Online Training for this CAMT Course!

To continue your education, you can also complete a brief online course on Air Conditioning Maintenance and Repair. This course will take approximately 30 minutes. You can access the course on your home computer, a computer in a public place such as a library, or a computer at work.

1. Go to the following web site: http://www.naahq.org/cps
2. Type the username and password you received.
3. Once you are logged in, you should see your Dashboard.
4. Your classes are listed under Required Training. You should be able to click on each learning track to access the modules.
5. Go through each learning track, and click on Launch to review each module within them. If the course does not open after clicking Launch, please make sure your pop up blocker is turned off.
6. After you complete each course, you are able to see it listed as Complete in the Learning track, as well as in Your Transcript.
7. If you have any issues, please contact education@naahq.org.

LIMITS OF LIABILITY AND DISCLAIMER OF WARRANTY

© 2015 by the National Apartment Association, 4300 Wilson Boulevard Suite 400 Arlington, VA 22203. All rights reserved. The course materials or any part thereof may not be reproduced, stored in a retrieval system, or transmitted, in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, or otherwise, without the prior written permission of the National Apartment Association Education Institute (NAAEI).

NAA retains copyright to the original materials and to any translation to other languages and any audio or video reproduction, or other electronic means, including reproductions authorized to accommodate individual requests based on religious or medical deferments from classroom participation.

DISCLAIMERS

Although NAAEI programs provide general information on apartment management practices, NAAEI does not guarantee the information offered in its programs is applicable in all jurisdictions or that programs contain a complete statement of all information essential to proper apartment management in a given area. NAAEI, therefore, encourages attendees to seek competent professional advice with respect to specific problems that may arise. NAAEI, their instructors, agents, and employees assume no responsibility or liability for the consequences of an attendee’s reliance on and application of program contents or materials in specific situations. Though some of the information used in scenarios and examples may resemble true circumstances, the details are fictitious. Any similarity to real properties is purely coincidental. Forms, documents, and other exhibits in the course books are samples only; NAAEI does not necessarily endorse their use. Because of varying state and local laws and company policies, competent advice should be sought in the use of any form, document, or exhibit.

POLICY STATEMENT REGARDING THE USE OF RECORDING DEVICES, AUDIO VISUAL EQUIPMENT, AND OTHER MEANS OF REPRODUCTION OR RECORDING OF THE “CERTIFICATE FOR APARTMENT MAINTENANCE TECHNICIANS” MATERIALS

All program contents and materials are the property of the National Apartment Association Education Institute, which strictly prohibits reproduction of program contents or materials in any form without the prior written consent. Except as expressly authorized in writing in advance, no video or audio recording of NAAEI programs or photocopying of “Certificate for Apartment Maintenance Technicians” materials is permitted. Authorized recording of programs or duplication of materials may be done only by the instructor on site.

© 2015 by the National Apartment Association
CAMT Training: Air Conditioning Maintenance and Repair Course

The National Apartment Association Education Institute thanks you for your time, talent, and technical expertise in training and developing the next generation of Certificate for Apartment Maintenance Technicians.

Whether you’re a subject matter expert or lay person…a seasoned instructor or a new teacher…this guide will help you become an even more engaging and effective trainer.

In this course on air conditioning, you’ll help maintenance technicians:

• Understand their role in air conditioning repair and maintenance.
• Improve their knowledge, skills, and abilities related to air conditioning.
• Perform air conditioning repairs with greater ability and confidence.
• Pursue the Certificate for Apartment Maintenance Technicians (CAMT) designation.

Although this course is targeted at technicians with one year of on-the-job experience, it can also be used to teach others who’d like to learn more about air conditioning maintenance and repair.

Course Prerequisites

The CAMT Electrical Maintenance and Repair Course: Participants need a solid foundation in electrical work to successfully understand and apply what’s taught in this air conditioning course. That’s why we strongly recommend they complete the CAMT “Electrical Maintenance and Repair” course beforehand.

Environmental Protection Agency (EPA) Certification: Participants should have, at a minimum, the EPA Type II certification. This certification allows technicians to work on any appliance that uses a high-pressure refrigerant such as R-22. These refrigerants are commonly used in apartment air conditioning systems.

Guide Contents

• Course overview
• Preparation instructions
• Course schedule
• Instructor script
• Appendix
Fast Facts: 
The Air Conditioning Maintenance and Repair Course

Course Type
- Instructor-led classroom training
- Uses short presentations, photos, videos, demonstrations, participant discussions, hands-on activities, and question and answer sessions to teach course material

Course Materials
- This instructor guide
- The Air Conditioning Participant Resource Guide (also for use as an on-the-job reference)
- CAMT USB flash drive
- The HVAC Servicing Procedures book, a technical manual participants will use to learn about more complex air conditioning topics

Course Length
Approximately 16 hours

Best Way to Schedule
- Two full-day sessions (include two 15 minute breaks and 30 minutes for lunch)
  OR
- Three five-and-one half hour sessions (include one 20-minute break in each session)
  OR
- Four four-hour sessions (include one 20-minute break in each session)

Course Location
If your area doesn’t have a CAMT training center, use the facility your affiliate provides and equip it with training and demonstration materials. (See the “Training Kit” section on the next page.)

Also consider touring a local apartment community so participants can see air conditioning systems in their real-world context. Not only will this enrich the training, but it will also help the learning stick.

Subject Matter Experts
Invite a subject matter expert—a current or retired air conditioning specialist, a trade school instructor—to volunteer his or her time to participate in the instruction. Experts are especially helpful for answering participants’ questions, giving real-world tips and tricks, and talking about industry trends. (Check with your affiliate if the expert requires compensation for helping with the course.)
Fast Facts:
The Air Conditioning Maintenance and Repair Course (continued)

Demonstrations and Hands-on Practice
Several topics in this course include a brief demonstration or a suggested hands-on activity to let participants actually see or do the repair.

If you can include these elements in your training, it will elevate and enrich the participants’ experience. Hands-on practice is especially valuable, because participants will get a chance to try out the skills they’ve learned in a safe environment, where mistakes do not have potentially serious consequences.

Demonstrations and hands-on practice, however, will require more planning and preparation on your part—and most likely, support from your NAA affiliate.

Training Kit
If you choose to conduct the recommended demonstrations and hands-on practice activities, work with your NAA affiliate to put together a kit of tools, materials, and equipment for the training. This kit won’t be expensive, but it’ll take some planning and time to complete.

Refer to the appendix for more details.

Online Training Scenarios
To reinforce what they’ve learned in the classroom, participants will complete 30 minutes of online training at home or back on the job. In this training, participants will troubleshoot three common but challenging air conditioning problems.

For more details on this training—and how to present it to participants—please see page 67 of this guide.
Preparing to Teach the Course

To give course participants a first-rate learning experience, plan to spend several hours preparing to teach this class.

When to Prepare

Depending on your experience with this course, begin preparing two to three weeks before the scheduled course date. That’s enough time to absorb the material without feeling rushed.

How to Prepare

• **Read the instructor guide carefully.** Get familiar with the organization and flow of the course, as well as the content and the leader’s instructions.

• **Go Through the HVAC Servicing Procedures Manual, too.** Read and fully understand the procedures you’ll be teaching from this manual. They’re noted in this instructor guide.

• **Look for ways to personalize the instruction.** Add your own stories, examples, and insights. Make the material come alive for the participants.

• **Mark up this guide.** Write notes throughout. Highlight passages you want to emphasize. Add prompts for your examples and explanations.

• **Practice.** Do a dry run of the material (or at least some of it) in front of willing colleagues or family members. Get their feedback. Find out: What are you doing well? What’s one thing you could improve?

When It’s Time to Teach the Course

• **Use this instructor guide.** Refer to it often to keep the class on track. Using notes will make you look natural, relaxed, and confident.

• **Approach the course as a conversation, not as a presentation.** Keep things open and easygoing. Pick yourself up if you make a “mistake.” Answer the questions you can. Most important, avoid the temptation to be the expert—simply share what you’ve learned.

• **Keep participants actively involved.** Allow participants to ask questions, share ideas with one another, and get as much hands-on experience as possible. Remember: telling isn’t training.

• **Be yourself.** Participants appreciate (and learn more from) instructors who are not only knowledgeable, but also approachable, personable, and dedicated.
Preparing the Classroom

To complete your final preparations, arrive at the training site at least one hour before class begins.

Find the Location of these Public Facilities or Services

- Rest rooms
- Kitchen facilities or vending machines
- Emergency exits

Prepare Materials

- Air Conditioning Participant Resource Guide for each participant
- Air Conditioning Instructor Guide (with all your preparation notes in it)
- CAMT USB flash drive
- HVAC Servicing Procedures Manual
- Training kit (make sure you have the right tools, materials, and demonstration equipment for this class)
- Sign-in form (to be turned in to the affiliate office after class)

Prepare and Test Equipment

- Computer with projector
- Flipchart with stand or whiteboard
- Markers
- Microphone or sound system (if needed)

Prepare a Learning-Friendly Classroom

- Arrange the tables and chairs in the room so that participants will be able to easily see and hear the videos, take notes, and talk with one another.
- Make sure the room isn’t too hot or cold.
- Ensure that there’s adequate lighting.
- Write the day’s training agenda on the flipchart or whiteboard.
Course Schedule-at-a Glance

The total classroom training time for the Air Conditioning Maintenance and Repair course is approximately 16 hours, typically delivered over three or four sessions.

The schedule below will help you plan your sessions.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Time Needed</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 minutes</td>
<td>Welcome and Introduction</td>
</tr>
<tr>
<td></td>
<td>30 minutes</td>
<td>Air Conditioning: You Are Here</td>
</tr>
<tr>
<td></td>
<td>45 minutes</td>
<td>Air Conditioning Safety</td>
</tr>
<tr>
<td></td>
<td>30 minutes</td>
<td>Key Air Conditioning Tools</td>
</tr>
<tr>
<td></td>
<td>45 minutes</td>
<td>Refrigerants and Their Special Properties</td>
</tr>
<tr>
<td></td>
<td>1 hour, 30 minutes</td>
<td>The Air Conditioning System</td>
</tr>
<tr>
<td></td>
<td>45 minutes</td>
<td>Simple Fixes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 2</th>
<th>Time Needed</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 hours, 30 minutes</td>
<td>Refrigeration System Repairs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 3</th>
<th>Time Needed</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 hours</td>
<td>Electrical System Repairs</td>
</tr>
<tr>
<td></td>
<td>1 hours</td>
<td>Air Distribution System Repairs</td>
</tr>
<tr>
<td></td>
<td>15 minutes</td>
<td>Unit Replacement</td>
</tr>
<tr>
<td></td>
<td>30 minutes</td>
<td>Problems and Solutions Grid</td>
</tr>
<tr>
<td></td>
<td>30 minutes</td>
<td>Key Takeaways, Action Plan, and Wrap-Up</td>
</tr>
</tbody>
</table>
Instructor Script:
Welcome and Introduction (30 minutes)

In this brief opening section, you’ll welcome participants, introduce yourself, and set the stage for this air conditioning course.

Leader’s Instructions:
Welcome participants to the course. Introduce yourself to the class, and then proceed with the script below.
Dive in…you’re going to do just fine!

Welcome. My name is _______________, and I’ll be your instructor for this CAMT course on air conditioning repair and maintenance.

Air conditioning is one of those magnificent inventions that make life better. In fact, most of us can’t imagine surviving the summer heat without turning the thermostat to the cool setting. But it wasn’t so long ago that open windows and the occasional fan were the only means of cooling a building—air conditioning is a relatively new innovation.

In 1902, the first air conditioning system began operating, making one Brooklyn printing plant owner very happy. Because the heat and humidity in the plant was constantly fluctuating, the size of the printing paper kept changing, causing the colored inks to misalign and produce blurred printing. The new air conditioning machine, however, created a stable environment, making clear four-color printing possible.

Industries flourished with the new ability to control the temperature and humidity levels during production. The quality of film, processed meats, medical capsules, textiles, and other products improved significantly because of air conditioning.

Cooling for human comfort, rather than industrial need, began in 1924 when shoppers flocked to the J.L. Hudson Department Store in Detroit to experience the “air conditioned” space. Movie theatres were the next public space to be cooled, and in 1928, the first residential air conditioner went on the market.

The Great Depression and World War II slowed the non-industrial use of air conditioning, but after the war, consumer sales started to grow again. The rest is history—cool and comfortable history.

A Closer Look at the Course
Over the next 16 hours, you’ll become part of the cooling story by learning the basics of air conditioning maintenance and repairs.

Turn to page Welcome i in your Resource Guide, so we can take a look how this entire course lays out.

Leader’s Instructions:
Cover any other remaining housekeeping items, such as the location of the rest rooms, emergency exits, and kitchen or vending machine facilities—as well as any registration or sign-in activities. Ask for any questions before moving on.
Instructor Script:  
Welcome and Introduction (continued)

Participant Introductions  
We’ve saved the most important part of this course overview for last—the chance to meet your fellow participants. So let’s take a few minutes, go around the room, and do those beginning-of-the-course introductions.

<table>
<thead>
<tr>
<th>Leader’s Instructions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ask participants to share their name, the name and location of their employer, and their experience with air conditioning during their time as a technician. This will give you a sense of the depth and breadth of knowledge in the room.</td>
</tr>
<tr>
<td>2. Introduce any subject matter experts who may be participating in the class. Have the experts share a few words about themselves.</td>
</tr>
<tr>
<td>3. And finally, tell participants more about yourself. Talk about your experience in the apartment industry, with training, or with air conditioning. Talk a little about your life away from work, too.</td>
</tr>
</tbody>
</table>

Thanks for doing that. It’s nice to get to know all of you better.

And now, let’s dive into our first “official” topic for the course.
You Are Here: Air Conditioning Maintenance and Repair (30 minutes)

In this part of the training, you’ll bring it all home to the aspiring CAMTs by talking about their role in air conditioning repairs.

Leader’s Instructions:

Instead of just lecturing participants on their air conditioning responsibilities, ask them to give you the answers. By allowing participants to talk, they use (and show off) their experience—and you actively involve them in the course. That’s important, because involvement is key to an engaging classroom experience.

By the way, this ask-a-question approach is easier for you, too. Rather than having to convey all sorts of information, you only need to fill in what the participants missed. But have a little patience—it may take participants a while to formulate their answers after you’ve asked your questions.

Let’s set the stage for everything you’ll be learning by relating it back to what you do on the job. In other words, let’s talk about your roles and responsibilities as they relate to maintaining and repairing air conditioning systems.

I’m going start things off by talking about one important responsibility: working safety. Air conditioning repairs, especially when they involve chemicals or electricity, can be dangerous. That’s why you’ll always need to follow the safety procedures we’ll be covering today, as well as those that your company has established.

No matter how busy you may be, you can never take shortcuts. Your personal safety depends on it. Your residents’ safety depends on it. And keeping the building in excellent shape depends on it, too.

So safety is one of your key roles and responsibilities. Now, tell me about the others.

Turn to page 1 in your Resource Guide, and take notes as the discussion unfolds.

Leader’s Instructions:

1. Ask participants: “Besides working safely, what are your other key roles and responsibilities as they relate to air conditioning repair?”

2. Accept all reasonable answers, but make sure participants touch on these:
   - Doing requested and permitted repairs (e.g., replacing switches, etc.)
   - Completing preventive maintenance tasks
   - Completing “make-ready” maintenance when an apartment turns
   - Performing unscheduled or emergency maintenance
   - Educating residents on air conditioning issues as needed; answering their questions
   - Complying with state and local regulations and building codes
   - Following your company’s policies and procedures for handling and documenting service requests, keeping maintenance records, and working with outside contractors like air conditioning specialists

3. When the responses are no longer forthcoming, fill in any answers you may need to.

Thanks for helping me build such a complete and accurate list of your responsibilities.
When to Call an Air Conditioning Specialist

Now, let’s tackle a related question: when to call a specialist. Follow along on page 2 of your Resource Guide.

You’ll need to call an air conditioning specialist when:

• Federal, state or local regulations require it.
• You don’t know how to do the task or feel uncomfortable doing it.
• Your workload is too heavy, or you can’t do the repair quickly enough to satisfy a resident.
• The job is just too big in size or scope.
• You do not have the specialty tools required to perform the service properly.
• When the broken item is still under a warranty.

If a specialist comes on site to do a repair or replacement, watch what they’re doing and ask questions—you might be able to do some or all of the work if it happens again.

Leader’s Instructions:

Ask participants: “Can you think of any other times when you might need an air conditioning specialist?” Accept all reasonable answers, and then move on.

That concludes our discussion on roles and responsibilities. Can I answer any questions before we move on?
Air Conditioning Safety (30 minutes)

In this part of the training, you’ll teach participants how to work safely as they perform air conditioning maintenance and repairs.

**Leader’s Instructions:**

To keep participants involved in the learning—and again, to take advantage of their experience, consider teaching this information by asking participants about it.

Have them close their Resource Guides, then ask them: “When you’re repairing an air conditioner, what sort of safety precautions do you take?”

Let participants tell you what they do, and then fill in any gaps using the safety information that follows.

**Introduction**

There are a number of hazards—primarily related to electricity and chemicals—to take seriously when you’re working with air conditioning.

You need to be aware of these hazards and protect yourself from them.

Turn to page 3 in your Resource Guide, so we can go over the key safety rules.

**Safety Rule #1: Turn the Power Off**

Before making repairs, always turn off the power to the air conditioning unit. Preferably the power should be off at the nearest accessible point such as the main breaker panel instead of or in addition to any cut off-boxes. Once the power is turned off, a multimeter is to be used to ensure that power is cut. Never take chances. Verify everything.
**Safety Rule #2: Wear Personal Protective Equipment (PPE)**

When working with air conditioners, wear the proper personal protective equipment to protect yourself from sparks, chemicals, cuts and scrapes, and burns.

This equipment includes:
- Gloves
- Face shields or goggles

In addition, wear appropriate footwear. Make sure you have a sturdy shoe with a protective toe box and a non-slip sole.
Air Conditioning Safety (continued)

Safety Rule #3: Follow Lockout/Tagout Procedures

Lockout/tagout is a safety procedure to make sure that power and energy sources, such as water and electricity, are properly shut off and secured.

You’ll use lockout/tagout procedures when repairing air conditioning systems.

Lockout Devices and Tags

Typical lockout devices that you’ll use include:

- Padlocks
- Gate and ball valve lockouts
- Circuit breaker lockouts
- Chains
- Cable
- Plug lockouts

Lockout tags usually are brightly colored so you can immediately see and identify them.

Your company should have lockout/tagout kits they want you to use. Check with your supervisor when you’re back on the job.

Where to Place Lockout Devices and Tags

Lockout devices and tags are typically applied to shut-off valves, plugs, or main service panels.

How to Lock and Tag Out

Your employer is required to train you on the complete lockout and tagout process. But here’s a high-level look at how it’s done:

1. Shut off the source of the power.
2. Attach a lockout device to this source, then lock and tag it.
3. Release or drain any energy left in the lines or equipment.
4. Test to be sure the energy is turned off and removed from the pipes, circuits, or equipment.

Once these lockout/tagout steps are complete, you can go ahead with the repair.
Safety Rule #4: Handle Refrigerants Correctly

Air conditioning systems use refrigerants, special chemicals that absorb and expel heat. Refrigerants can also deplete the earth’s ozone layer, so Section 608 of the Clean Air Act of 1990 requires refrigerant to be handled in a safe, environmentally-friendly way.

The Environmental Protection Agency (EPA) is responsible for implementing and enforcing the provisions of Section 608. Under federal law:

- No refrigerant can be released into the air (with the exception of de-minimus releases).
- If you observe a leak, you must report it to your supervisor or lead technician.
- If you’re getting rid of an air conditioning system, any refrigerant and oil that remains must be recovered and properly disposed of.
- People who use and dispose of refrigerants and oils must pass an Environmental Protection Agency (EPA) certification test on proper refrigerant practices.
- In addition, protect yourself when working with refrigerant. Have adequate ventilation, wear hand and eye protection, and avoid getting refrigerant on your skin.

Safety Rule #5: Use Safety Data Sheets

A Safety Data Sheet (SDS) is a document that contains information on a chemical-containing product such as refrigerant, oil, or solder. Use a SDS to learn about the chemical properties, the health hazards, and the required personal protective equipment (PPE) you’ll need to work with a product safely.

Safety Rule #6: Keep Tools and Equipment in Good Working Order

You’ll use a variety of hand and specialized tools to maintain and repair the air conditioning systems in your apartment community. The Occupational Safety and Health Administration (OSHA) requires that you keep your tools and their safety features in good working order. For example, keep gauges properly calibrated so you can diagnose air conditioning issues accurately.
Group Discussion on Air Conditioning Safety (15 minutes)

Now that you’ve covered the baseline information on air conditioning safety, capitalize on a key benefit of classroom learning—that is, the chance for people to learn from one another—by conducting a lively and focused group discussion.

Leader’s Instructions:

Hold a 15-minute discussion on air conditioning safety. You can do this in a variety of ways, such as:

• Using the safety section of the HVAC Servicing Procedures manual to present additional material on air conditioning safety.

• Asking participants to share their stories and experiences.

• Holding a question and answer session.

• Asking participants to share their best “tips and tricks” related to air conditioning safety.

Let participants know how the discussion will work, and encourage them to take notes on page 7 of their Resource Guide.
Key Tools for Air Conditioning Repairs (30 minutes)

The aspiring CAMT needs to be well and safely equipped to perform air conditioning maintenance and repairs. In this part of the training, you’ll provide an overview of the key repair and testing tools every technician needs.

Introduction

You’ll need several tools to repair and maintain the air conditioning system in your apartment community.

Good hand tools will help, but more important are the specialty tools you’ll need to work with an air conditioner’s refrigeration system.

In the next few minutes, you’ll receive a brief overview of these key tools, so you can become familiar with them. When we get into specific repair procedures, we’ll cover how to use these tools correctly.

Turn to page 8 in your Resource Guide.

The Basic Hand Tools

Slotted and Phillips screwdrivers can help you with many air conditioning repairs.

An adjustable wrench has a movable jaw that lets you fit the wrench to many sizes of nuts and bolts.

A ratchet wrench has interchangeable sockets to fit various sizes of nuts and bolts. You use it to tighten and remove these nuts and bolts.

A tongue and groove pliers has a movable handle that lets you adjust the jaws for maximum gripping strength.

A needlenose pliers has thin jaws for grabbing small things.

A utility knife has a sharp single-edge razor that can be use to cut a variety of materials.
Key Tools for Air Conditioning Repairs (continued)

The Basic Hand Tools

An *Allen wrench set* can be used to remove blower wheels and fan blades—it can also be used for opening or closing some types of air conditioning service valves.

*Lockout/tagout kits* should be used to identify that a power source, such as a main shut-off valve or circuit breaker, is shut off and secured.
Key Tools for Air Conditioning Repairs (continued)

Specialty Air Conditioner Repair Tools

A multimeter is a “must-have” battery-operated tool used to measure electrical voltage, test for continuity, and test resistance.

A digital thermometer measures the temperature of refrigerant lines (suction and liquid lines) when charging cooling systems. It is also used to measure return and air supply temperatures. Alternatively, an analog thermometer may be used depending on the task.

Refrigerants are chemicals that can absorb and expel heat. Common refrigerants include R-22, R-134A, and R-410A.

An electronic leak detector can help you locate the general area of leaks in the air conditioning system. Many leaks are very tiny and can’t be easily detected by sight or sound.

A manifold gauge set obtains pressure readings at different points in the air conditioning system. It has two gauges: one reads the low-pressure side of the system; the other measures the high-pressure side.

Soap bubbles (or a special type of soap in a bottle with an application dabber) are used to pinpoint leaks once an electronic leak detector has located the general area of a leak.
Key Tools for Air Conditioning Repairs (continued)

Specialty Air Conditioner Repair Tools

A **Schrader valve core replacement tool** allows you to replace a valve core stem without venting or losing any of the refrigerant in the system. The tool connects to an air conditioner’s Schrader valve and allows a technician to unscrew and replace the valve stem with a new one.

The **Environmental Protection Agency (EPA)** requires that technicians recover refrigerant instead of releasing it into the air. **Recovery units** are used to remove refrigerant from an air conditioning system and store it in a container that’s been approved by the EPA.

An **electronic charging scale** ensures that the correct amount of refrigerant is measured into an air conditioning system when it is being charged. You can also use it to measure the amount of refrigerant you recover from a system and store in a recovery cylinder.

A **vacuum pump** is a motor-driven pump to help you evacuate and dehydrate air conditioning systems.

A **fan blade puller** is a specialty device used to remove fan blades and blower wheels from air conditioning motor shafts without damaging the blades or wheels.
Refrigerants and their Special Properties (45 minutes)

In this part of the training, you’ll lay the groundwork for all the information to come by giving participants an overview of refrigerants.

Introduction

Turn to page 12 in your Resource Guide.

Contrary to popular belief, air conditioning does not add cool air to an apartment—rather, it takes heat away from it. That’s because air conditioning takes advantage of the effects of evaporation.

Think about what happens when you get out of the shower or swimming pool. Your body is wet, you begin to feel cooler… ever wonder why? Well, it’s the water evaporating from the surface of your skin—the evaporation removes the excess heat and cools you.

An air conditioning system, however, doesn’t use evaporating water to create the cooling effect. It uses a special chemical called a refrigerant instead.

Let’s take a closer look.
Refrigerants and their Special Properties (continued)

What are Refrigerants?

Refrigerants are chemical compounds that move heat in a refrigeration system. They do this by changing their state from a liquid to a vapor (or gas)—and back to a liquid again.

More specifically, refrigerants:

• Absorb heat by evaporating (changing from a liquid state to a vapor) at a low temperature and pressure
• Expel heat by condensing (changing from a vapor state to a liquid) at a higher temperature and pressure

Now that may not sound particularly impressive, but you need to remember that refrigerants begin to boil—that is, change from liquid to vapor—at very low temperatures. In fact, the boiling point of a refrigerant can be 40, 50, or 60 degrees below zero. So when the air conditioning system turns its liquid refrigerant into a vapor, it can move enormous amounts of heat and “cool” the air.

Refrigerant Types and Terms

**Chlorofluorocarbon (CFC) –** This refrigerant is made up of chlorine, fluorine and carbon. Due to the large quantity of chlorine in its ingredients, it is heavily regulated and very seldom used any more in comfort cooling air conditioning. (Example: R-12)

**Hydrochlorofluorocarbon (HCFC) –** This refrigerant was produced as a transitional replacement for CFCs since it has less of an ozone depletion potential due to a smaller amount of chlorine as an ingredient. As HCFCs do contain some chlorine they are scheduled for replacement by other refrigerants that contain no chlorine. (Example: R-22)

**Hydrofluorocarbon (HFC) –** This refrigerant has no effect on the ozone layer due to its containing no chlorine and it is used in newer equipment. (Example: R-410A) As HCFC refrigerants go away, more and more of this type of refrigerant will be used.

**OEM “Virgin” Refrigerant –** Term used to describe the refrigerant that the installed equipment was designed to work with. Typically comfort cooling equipment installed before 2011 was designed to work with R-22. New systems installed after 2011 may contain R-410A.

**Retrofit Refrigerant –** This HFC refrigerant is designed to replace the HCFC refrigerant that the equipment was originally designed around. A common application is to replace R-22, due to its price, while not requiring a change out of the entire mechanical system, as would be required if changing to R-410A. Example: R-407C, R-438 or R-422B (NOTE: using a refrigerant in a system other than what that system was designed to operate with may void the equipment warranty and/or shorten its expected life. There are several retrofits available, and some of them may require additional service, such as an oil change from mineral oil to polyolester oil. Do NOT mix refrigerants.)
What Makes a Good Refrigerant?
There are many different types of refrigerants in use, but the best ones:

- Have low boiling points
- Are non-toxic and non-reactive
- And are safe for the earth’s ozone layer, just as Section 608 of the Clean Air Act requires

For many years, chemical compounds called hydrochlorofluorocarbons (HCFCs) were the refrigerants of choice, because they boiled at just the right temperature and were non-toxic. Perhaps you’ve heard of R-22, a HCFC used in many air conditioning systems.

Today, however, HCFCs are being replaced by hydrofluorocarbons (HFCs). HFCs do all that CFCs and HCFCs do, but they don’t damage the earth’s ozone layer, and therefore, meet the Clean Air Act requirements. Examples of HFC refrigerants include R-134A and R-410A.

To find out more about the Section 608 Clean Air Act requirements, see this page at the Environmental Protection Agency website: www.epa.gov/Ozone/title6/608/608fact.html.
Refrigerants and their Special Properties (continued)

The Pressure-Temperature Relationship

The goal of all refrigerants is to move heat. Different refrigerants operate at different pressures. For example, R-22 at 40 degrees will have a pressure of 70 pounds per square inch gauge (psig), whereas R-410A at 40 degrees will have a psig of 125.

What’s more, as the temperature of the refrigerant rises, so does its pressure. Conversely, if this temperature drops, the pressure does, too. That’s why you can’t charge all air conditioning units to the same pressure. If you did, some units would cool well, and others wouldn’t.

This pressure-temperature relationship also explains why you need a quality digital thermometer to measure the temperature of the refrigerant lines. If you don’t have one, you could under or overcharge the unit.
Refrigerants and their Special Properties (continued)

Saturation Temperature
The second key concept about refrigerants is saturation temperature, also known as the boiling point. It occurs when the air conditioning system has equal parts of liquid and vapor refrigerant. At saturation, the system can move the heat from inside the building to outside the building.

Like the pressure-temperature relationship, knowing the saturation temperature is critical to keeping a unit properly charged.

You can easily find the saturation temperature using your manifold gauge set. Let’s watch a short video to see how.

Leader’s Instructions:
1. Show the video titled “Manifold Gauge Set” on the Air Conditioning DVD.
2. Ask for comments and questions afterwards.

Finding Saturation Temperature
The saturation temperature and pressure relationship for each refrigerant is different based upon the ingredients used in that refrigerant. Here are some examples of the pressures of different refrigerants when the refrigerant has a saturation temperature of 70°F:

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>PSIG at 70°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-22</td>
<td>121</td>
</tr>
<tr>
<td>R-410A</td>
<td>201</td>
</tr>
<tr>
<td>R-422B</td>
<td>110</td>
</tr>
<tr>
<td>R-438</td>
<td>112</td>
</tr>
<tr>
<td>R-407C</td>
<td>117</td>
</tr>
</tbody>
</table>

For the refrigerant to function properly in a system it is important to have an accurate relationship. Each refrigerant will have its own Temperature Pressure chart. In some instances this will be shown on the inner numbers of a Manifold Gauge. In other cases, such as with many retrofit refrigerants, the T&P chart is provided by the refrigerant manufacturer.
The Air Conditioning System (1 hour, 30 minutes)

*In this part of the training, you’ll give the aspiring CAMTs a comprehensive overview of an air conditioning system.*

**Leader’s Instructions:**

If you don’t have a CAMT training center, locate an affiliate apartment community in the area that has the split air conditioning system described below.

In addition, see if you can get a condensing unit (and perhaps a window air conditioner) for participants to “explore” in the classroom.

Again, the training experience will become so much richer and useful for participants if they can see what they need to learn.

**Introduction**

Now that you’ve got a handle on refrigerants, let’s see how they work in an air conditioning system.

Turn to the next page in your Resource Guide.

In simple terms an air conditioner works in the same way a refrigerator does: It takes heat from inside the box and relocates that heat to outside of the box. In the case of an apartment the system absorbs heat inside of the apartment and carries that heat outside the home. To move heat, all refrigeration systems have four main parts: a compressor, a condenser, a metering device, and an evaporator.

- The compressor and condenser are usually outside of the building; the metering device and the evaporator are usually inside the building.
- The inside and outside units are connected by refrigerant lines and wiring.

Central air conditioning also uses an air-handling system to circulate the air. A blower pushes warm air from the apartment over the evaporator, where it is “cooled.” This air then moves into the plenum and goes out through supply ducts and registers, where it provides welcome relief for residents.
The Air Conditioning System

Air Conditioning is more than just “cooling”. Actually the refrigeration system performs several vital functions to aid in our residents’ comfort.

We’ll start with a big picture overview, and then dive into the details of the refrigeration cycle.

The Big Picture

In simple terms an air conditioner works in the same way a refrigerator does: It takes heat from inside the box and relocates that heat to outside of the box. In the case of an apartment the system absorbs heat inside of the apartment and carries that heat outside the home. To move heat, all refrigeration systems have four main parts: a compressor, a condenser, a metering device, and an evaporator.

- The compressor and condenser are usually outside of the building; the metering device and the evaporator are usually inside the building.
- The inside and outside units are connected by refrigerant lines and wiring.

Central air conditioning also uses an air-handling system to circulate the air. A blower pushes warm air from the apartment over the evaporator, where it is “cooled.” This air then moves into the plenum and goes out through supply ducts and registers, where it provides welcome relief for residents.
High-Level Air Conditioning
(1 hour, 30 minutes)

High-Level Air Conditioning Illustration

What About Window Air Conditioners?
A window (or room) air conditioner has everything contained in one “box.” The units are made small enough to fit into a standard window frame. You close the window down on the unit, plug the unit in, and turn it on to get cool air.

If you were to take the cover off of an unplugged window unit, you’d find it contains:

- A compressor
- A metering device
- A condenser coil (on the outside)
- An evaporator coil (on the inside)
- Two fans (often propelled by a single motor with one fan on each end of the motor)
- A control unit

The fans blow air over the coils to expel heat to the outside and to circulate cooled air around the room.
The Refrigeration Cycle in an Air Conditioning System

In this part of the training, you’ll give participants a detailed walkthrough of the refrigeration cycle. Take your time and encourage questions.

Leader’s Instructions:
Have participants turn to page 20 in their Resource Guide.
If you can, bring this alive by comparing the diagram below to an actual air conditioning system—or at least to the condensing unit.

The Flow of Refrigerant in the System
The Refrigeration Cycle in an Air Conditioning System (continued)

The Flow of Refrigerant in the System (continued)

1. **The Compressor:**
   The compressor pulls low-pressure gas vapor refrigerant from the evaporator through a pipe called a suction line.
   The compressor then “squeezes” the refrigerant, which now becomes a hot, highly pressurized gas vapor.

2. **The Condensing Coils and 3. the Fan:**
   The hot, high-pressure vapor begins to flow through a condensing coil, which is made up of tubes embedded in a matrix of thin metal fins, like a radiator on a car engine.
   A fan moves outside air past the metal fins, which dissipates heat from the refrigerant in the coil. This causes the refrigerant to reach its saturation temperature and change its state: the hot vapor condenses into a highly pressurized liquid.
   This condensation process allows the refrigerant to get rid of the heat it has picked up from the inside of the apartment and expel it into the outside air.
   The “cooler” high-pressure liquid then travels through a pipe called the liquid line and enters the building.

4. **The Metering Device**
   The high-pressure liquid is now forced through a tiny opening in the metering device. There are two types of metering devices. On older systems, it is more likely to be a fixed orifice, and is commonly called an orifice, piston, or capillary tube. This means that the metering device contains a small hole of a fixed size and diameter. In newer systems it is possible that the metering device is a Thermostatic Expansion Valve (TXV). A TXV is a metering device that will “self-adjust” the amount of refrigerant that passes through based upon conditions.
   The refrigerant passes through this device, and on the other side, its pressure is lower. The refrigerant turns into a fine mist so it can spread out and more easily absorb heat.
   A common misconception is that the refrigerant changes from a liquid to a vapor at this metering device. This is not true—the refrigerant changes state when it reaches its saturation temperature in the evaporator or condensing coil.

5. **The Evaporator and 6. the Blower**
   This mist now travels through the indoor set of coils, called the evaporator. The blower moves warm air from the apartment across the coils, which allows the refrigerant to absorb heat from the air. This causes the refrigerant to boil, evaporate, and remove heat from the air.
   As the heat is being absorbed by the refrigerant on the inside of the evaporating coil, another process is taking place on the outside of this coil. Moisture condenses out of the air that passes across it; this condensate (or water) is then collected in an evaporator pan attached to the coil.
   As this drier, cooler air passes from the evaporator coil into the air ducts and through the apartment, the cool low-pressure refrigerant vapor returns to the compressor through the suction line, and the cycle starts over again.
Key Parts of an Air Conditioning System

You’ve just told the aspiring CAMTs the complete, uninterrupted story of the refrigeration cycle. Now, let’s break down that story, by taking a closer look at the key parts of an air conditioning system.

Leader’s Instructions:
Again, we encourage you to bring as much of the following alive as you can, by showing participants the actual parts in the system.

**Blower:** A device that moves air across the evaporator coil. Blowers may be single speed, multiple speed, or variable speed.

**Compressor:** A specialized pump that increases the temperature and pressure of refrigerant vapor so it can move throughout the air conditioning system and do its “work” of absorbing and expelling heat. Refrigerant enters the compressor as a cool, low-pressure vapor; it leaves as a hot, high-pressure vapor.

**Condenser Coils:** With the help of a fan, these coils condense the hot, high-pressure vapor from the compressor into a cooler, high-pressure liquid. The coils have metal fins to help dissipate heat.

**Electrical Controls:** Electrical controls for an air conditioning system include shut-off switches at the unit and fuses or circuit breakers at the main service panel. They can also include, but are not limited to, a thermostat or other low voltage circuitry.

**Evaporator Coils:** These coils allow the refrigerant to absorb heat from the indoor air, causing the refrigerant to increase in temperature, change into a vapor, and then evaporate. This evaporation process produces the cooling effect in the building.

**Evaporator (or Condensate) Pan:** Water (or condensate) is produced when the blower moves warm moist air over the evaporator coil. The condensate runs down the coil to a collecting pan, which then drains to piping used to dispose of the water.
Key Parts of an Air Conditioning System (continued)

**Fan:** A fan in the condenser moves outdoor air across the condensing coil to remove the heat the refrigerant picked up in the evaporator coil. This lowers the temperature of the refrigerant and causes it to condense back into a liquid state.

**Refrigerant:** The chemical that circulates throughout the air conditioning system, absorbing and expelling heat as it is boiled and condensed.

The most common refrigerant currently used in apartment cooling systems is R-22. Newer systems, however, use more environmentally friendly refrigerant such as R-410A to comply with governmental regulations.

Refrigerant is pumped into the air conditioning unit at the factory, along with a measured amount of lubricating oil to help it move through the compressor.

**Metering Device:** This device regulates the flow of highly pressurized liquid refrigerant that passes into the evaporator. When the refrigerant passes through the device, it changes from a high-pressure liquid to a reduced-pressure mist. Today, the most common metering device used in apartment cooling systems is a capillary tube; some newer systems may use a thermostatic expansion valve (TXV).

**Return:** Warm air from inside the apartment enters here, thanks to the blower pulling it from the living space. This air is then moved across the evaporator coil.

**Refrigerant lines:** These pipes are made of copper and transport refrigerant between the condenser and evaporator coils. There is a suction line (larger diameter) and a liquid line (smaller diameter).

The suction line, also called the low-pressure line, returns low-pressure superheated refrigerant vapor from the evaporator coil to the compressor. The liquid line, also called the high-pressure line, connects the compressor to the condensing coil and then to the metering device.
Key Parts of an Air Conditioning System (continued)

Service ports: These valves allow access to the refrigerant for any diagnostic or servicing needs. The ports are usually located on the refrigeration lines near the compressor, but can be at differing points in the line set. Some ports can also be used to isolate one part of the refrigerant system from another by repositioning a valve stem.

Thermostat: People use this device to turn the air conditioning on and off, as well as to set the desired indoor temperature. Thermostats can be programmable and set digitally—or they can be analog and set by a lever or a dial.

Supply: Located on the discharge side of the evaporating coil, the supply delivers cool air to the apartment. The supply includes the building’s plenum, supply duct, branch ducts, and wall registers.
Simple Fixes (45 minutes)

Sometimes, a seemingly difficult air conditioning problem can be solved with the simplest of solutions.

In this part of the training, the aspiring CAMT will learn how to do some quick and easy fixes for an air conditioning system.

Introduction

Now that we’ve covered how an air conditioning system works—along with its key parts—we’re going to spend the rest of our time on specific repair procedures. That means we’ll explore fixes to:

• The refrigeration system
• The electrical system
• And the air distribution system

But before we move to these more complex repairs, we’re going to start with a few simple things you can do to try to solve the air conditioning problem. When troubleshooting issues, it’s always best to try the quick and easy fix first.

Turn to page 24 in your Resource Guide.
## The “Simple Fix” Problem and Solutions Grid

If an air conditioning unit is experiencing any of these problems, try some of these simpler solutions first. If these fail, move on to the more complicated fixes related to the refrigeration, electrical, or air handling systems. You’ll be learning more about these fixes later in the training.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution(s)</th>
</tr>
</thead>
</table>
| The condensing unit does not run                   | 1. Be sure the thermostat in the apartment is set to “cool” and is set at an appropriate temperature.  
2. Check the service panel for a tripped or blown breaker.  
3. Check the outdoor disconnect to make sure it is working.  
4. Check the fuse at the condensing unit (if so equipped).                                                                                                                                                                                                                   |
| The system runs, but it does not cool              | 1. Visually inspect the condensing unit. If it needs to be cleaned, see page 27 for instructions.  
2. Inspect the indoor air filter to see if it is clogged. See page 28 for instructions on replacing the filter.                                                                                                                                                                          |
| Water drips from the bottom of the evaporator when the unit is running | 1. The evaporator pan and drain may need to be cleared (see page 29).                                                                                                                                                                                                                                                                   |
| The condensing unit is noisy                       | 1. Check for a loose fan blade (see page 30).  
2. Make sure the condensing unit is level.  
3. Tighten all the screws holding the frame and covers together. Replace any that are missing.                                                                                                                                                                               |
| The system cycles too often                        | 1. Check the thermostat for proper installation (levelness, correct location, secured to the wall). Also check and confirm that the hole for the thermostat wiring is sealed behind the thermostat so it will not sense interior wall temperature.  
2. Air may be leaking into the apartment from doors, walls, receptacle outlets, or holes in walls or cabinets. See if you can isolate the leak and fix it.                                                                 |
Cleaning the Condenser

In a split air-conditioning system, the condenser unit is located outside the apartment on the grounds or on the roof. It is prone to accumulating dirt and debris from trees, lawn mowing, and airborne dust—and this can affect its performance.

Safety
Make sure the power is turned off.
Use lockout/tagout procedures.
Wear eye protection.
Wear sturdy gloves.

Leader’s Instructions:
1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 28 of the participants’ Resource Guide.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

Tools and Materials Needed
- Lockout/tagout device
- Screwdriver
- Garden hose
- Spray nozzle

How-to Steps
The condenser has a fan that moves air across the condenser coil. You’ll need to clean the coil on the opposite side of the intake, so before you turn off the power to the air conditioner, check to see which direction the air moves across the coils. After doing that:

1. Turn off the power to the unit.
2. Cut down any grass, weeds, or vines that have grown around condenser unit; they could be obstructing airflow.
3. Clean the condenser coil with a garden hose fitted with spray nozzle. Take care to not “mash” the fins and damage them.
Replacing a Filter

If the system is running, but is not as cool as it should be, the filter may need to be replaced.

Leader’s Instructions:

1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 29 of the participants’ Resource Guide.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

Safety

Wear eye protection.
Wear sturdy gloves.

How-to Steps

1. Locate the filter(s) in the unit.
   Remove the housing as needed to access and remove the filter.
2. Reinstall an exact replacement filter (be sure the size is the same), making sure that the area around the filter also is clear of debris. Take care to install the filter correctly. Many have arrows or indicators showing which direction the airflow should follow for correct filtration, performance, and lifespan.
3. Replace the housing.

Tools and Materials Needed

- Replacement filter
- Lockout/tagout device
- Screwdriver
Clearing the Evaporator Pan and Drain Line

If water is dripping from the inside system where the air conditioner is running, the evaporator condensation pan and drain line may need to be cleaned.

Leader’s Instructions:

1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 30 of the participants’ Resource Guide.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

Safety

Wear eye protection.

Wear sturdy gloves.

Tools and Materials Needed

- Screwdriver
- Nut drivers
- Compressed air or nitrogen
- Water hose (or faucet adapter hose setup)
- Wet-dry vacuum
- Chlorine bleach
- Condensate pan algaecide tablets

How-to Steps

1. Access the interior condensation “catching area” of the evaporator pan and locate the main drain line hole. Blow the line with compressed air or nitrogen to get the drain working again.
2. Flush the interior of the pan with water, washing any slime down the drain. (If excess lint, debris, or materials are present, use a wet-dry vacuum to clean the pan.)
3. Flush the drain again with water.
4. Place algaecide tablets in the evaporator pan at various places, but avoid the drain hole area. Algaecide tablets help prevent future drain line stoppages, reduce condensate pan smells, and reduce airborne bacteria that can circulate with the airflow.
Tightening Loose Fan Blades

*If the outside condenser is noisy, a loose fan blade may be the culprit.*

**Leader’s Instructions:**

1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 31 of the participants’ Resource Guide.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

**Safety**

Make sure the power to the unit is off.

Use lockout/tagout procedures

Wear eye protection.

Wear sturdy gloves.

**How-to Steps**

1. Turn off the power to the unit.
2. Lock and tag out the circuit.
3. Remove the housing.
4. Visually inspect the setscrews on the fan’s hub for obvious damage or a loose screw.
5. If they are loose, tighten the setscrews with an Allen wrench or a crescent-type wrench.
6. Check the fan’s rotation to make sure it is smooth after you have tightened the screws.
7. Check the fan blades for damage and blade pitch.
8. Replace the housing.

**Tools and Materials Needed**

- Lockout/tagout device
- Screwdriver
- Wrench
Electrical System Repairs (3 hours, 30 minutes)

In this part of the training, you’ll show the aspiring CAMT how to make key repairs to the “nerve center” of an air conditioning system, the electrical system.

Introduction

Turn to page 32 in your Resource Guide.

In this next part of the training, we’ll be turning our attention to the electrical system that powers an air conditioner, as well as the most common repairs you’ll make to this system.

Troubleshooting electrical systems may seem complex—and indeed, sometimes it can be—but it’s easier to understand when you categorize electrical components according to the function they perform in an air conditioning unit. These categories are:

- Power sources
- Input power distribution circuits
- Load circuits
- Control circuits

Let’s look at each type in a little more depth.

Power Sources

Although it depends on the type and age of the equipment, there are usually two power sources for an apartment air conditioning system. There is 240-volt service to the outside unit, as well as 120 or 240 volts for the inside unit.

Input Power Distribution Circuits

Input power distribution circuits are the source of power for the air conditioning unit. They usually consist of the power wiring from the main electrical service head…to a disconnect switch near the unit…and from this switch to the unit itself. These circuits also include protective devices such as fuses and circuit breakers.

Control Circuits

Control circuits are the link between the load and the input power. They start, stop, or otherwise control the operation of a load. These circuits usually contain one or more control devices such as relays, switches, or thermostats to apply or remove power from the loads.

Control circuits usually operate at 24 volts, and are also known as the low-voltage circuits. Because they are low voltage, they are safer to operate, draw less power, and have smaller and lighter wiring.

Load Circuits

Loads are devices that convert electrical energy to another type of energy such as heat or mechanical motion. In this process, loads consume power.

Compressor motors and fan motors are loads found in air conditioning units.

Because the load circuits are both energized and operate at the input voltage level, they’re often called the high-voltage circuits.
Measure the Input Voltage

When you troubleshoot electrical problems, the input voltage and its connections are usually the first things you check.

You measure input voltage to determine if the proper amount of voltage is being supplied to an air conditioning unit so it can operate efficiently and economically.

Too much or too little input voltage can cause overheating and the possible failure of a compressor or fan motor.

Additionally, make sure all the connections are secure. A circuit with a loose wire may show full and complete voltage, but once a load is supplied to it, the voltage will often disappear or be so much reduced that it will not supply enough voltage to operate an electrical appliance or device. So besides testing for proper voltage, checking for loose connections is very important, too.

How-to Steps

To learn how to measure the input voltage of an air conditioning system, we’re going to turn to the HVAC Servicing Procedures manual now.

As we go through the steps, feel free to take notes on page 33 of your Resource Guide.

Leader’s Instructions:

1. Have participants turn to pages 40 through 43 in the HVAC Servicing Procedures manual.
2. Cover the procedure for measuring input voltage on a single-phase system. Be sure to explain how to read the schematic on page 43.
3. If possible, demonstrate the technique using the multimeter.
4. If possible, let participants practice measuring the input voltage.
5. Ask for questions.
6. Have participants and any invited subject matter experts share their best ideas and advice.
Test Fuses and Circuit Breakers

Fuses and circuit breakers can also be the source of electrical problems. Here’s how to check the condition of both.

If an air conditioning system’s input voltage is correct, you may want to troubleshoot the fuses and circuit breakers serving the system.

In particular, you may want to check the continuity of the disconnect box fuse(s), and the condition of the main service panel circuit breaker(s) that distribute power to the air conditioning system.

How-to Steps

To learn how to measure the condition of disconnect box fuses and main service panel circuit breakers, let’s turn to the HVAC Servicing Procedures again.

As we go through the steps, feel free to take notes on page 34 of your Resource Guide.

Leader’s Instructions:

1. Cover the procedure for checking the continuity of the disconnect box fuses and the condition of the main service panel circuit breaker that serves the air conditioning unit.

2. If possible, demonstrate the technique using the multimeter.

3. If possible, let participants practice measuring the continuity of the disconnect box fuse(s).

4. Ask for questions.

5. Have participants and any invited subject matter experts share their best ideas and advice.
Check the Thermostat Operation

When an HVAC system is malfunctioning, a good place to start is the device that controls everything: the thermostat.

Introduction

When an air conditioner isn’t running, a relatively simple troubleshooting step is to check the thermostat.

Of course, you want to make sure that the thermostat is set to “cool” and an appropriate temperature, but you may also want to check the input voltage of the thermostat, its fan circuit section, and its cooling circuit section.

A good place to begin troubleshooting an HVAC service request is at the thermostat. By testing the thermostat, and in turn checking all of the connections that are made here, we can begin to isolate specific problems and the components that are causing them. The place to start is to be aware of wiring and the standard practices of installers and system manufacturers.

The HVAC industry has specified wire colors that are used in the low voltage or control circuits of HVAC equipment. By being familiar with this common color coding we can separate out the individual circuits of our system. (Note: verify before assuming that any wire performs a specific function.)

- Red – Carries power to the thermostat
- Green – Carries power from the thermostat to fan control (often a fan relay)
- Yellow – Carries power to the condensing unit outside (often a contactor)
- White – Carries power to the heat source for the system (often a sequencer or gas valve)

Troubleshooting From the Thermostat

1. Find the schematic for your system to use as a reference
2. Remove the cover from the thermostat to expose the low voltage wiring connections
3. Identify the connectors and the wires that are attached
4. Using a jumper wire, carefully complete the circuit between any of the other 3 wires to test for operation. (For example: completing the circuit R to G should cause the indoor fan motor to operate.)
5. If all circuits operate properly (operations function when control voltage is applied to them) then the problem is the thermostat itself.

Leader’s Instructions:

1. Cover the procedure for checking the input voltage and fan circuit section of the thermostat, as well as the procedure for checking the cooling circuit.
2. If possible, demonstrate the technique using the multimeter.
3. If possible, let participants practice measuring the input voltage, the fan circuit sections, and the cooling circuit sections of the thermostat.
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.
Load Circuits: Compressors

The compressor is the heart of the cooling system. It creates the pressure difference that causes the refrigerant to flow throughout the system.

In this part of the training, the aspiring CAMT will learn how to troubleshoot the compressor, particularly the relays, capacitors, and motor windings associated with it.

Introduction

Turn to page 36 in your Resource Guide.

Compressor motors are one of the primary electrical loads used in cooling systems.

Since compressors are expensive and replacing them takes a lot of time, you want to be absolutely sure a compressor is bad before you replace it. That’s why you’ll be learning a series of important tests in this part of the training.

What You’ll Learn

Although compressors can develop problems such as seizing, leaking compressor valves, and generating too much noise, our training will concentrate on the more common electrical (or load circuit) problems. These include:

• Bad capacitors
• Open or shorted motor windings
• Grounded windings

You’ll learn how to test for all of these conditions.
A Compressor Motor Start Relay

A relay is a magnetically operated device consisting of coil and one or more sets of contacts that are used to connect or disconnect the supply voltage circuit to the start winding of a compressor. Sometimes a compressor will have a separate start relay.

Introduction

The compressor motor start relay removes the start capacitor from the motor starting circuit (as determined by the motor ampere draw), usually equivalent to when the motor reaches 75 to 80 percent of its starting speed.

Motor start relays fail when their contacts remain closed. When this happens, the start capacitor of the motor remains in the compressor start circuit, causing the start winding to overheat and fail. When the contactors are stuck closed, they may also cause the start capacitor to fail.

How-to Steps

To learn how to check the operation of the motor start relay, let's go back to HVAC Servicing Procedures manual.

As we go through the steps, feel free to take notes on page 37 of your Resource Guide.

Leader's Instructions:

1. Cover the procedure for checking the operation of the motor start relay.
2. If possible, demonstrate the technique using an ammeter.
3. Ask for questions.
4. Have participants and any invited subject matter experts share their best ideas and advice.
Check the Start and Run Capacitors

If the correct amount of voltage is reaching a motor (either fan or compressor) and that motor will not start, the problem may be the capacitor instead of the motor itself. A capacitor is an electrical storage device consisting of a layer of insulation sandwiched between two metal plates. Here’s how to check the capacitors for the compressor.

Introduction

Turn to page 38 in your Resource Guide.

Run and start circuits on compressor motors use capacitors that affect the wattage, amperage draw, torque, speed, and efficiency of the motor.

Some compressor motors have start capacitors, electrical storage devices that help to overcome the torque needed to start a motor, and some will have run capacitors that help motors run more efficiently. The most common problems affecting capacitors are that they may be open—or that they may short out and fail. A shorted capacitor may give you a visual clue of its failure by bulging or leaking.

Open, Shorted, and Working Capacitors

An open capacitor occurs when you attach the Ohm meter leads to the capacitor and the meter does not register anything (measures infinity). A short is when the meter registers little or no resistance (zero Ohms), and stays there.

A working capacitor will charge up rapidly and come back down the scale more slowly. How fast a meter returns to the infinite position (on an analog meter Ohm meter) or the zero reading (on a digital Ohm meter), is determined by the actual size in Microfarad of the capacitor as stamped on its casing. For example, a 5uF capacitor will swing fast to peg your meter scale and will quickly return to the infinite position in less than a second. A larger uF capacitor such as a 35uF capacitor will also peg your meter scale very fast but then, slowly to return to the infinite position of your meter scale as the capacitor discharges.

Polarization and Capacitors

Once you test a capacitor with a meter, you need to reverse your meter leads on the capacitor terminal posts to retest the capacitor again. That’s because capacitors are made for alternating current, and they store current in two directions (positive the first time, negative the second time). Once you perform a bench test one time, you must swap the polarity on the terminals (reversing the positive/negative) supply voltage to the capacitor terminals. Your meter contains a battery; this battery is used to charge up a capacitor to test it. When you swap your meter leads, it swaps the polarity supplied to the capacitor terminals.

Defective Capacitors

If you find a capacitor to be defective, be sure to replace it with one specified by the manufacturer.

New motor = New capacitor

Do not install an old capacitor on a new motor. This can cause the motor to fail prematurely due to electrical “noise” caused by the old component. A new capacitor can be placed on an old motor.

Beware the Capacitor

Before you do any work on a compressor motor, turn off all power to the unit and lock and tag out the circuit. Then, be sure to discharge the start and run capacitors using a screwdriver, or the capacitor discharge tool. If you fail to follow these critical safety steps, you could receive a severe shock.
Check the Start and Run Capacitors (continued)

How-to Steps
To learn how to test the start and run capacitors associated with compressor motors, let’s turn to the HVAC Servicing Procedures manual once again.

As we go through the steps, feel free to take notes on page 39 of your Resource Guide.

Leader’s Instructions:
1. Cover the procedure for testing the start and run capacitors for compressor motors.
2. Demonstrate the technique for discharging a capacitor, using a screwdriver or the capacitor discharge tool.
3. Demonstrate how to measure the resistance in a capacitor.
4. If possible, let participants practice discharging a capacitor and measuring the resistance.
5. Ask for questions.
6. Have participants and any invited subject matter experts share their best ideas and advice.
Test the Compressor Motor for Open or Shorted Windings

Because many of the systems found in the apartment industry are hermetic (meaning that all of the components for the compressor to do its job are found in an enclosed and sealed shell) the only means we have of inspecting the motor inside the compressor is to check the terminals or electrical connections.

Leader’s Instructions:
1. Cover the procedure for testing the compressor motor for open or shorted windings.
2. Demonstrate how to test for these open or shorted windings.
3. If possible, let participants practice the technique.
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

How-To Steps
There are 3 terminals that are often found under an access cover on the outside of the compressor. These terminals are labeled:
- C – Common
- S – Start
- R – Run

Let’s go through the steps to diagnose a compressor motor using the terminals.
1. After verifying that there is the proper amount of voltage being supplied to the compressor, turn off the power.
2. Perform the steps to Lockout and Tagout the electrical system.
3. Verify that all capacitors attached to the system are drained of any stored energy.
4. Access the compressor and inspect it up close.
   a) Is it excessively hot? If so, the compressor may be out on overheat. To verify this:
      i) Place the leads of a continuity tester on C and either of the other two terminals.
      ii) There will not be continuity between C and any other terminal.
   b) Are the wires melted at the connection? If so, check the terminals for corrosion.
      i) If possible, cut the end of the wire where melted and replace the connectors on the wire.
      ii) If not possible, replace the wire and connector completely.
   c) Are the terminals excessively corroded? If so, the terminals may need replacing.
Test the Compressor Motor for Open or Shorted Windings (continued)

5. Check the compressor motor for grounding.
   a) Touch one lead from your Ohm meter to the shell of the compressor. (Note: if needed, scratch through any paint layer to ensure a good connection to ground.)
   b) Use the other lead to verify if any of the terminals show continuity to ground.
   c) If any show continuity, your compressor is dead. You can stop diagnosis here.

6. Verify the motor windings by identifying terminals.
   a) If the compressor is cold (not out on overheat) remove the wires and access the terminals.
   b) Test and note the amount of resistance between the 3 terminals. This amount should follow the following rules:
      i) C to R will be the lowest number of Ohms.
      ii) C to S will be the next highest amount of Ohms.
      iii) R to S will be the highest amount of Ohms.
   c) Add the two lowest amounts of Ohms. This amount should equal the highest reading; if it doesn’t, the compressor is bad.

Group Discussion on Electrical Systems

Once again, hold a group discussion to extend and enrich the classroom training experience.

Leader’s Instructions:

Hold a 10 to 15-minute discussion on the electrical system of an air conditioning unit. Again, you can do this in a variety of ways, such as:

- Presenting additional material on these electrical systems, or having an invited subject matter expert do it.
- Asking participants to share their stories and experiences.
- Holding a question and answer session.
- Asking participants to share their best “tips and tricks” related to air conditioning electrical systems.

Let participants know how the discussion will work, and encourage them to take notes on page 41 of their Resource Guide.
Refrigeration System Repairs (4 hours, 30 minutes)

In this part of the training, you’ll learn how to work with the heart of an air conditioning system, the refrigeration system.

Introduction

To be able to completely service air conditioning equipment (that is, to adjust the efficiency and effectiveness of the equipment designed to control the indoor environment) we must bring everything together that we have covered thus far as one complete system. This means that before any refrigerant measurements can take place, a few items must be completed.

Before making any refrigerant measurements or repairs:

• The maximum designed airflow must occur. This means:
  - All vents are open in the apartment
  - All doors to rooms are open in the apartment
  - The evaporator coil and filter are clean
  - The condenser coil is clean

• Close all windows to the apartment

• Verify all electrical and/or mechanical items in the system are operating properly

Keep in mind all safety information as well as any local, state, or federal regulations that apply. Ensure that you have the proper certifications to purchase and use refrigerants before beginning any of the following repairs.

We’ll be putting the information you already know about air conditioning and refrigerants to good use in this section—soon, you’ll see things like the pressure-temperature relationship, saturation temperature, and liquid and suction lines put into action.

We’re also going to be turning to the HVAC Servicing Procedures manual more often, especially to deal with more of the complex issues.

What We’ll Be Covering

• Using the superheat and subcooling methods to check and adjust the refrigerant charge
• Recovering refrigerant
• Evacuating and dehydrating the refrigeration system
What if the price of R-22 gets too high?

Every comfort cooling air conditioning system is designed around the boiling/condensing temperature of one specific refrigerant. In the case of older systems this is generally R-22. Because of the regulations previously mentioned, and to protect the environment, the EPA is controlling how refrigerants are introduced and used in refrigeration. As the price of R-22 increases, it will become more and more likely that a less expensive option is required. The options are essentially these two: Retrofit or Replace. ***

Retrofit refrigerants will work in the existing R-22 designed equipment without a lot of potentially costly service. Remove the existing refrigerant, replace all schrader valves, and use a retrofit refrigerant to proper levels as determined by the refrigerant manufacturer. The benefit of this option is very little cost to perform the repair. The downside of this option is since the system was designed to operate with a different refrigerant the system may experience a decreased lifespan.

Replacement refrigerants such as R-410A will not work in equipment designed for R-22. This means that at the minimum the entire condensing unit and metering device must be replaced and then R-410A may be used. Depending on the age, type and/or manufacturer of the system, all components (including the lineset and evaporator coil) must be replaced for R-410A to work. The benefit of this type of service is it is a long-term solution that in many instances will result in a warranty for the new equipment. The downside is the cost.

Verifying Proper Refrigerant Levels

Proper refrigerant levels are important to ensuring that the system is moving heat properly while simultaneously controlling the comfort level of the indoor air quality. If there is too much refrigerant in the system, the system will not remove as much moisture from the air and will shorten equipment life. If the quantity of refrigerant, often called refrigerant charge, is too low the evaporating coil can freeze up, causing restricted or blocked air flow and no heat removal.

There are three manufacturer-approved methods for determining a proper charge in an air conditioning system.

Weight: This method is frequently used on small systems, such as a window unit or PTAC, where the manufacturer states the exact amount of refrigerant, often in ounces, required for proper operation. This method is the easiest and most accurate as a technician just adds the stated amount into the system. Due to the fact that all hydrogen-containing refrigerants also contain carbon, the EPA has begun to comment on them being a greenhouse gas (hydro-carbon). At time of publication, there are no current regulations restricting any comfort cooling refrigerant based upon them being an “agent for global climate change”.

Superheat charging: This method is used in systems that have a fixed metering device (piston, capillary tube or orifice).

Subcool charging: This method is used in a system that has a thermostatic expansion valve-type metering device.

Let’s take a closer look at the two methods most commonly used by Apartment Maintenance Technicians; the Superheat and Subcool methods.
The Superheat Method

In this part of the training, you’ll learn about the superheat method for charging air conditioning systems.

Introduction

One of the most common methods to check and adjust the charge of an air conditioning system is the superheat method. This method will help you get the charge just right, which, in turn, will increase the efficiency, cooling power, and life of the system.

About Superheat

Superheat is the heat added to a refrigerant after it has changed to a vapor. By knowing the amount of superheat in the evaporator, you can tell if the system is properly charged.

When to Use the Superheat Method

You’ll use the superheat method in air conditioning systems that use capillary tubes (or some other fixed orifice) as the metering device.

How It Works

The superheat method uses the operating pressures and temperatures of the air conditioning system to see if the system is properly charged.

To determine the amount of superheat, you’ll use a manifold gauge set and a digital thermometer. Then do some simple arithmetic.

The Basic Superheat Calculation

Suction Line Temperature  ➥  Evaporator Saturation Temperature  ➥  Existing System Superheat
Calculate the Superheat in the System

Follow the steps below to calculate the superheat of an air conditioning system with a capillary tube. In this case, assume R-22 is the refrigerant.

Leader’s Instructions:

1. Show the “The Superheat Method” video on the Air Conditioning DVD. Encourage participants to take notes on page 45 of their Resource Guide.
2. Reinforce the information in the video by briefly covering the how-to steps below.
3. Allow participants to practice:
   a. Break the participants into three or four groups, depending on the number of students. Give each group a manifold gauge set and a digital thermometer.
   b. Let each group determine the superheat. Watch for safe behaviors and point out areas where caution is needed.
4. Debrief the activity. Ask questions such as:
   a. “What did you think about this task?”
   b. “What was easy?”
   c. “What was more challenging?”
5. Have participants and any invited subject matter experts share their best ideas and advice.

Safety

Wear eye protection.
Wear sturdy gloves.

Tools and Materials Needed

- Manifold gauge set
- Digital thermometer
- Pencil/pen
- Paper

How-to Steps

1. Set up your equipment.
   a. Attach the manifold gauge set to the service port. The high-side gauge goes to the high-pressure side; the low-side gauge goes to the low-pressure side. Be sure the hoses are purged of air and the valves on the manifold gauge set are closed.
   b. Install a digital thermometer probe on the suction line of the condensing unit under the insulation near the service valve.
2. Run the system for a full 15 minutes to let it stabilize.
   a. While the system is running determine the amount of Superheat that the system is supposed to have based upon existing conditions. (For most accurate and efficient service, follow manufacture specifications.) If manufacturing specifications are not available follow the next chart.
Calculate the Superheat in the System (continued)

How-to Steps

b. Measure the airflow at both the condensing unit (outside air) and the air at the return grill (inside the apartment).
   Determine where the numbers cross in the chart above. This number is the Desired Superheat.

3. Record the saturation temperature. This is done by reading the pressure on the blue (compound) gauge of the manifold and converting that to temperature using a Temperature and Pressure (T&P) chart. For R-22 or R-410A you can refer to the manifold face or this chart.***

<table>
<thead>
<tr>
<th>SYSTEM SUPERHEAT</th>
<th>Return Air Temperature (°F Drybulb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Condenser Inlet Temperature (°F Drybulb)</td>
<td>65</td>
</tr>
<tr>
<td>65</td>
<td>100</td>
</tr>
<tr>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>90</td>
<td>7</td>
</tr>
<tr>
<td>85</td>
<td>5</td>
</tr>
<tr>
<td>80</td>
<td>5</td>
</tr>
<tr>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>70</td>
<td>5</td>
</tr>
<tr>
<td>65</td>
<td>13</td>
</tr>
<tr>
<td>60</td>
<td>17</td>
</tr>
</tbody>
</table>

Source:ESCO Press System Performance (used with permission).

<table>
<thead>
<tr>
<th>Refrigerant Saturation Temp °F R-22 R-410A</th>
<th>Refrigerant Saturation Temp °F R-22 R-410A</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F</td>
<td>psig</td>
</tr>
<tr>
<td>20</td>
<td>43.1</td>
</tr>
<tr>
<td>22</td>
<td>45.3</td>
</tr>
<tr>
<td>24</td>
<td>47.6</td>
</tr>
<tr>
<td>26</td>
<td>50.0</td>
</tr>
<tr>
<td>28</td>
<td>52.4</td>
</tr>
<tr>
<td>30</td>
<td>55.0</td>
</tr>
<tr>
<td>32</td>
<td>57.5</td>
</tr>
<tr>
<td>34</td>
<td>60.2</td>
</tr>
<tr>
<td>36</td>
<td>62.9</td>
</tr>
<tr>
<td>38</td>
<td>65.7</td>
</tr>
<tr>
<td>40</td>
<td>68.6</td>
</tr>
<tr>
<td>42</td>
<td>71.5</td>
</tr>
<tr>
<td>44</td>
<td>74.5</td>
</tr>
<tr>
<td>46</td>
<td>77.5</td>
</tr>
<tr>
<td>48</td>
<td>80.8</td>
</tr>
<tr>
<td>50</td>
<td>84.1</td>
</tr>
<tr>
<td>52</td>
<td>87.4</td>
</tr>
<tr>
<td>54</td>
<td>90.8</td>
</tr>
<tr>
<td>56</td>
<td>94.4</td>
</tr>
<tr>
<td>58</td>
<td>98.0</td>
</tr>
<tr>
<td>60</td>
<td>101.7</td>
</tr>
<tr>
<td>62</td>
<td>105.1</td>
</tr>
<tr>
<td>64</td>
<td>109.3</td>
</tr>
<tr>
<td>66</td>
<td>113.6</td>
</tr>
<tr>
<td>68</td>
<td>117.9</td>
</tr>
<tr>
<td>70</td>
<td>121.2</td>
</tr>
<tr>
<td>72</td>
<td>126.0</td>
</tr>
<tr>
<td>74</td>
<td>130.8</td>
</tr>
</tbody>
</table>

***if other refrigerant is used, refer to that specific refrigerant’s (T&P) chart
Calculate the Superheat in the System (continued)

How-to Steps

4. Read and record the temperature on the digital thermometer attached to the suction line.

5. Subtract the saturation temperature from suction line temperature to get the superheat. Ideally, this number will match the equipment manufacturer’s general specifications.

6. Record this number as Existing Superheat.

7. Compare the amount of Existing Superheat to the amount of Desired Superheat.

8. Adjust the amount of refrigerant as follows:
   - If Existing Superheat is too low, then remove refrigerant. Perform recovery.
   - If the Existing Superheat is too high, then add refrigerant. Charge the system.

9. Wait 15 minutes for the system to allow the new refrigerant level time to circulate and then verify that the changes are correct. If the amount of Desired Superheat does not match the amount of Existing Superheat, repeat this step and adjust the level of refrigerant until they do.

Here is an example situation. Using the conditions at the apartment to answer the questions that follow.

Sample Service Request: An R-22 air conditioning system is operating; however it is not removing heat properly. The technician has verified that both coils are clean, air is flowing and the system has a new filter. The conditions are as follows:

- Return temp: 80˚
- Condenser inlet temp: 90˚
- Low side (Blue gauge) PSI: 68 psi
- Line temp at low side Service Valve: 68˚

Suction line (low side) temperature: __________

Saturation Temperature: __________

Existing Superheat: __________
Desired Superheat: __________

- What statement can be made about the amount of refrigerant in the system? ________________
  - The system is overcharged
  - The system is undercharged
  - There is the correct amount of refrigerant
- Based upon this information, would you add or remove refrigerant? ________________
The Subcooling Method

And now, here’s the subcooling method for charging air conditioning systems.

Introduction

The other manufacturer-specified method for verifying the amount of refrigerant in a system is checking Subcooling. This method will help charge a newer style system that can’t be charged by Superheat.

About Subcool

Subcooling is the heat removed from the refrigerant after it has condensed to a liquid. Since this is often not affected by the length of the lineset between the coil and service valve, it can be an accurate way of setting the charge.

When To Use Subcool Measurements

You’ll use the Subcool method when working on a system that uses a Thermostatic Expansion Valve (TXV) as the metering device. Since using a TXV allows for the superheat to float (rise and fall) based upon conditions we cannot use superheat as the measurement when one is present.

How It Works

To measure Subcool you will need your manifold gauge set, a thermometer and the Superheat charging chart from the manufacturer of the system being serviced.

Once the system has run for at least 15 minutes, you have verified the system operation and the filters and coils are clean, you are ready to find Subcooling. Subcooling is simply the difference between the saturation temperature of the refrigerant in the condensing coil, and the temperature of the refrigerant at the service valve.

The amount of Subcooling is then compared to the manufacturer specifications found in their documentation or service manual. Often, this information is found on the inside of one of the service covers. The desired amount can vary by unit size and manufacturer so an exact expected standard is not provided here.

The Basic Subcooling Formula

Condenser Saturation Temperature (red gauge) – Liquid Line Temperature = Existing Subcooling
Calculate the Subcooling Temperature

Follow the steps below to calculate the subcooling temperature of an air conditioning system with a thermostatic expansion valve. In this case, assume R-410A is the refrigerant.

Leader’s Instructions:

1. Show the “The Subcooling Method” video on the Air Conditioning DVD. Encourage participants to take notes on page 49 of their Resource Guide.

2. Reinforce the information in the video by briefly covering the how-to steps below.

3. Allow participants to practice:
   a. Break the participants into three or four groups, depending on the number of students. Give each group a manifold gauge set and a digital thermometer.
   b. Let each group determine the subcooling. Watch for safe behaviors and point out areas where caution is needed.

4. Debrief the activity. Ask questions such as:
   a. “What did you think about this task?”
   b. “What was easy?”
   c. “What was more challenging?”

5. Have participants and any invited subject matter experts share their best ideas and advice.

Safety

Wear eye protection.

Wear sturdy gloves.

Tools and Materials Needed

- Manifold gauge set
- Digital thermometer
- Pencil/pen
- Paper
- Manufacturer Subcooling standards
Calculate the Subcooling Temperature (continued)

How-to Steps

1. Set up your equipment.
   a. Attach the manifold gauge set to the service port. The high-side gauge goes to the high-pressure side; the low-side gauge goes to the low-pressure side. Be sure the hoses are purged of air and the valves on the manifold gauge set are closed.
   b. Install a digital thermometer probe on the liquid line, at the outlet of the condensing unit under the insulation.

2. Run the system for a full 15 minutes to let it stabilize.

3. Measure the condenser saturation temperature. To do this, read the liquid line pressure on the manifold gauge, and then line it up with the temperature scale on the inside of the gauge. Record this number.

4. Read and record the temperature on the digital thermometer attached to the liquid line. Record this number.

5. Subtract the liquid line temperature from the condenser saturation temperature to determine the amount of sub-cooling. This number should match the amount specified by the manufacturer. If it does not (higher or lower) than adjust the amount of refrigerant using the following chart as a guide:

<table>
<thead>
<tr>
<th>If</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The number is too low (needs to increase)</strong></td>
<td>Charge the system with refrigerant.</td>
</tr>
<tr>
<td></td>
<td>Open the suction line service port, the low-side valve on the manifold gauge set, and the valve on the refrigerant cylinder. Add refrigerant vapor until the suction line temperature is lowered to the correct level, and the system is generating the correct amount of superheat.</td>
</tr>
<tr>
<td></td>
<td>Remember: Always wear personal protective gear, including eye and hand protection, when working with refrigerant.</td>
</tr>
<tr>
<td><strong>The number is too high (needs to decrease)</strong></td>
<td>The system is overcharged, meaning there is too much refrigerant. Remove the excess refrigerant, following the steps on page 42.</td>
</tr>
</tbody>
</table>

A Note about Blended Refrigerants

Refrigerants that are a part of the 400-series numbering system (Example: R410a, R438, R422b, R407c, Etc...) are blended refrigerants. This means that they contain components that are not a complete mixture. Using a blended refrigerant is similar to any other refrigerant as they both must enter a running system on the low pressure side. Generally speaking, this is performed through a service valve located just before the compressor.

Using a blended refrigerant does require a small procedural change. Due to the different pressures of the components making up the refrigerant in the jug (fractionation), the refrigerant must leave the jug as a liquid. In many instances this will require the technician to turn the jug upside down.

This can cause a problem as, if the liquid refrigerant reaches the compressor, it can damage the valves or other components inside. To prevent this either the technician will have to manually throttle (reduce the flow of liquid through the manifold by almost completely closing the low side manifold valve) or use a charging adapter. **Blended refrigerants must leave their container in liquid state that should boil to vapor before entering the compressor.**
Performing Repairs With Refrigerant

It’s against the law to vent (or release) refrigerant in the air. That’s why Environmental Protection Agency (EPA) regulations require that refrigerants be recovered instead.

Introduction

Turn to page 40 in your Resource Guide.

Proper service with refrigerant begins with an understanding of the regulations that govern its use. These regulations do not cover the in’s and out’s of making repairs on a system to increase that system’s lifespan and efficiency. In this section we’ll look at some terms and methods that can allow us to make our systems run longer and operate better.

The three R’s of Refrigerant Handling

Recover – To remove refrigerant from a system in a way that prevents it from escaping into the environment.

Recycle - To return recovered refrigerant back in to the same or another system owned by the same owner. An example of this is a technician that recovers refrigerant from one apartment, after verifying the refrigerant is clean and dry, and uses that same refrigerant in a different apartment’s system.

Reclaim - To take recovered refrigerant that cannot be recycled on site and turn it over to a chemical company, often by way of a supplier, for that chemical company to “clean” the refrigerant so that it can be resold and reused in the marketplace.

Leak detection and charging

There are only 2 times in the life of an operating AC system when refrigerant should be added. Those are:

1. The system has a leak
2. The system was not charged properly to begin with.

Refrigerant does not spoil or go bad in a system. If proper service has been performed throughout the life of the system there should not be a need to continually add refrigerant. Here are some tips to locate leaks and prevent further damage from improper service.

- Every time hoses are connected to the system, purge out the trapped air in them by quickly opening and closing the end of the hose away from the service valve connection.
- Keep schraeder ports capped at all times. To decrease leaks, utilize metal caps with an o-ring.
- Verify that your gauges are at zero psi before connecting them to a system every time.
- Use an electronic leak detector outside when there is no wind. Any air movement at all will cause the refrigerant to move before detection.
- Use soap bubble leak detectors around any joints or fittings of the pipe to check for the presence of leaks in these areas.
Evacuating and Dehydrating the System

In this part of the training, you’ll show the aspiring CAMT how to remove two enemies of the refrigeration system—excess air and moisture.

Introduction

Turn to page 52 in your Resource Guide.

When air and moisture get trapped in a refrigeration system, they’ll need to be evacuated with a vacuum pump. Air reduces the amount of heat transfer and may cause a system to operate erratically. Moisture can freeze-up in the system and block the flow of refrigerant; it can also combine with refrigerant and oil, creating sludge and acid.

How Evacuation Works

Before a system is charged, either for the first time from install or after a repair has been made, evacuation must occur. This means all of the air, moisture, and any other gasses must be removed.

When an air conditioning system is evacuated, the vacuum pump creates a difference in pressure between the system and the pump. This, in turn, causes the air and moisture trapped in the system at a higher pressure to move to a lower pressure area created in the vacuum pump.

When the vacuum pump lowers the pressure in the system enough (determined by the ambient temperature of the system), the trapped liquid moisture will boil and change into vapor. Then, just like air, this water vapor is pulled out of the system, processed through the vacuum pump, and released to the atmosphere.

When to Evacuate a System

You’ll need to evacuate an air conditioning system anytime it has been opened to the atmosphere, for example, after fixing a leak or replacing a part like a compressor.
Evacuating and Dehydrating the System (continued)

Two Methods of Evacuation

- The deep vacuum method is typically used when making a repair that involves refrigerant recovery.
- The triple evacuation method is typically recommended for especially "wet" systems.

Note: The process of evacuation is performed while there is NO refrigerant in a system. In other words, before the system starts up. For more detailed information about performing system evacuation and vacuum pump maintenance, refer to pages 22-23 in HVAC Servicing Procedures.

How-to Steps

To learn how to evacuate and dehydrate an air conditioning system, we’re going to turn to the HVAC Servicing Procedures manual now.

As we go through the steps, feel free to take notes on page 53 of your Resource Guide.

Leader’s Instructions:

1. Have participants turn to pages 24 and 25 in the HVAC Servicing Procedures manual.
2. Cover the procedure for evacuating and dehydrating a system. Point out the steps participants must use for the deep vacuum method and the triple evacuation method.
3. If possible, demonstrate the technique—or key parts of it—using a manifold gauge set, a vacuum pump, a vacuum gauge, a nitrogen cylinder, and a service hose, tee, and adapters. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

For More Information

If you’d like to explore the topic of evacuation and dehydration in more depth outside of class, refer to Section 4 of your HVAC Servicing Procedures manual.
Group Discussion on the Refrigeration System

Once again, hold a group discussion to extend and enrich the classroom training experience.

Leader’s Instructions:

Hold a 15-minute discussion on the refrigeration system. Again, you can do this in a variety of ways, such as:

- Presenting additional material on the refrigeration system, or having an invited subject matter expert do it.
- Asking participants to share their stories and experiences.
- Holding a question and answer session.
- Asking participants to share their best “tips and tricks” related to the refrigeration system.

Let participants know how the discussion will work, and encourage them to take notes on page 54 of their Resource Guide.
Air Distribution (1 hour)

Air distribution (or circulation) is a basic feature of both gas and electric furnaces. So it’s a good place to start our discussion of common heating problems and solutions.

Leader’s Instructions:
Work with your local affiliate to obtain a direct drive blower to support this instruction. You can work with various suppliers, who may be willing to donate new, used, or ready-to-recycle blowers.

Spend about 10 minutes comparing the diagram in this section to the actual unit. That way, participants will “experience” each part of the blower as you describe it.

The Big Picture

When the living space in an apartment requires for the temperature level to decrease or for the humidity to be removed, one of the first operations to occur is for the fan to be turned on. This occurs because air is used as the “carrier” for heat or moisture to a system for removal. In a standard air conditioning system, whether it is a small window type unit, split system, or even a large chiller, the movement of air is required for any conditioning to occur. Inside the apartment, air is removed by a blower from the living space and forced through the evaporating coil. This will enable the air to lose heat as the coil is a lower temperature (heat always transfers from a higher temperature to a lower temperature). In addition to this heat transfer, moisture in the air condenses out of the air onto the surface of the coil. The moisture, or condensate, runs down the evaporating coil where it is drained from a condensation pan. The lower-temperature, drier air is then circulated back to the living space in the apartment, thereby lowering the temperature of the apartment. On the outside of the apartment or living space, air circulation is just as important. Outside air is pulled or pushed by a fan through the condensing coil. Due to this coil’s higher temperature than the outside air, heat is removed from the coil and is carried away by the air. This explains why you feel warm or hot air coming off of the top of this outside unit.

In truth both inside and outside units are self contained meaning that they don’t share any air. Instead, the only thing that moves from inside to the outside is heat. In this part of the training you’ll learn more about the systems that cause this air movement, particularly the blower assembly and the key operations of the motors that are used in air distribution.

Inside a blower assembly there are 2 types of motor that may be found. It is important to be aware of these types as troubleshooting each of them has separate procedures.

- PSC motor: Permanent Split Capacitor motor
  - A PSC motor is the most common type of motor currently in use for blowers found in the apartment industry.
  - This motor type is identifiable by the capacitor that is connected to the motor and must be present for this motor to operate.
  - Speed is determined by individual circuits. Common speed circuit colors(on the motor***):
    - Black = High
    - Blue = Medium
    - Red = Low

- ECM: Electronically Commutated Motor
  - An ECM is a more efficient motor that is replacing PSC motors in many applications
  - This motor type is identifiable by the control module that is attached to the back end of the motor
  - Speed is determined by the programming of the control module. (120v or 240v Power*** is constantly supplied, control voltage determines program, program is set by mfg.)

***verify to manufacturer specifications

Both ECM and PSC Motors require a capacitor for operation. Before performing ANY service on a motor, follow Lock Out Tag Out procedures, and verify that the capacitor is discharged. Failure to do so is extremely dangerous.
Air Distribution (continued)

There are two types of blowers: belt drive and direct drive. In this training, we’ll be focusing on direct drive motors, the type most commonly found in apartment communities.

Belt Drive

Direct Drive

(Tap-wound motor shown)
Air Distribution (continued)

Components of a Direct Drive Motor

- Cutoff Plate
- Blower Wheel
- Note: The blower wheel also has a balancing weight.
- Motor Mounting Band
- Grommet
- Motor Mounting Arm
- Fan Motor
- Capacitor
- Housing
- Set Screw
Lubricate the Blower Motor

Noisy airflow? Try lubricating the blower motor.

Leader’s Instructions:

1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 58 of the participants’ Resource Guide.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

Safety

Make sure the power to the furnace is turned off.
Use lockout/tagout procedures.
Wear eye protection.

Tools and Materials Needed

- Lockout/tagout device
- Screwdriver
- Oil for lubricating the motor

How-to Steps

1. Turn off the power to the furnace at the main service panel.
2. Lock and tag out the service panel.
3. Remove the access panel.
4. Oil the motor according the instructions on the motor. In most cases, a few drops will do it; too much oil will attract lint and dust that can adversely affect the motor’s operation.
5. Replace the access panel and restore power to the unit.
Test a Blower Motor

When you suspect the blower motor is defective, follow the testing steps below.

**Leader’s Instructions:**

1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 59 of the participants’ Resource Guide.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

**Safety**

Make sure the power to the furnace is turned off.

Use lockout/tagout procedures.

Wear eye protection.

**Tools and Materials Needed**

- Lockout/tagout device
- Screwdriver
- Multimeter

**How-to Steps**

1. Turn off the power at the main service panel.
2. Lock and tag out the service panel.
3. Remove the access panels to the blower.
4. Remove the motor wire leads. Identify the wires for later reinstallation.
5. Carefully discharge and disconnect the capacitor.

   **WARNING:** A capacitor acts like a high-voltage battery that can shock you even when it is disconnected. Make sure it is fully discharged before proceeding.

6. Test the motor for the proper electrical resistance.
   a. Make sure the power wires are disconnected from the motor. If it is easy to do, remove the motor from the appliance, though motors can be tested in place.
   b. Set the multimeter to R X 1.
   c. Attach one of the multimeter’s probes to the motor’s common lead.
   d. Attach the other probe in turn to each of the other wires on the motor. A low or moderate reading (in ohms) means the motor is working. A zero or infinite reading means the motor’s windings or another component (internal overload) is open and unable to support the flow of electricity.

7. If the motor is faulty, replace it.
Replace a Blower Motor

*If a blower motor is faulty, replace it, following the steps below.*

### Leader's Instructions:

1. Introduce the topic.
2. Cover the how-to information below. (This information is also on page 60 of the participants’ *Resource Guide*.)
3. If possible, demonstrate the technique, using the tools and materials indicated. (Or, have a participant demonstrate the technique as you describe it.)
4. Ask for questions.
5. Have participants and any invited subject matter experts share their best ideas and advice.

### Safety

Make sure the power to the furnace is turned off.

Use lockout/tagout procedures.

Wear eye protection.

### How-to Steps: Removing the Old Motor

1. Remove the blower assembly from the furnace.
2. Loosen the squirrel cage setscrews.
3. Remove the motor support bracket screws.
4. Pull the motor free from the squirrel cage. (You may need to apply some penetrating oil to loosen the squirrel cage from the shaft.)
5. Loosen the belly band.
6. Remove the motor from the bracket.

### How-to Steps: Installing the New Motor

1. Install the new motor on the motor bracket.
2. Install the motor shaft into the blower assembly.
3. Secure the blower assembly to the motor housing.
4. Center the squirrel cage in the housing and then secure the blower assembly to the motor shaft.
5. Install the blower assembly into the furnace.
6. Make the proper wiring connections.
7. Turn the motor on and check it for the proper rotation.
8. Inspect the rubber grommets that insulate the motor from the metal housing.

### Tools and Materials Needed

- Lockout/tagout device
- Screwdriver
- Adjustable wrench
- Nut driver
- Allen or key wrench
- Penetrating oil
- Replacement blower motor (Be sure it has the same frame, horsepower, RPMs, rotation direction, shaft size and type, speeds, and amperage draw as the motor you’re replacing.)
Group Discussion on Air Distribution

Once again, hold a group discussion to extend and enrich the classroom training experience.

**Leader’s Instructions:**

Hold a 10-minute discussion on air distribution. Again, you can do this in a variety of ways, such as:

- Presenting additional material on air distribution, or having an invited subject matter expert do it.
- Asking participants to share their stories and experiences.
- Holding a question and answer session.
- Asking participants to share their best “tips and tricks” related to the air distribution system.

Let participants know how the discussion will work, and encourage them to take notes on page 61 of their Resource Guide.
Unit Replacement (15 minutes)

In this part of the training, you’ll spend a few minutes discussing how to replace an air conditioning unit.

Leader’s Instructions:

Hold a 15-minute discussion on unit replacement. Again, you can do this in a variety of ways, such as:

- Presenting additional material on replacing air conditioners, or having an invited subject matter expert do it.
- Asking participants to share their stories and experiences.
- Holding a question and answer session.
- Asking participants to share their best “tips and tricks” related to replacing units.

Let participants know the how the discussion will work, and encourage them to take notes on page 62 of their Resource Guide.
Air Conditioning Problems and Solutions (30 minutes)

Now that the aspiring CAMT has learned the key concepts about an air conditioner’s refrigeration, electrical, and air distribution systems, you’ll tie it all together with a discussion of the problems and solutions the aspiring CAMT is most likely to see.

Introduction

Turn to page 63 in your Resource Guide.

So far, you’ve not only learned how air conditioning works, but you’ve also learned how to test and repair key parts of the refrigeration, electrical, and air distribution systems.

We’re now going to look at all this information in a different context, that is, in terms of common air conditioning problems and solutions. What we’ll be covering is not an exhaustive list of everything that can go wrong with an air conditioning system, but you can use this problems and solutions grid to help you get started down the correct troubleshooting path.
The Grid:
Air Conditioner Problems and Solutions

<table>
<thead>
<tr>
<th>Problems</th>
<th>Possible Causes and Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>The condensing unit does not run</td>
<td>1. Be sure the thermostat in the apartment is set to “cool” and is at an appropriate temperature.</td>
</tr>
<tr>
<td></td>
<td>2. Check the service panel for a tripped or blown breaker or fuse.</td>
</tr>
<tr>
<td></td>
<td>3. Check the disconnect switch. Turn it on if needed.</td>
</tr>
<tr>
<td></td>
<td>4. The unit may not be receiving enough power. Use your multimeter to make sure the unit is receiving the proper input voltage.</td>
</tr>
<tr>
<td></td>
<td>5. There may be a continuity problem with the disconnect box fuse. Test the fuse with your multimeter and replace it if needed.</td>
</tr>
<tr>
<td></td>
<td>6. The compressor may be overloaded. Allow it to cool, and then reset it.</td>
</tr>
<tr>
<td></td>
<td>7. The compressor or fan motor capacitor may be defective. Discharge the capacitor, test it, and replace it if necessary.</td>
</tr>
<tr>
<td></td>
<td>8. The fan motor may be bad. Test the fan motor and replace it if needed.</td>
</tr>
<tr>
<td></td>
<td>9. The compressor motor may be bad. Test the compressor motor and replace it if needed.</td>
</tr>
<tr>
<td></td>
<td>10. The unit’s contactor may be bad.</td>
</tr>
<tr>
<td>The condensing unit is noisy</td>
<td>1. The access panel screws may be missing or loose. Tighten them.</td>
</tr>
<tr>
<td></td>
<td>2. The condensing unit may not be level. Level it.</td>
</tr>
<tr>
<td></td>
<td>3. The fan blades may be hitting the bracket or the grille. Adjust them and replace them if need be.</td>
</tr>
<tr>
<td></td>
<td>4. The fan blades may be bent. Replace them.</td>
</tr>
<tr>
<td></td>
<td>5. The fan motor may need oiling. Apply a few drops of oil according to the instructions on the motor itself.</td>
</tr>
<tr>
<td></td>
<td>6. The fan motor may be going bad. Test the motor and replace it if needed.</td>
</tr>
<tr>
<td></td>
<td>7. The compressor mounts may be worn or loose. Tighten the mounts or replace the bushings.</td>
</tr>
</tbody>
</table>
## Air Conditioner Problems and Solutions (Continued)

<table>
<thead>
<tr>
<th>Problems</th>
<th>Possible Causes and Solution</th>
</tr>
</thead>
</table>
| The condensing unit is hot to the touch | 1. Air may not be able to circulate around the condenser. Clear any debris and trim bushes or trees back at least two feet from the unit. If that does not work, the unit may have to be moved to ensure the proper clearances around the equipment.  
2. The condensing unit may be dirty. Clean it.                                                                                                                                    |
| The system runs, but it does not cool  | 1. Be sure the thermostat in the apartment is set to “cool” and is set at an appropriate temperature.  
2. The indoor air filter may be dirty or clogged. Inspect the filter and clean or replace it as necessary.  
3. The condensing unit may be dirty. Inspect the unit, clear any obstructions, and clean the coils and fins as needed.  
4. There may be a problem with the system superheat (systems with capillary tubes) or the system subcooling (systems with thermostatic expansion valves). Measure and calculate the superheat or subcooling in the system, repair any leaks, and adjust the refrigerant charge as needed.  
5. The fan motor may be bad. Test the fan motor and replace it if necessary.  
6. The compressor may be defective. Test the compressor and replace it if needed.                                                                                                     |
| The system cycles too often            | 1. Check the thermostat for proper installation (levelness, correct location, secured to the wall). Also check and confirm that the hole for the thermostat wiring is sealed behind the thermostat so it will not sense interior wall temperature.  
2. Air may be leaking into the apartment from doors, walls, receptacle outlets, or holes in walls or cabinets. See if you can isolate the leak and fix it.  
3. The thermostat may be in the wrong place. Move it.  
4. The thermostat may have a short. Replace it.                                                                                                                                       |
Key Takeaways, Action Plan, and Wrap-up (30 minutes)

Participants have just spent a few days learning about air conditioning and maintenance and repair. It’s time for them to make the most of their newfound knowledge by taking action on what they have learned.

In this part of the training, participants will briefly review the key takeaways for this course, write a brief “Start/Stop/Continue” action plan, and then be introduced to the supplemental online training for this course.

Well, you’ve come a long way. Over the last few days, we’ve covered all of these air conditioning topics:

- Your roles and responsibilities
- Air conditioning safety
- Tools and equipment for air conditioning repairs
- Air conditioning basics
- Simple fixes
- Refrigeration system repairs
- Electrical system maintenance and repairs
- Air distribution system maintenance and repairs

To cross the finish line for this course, we have just three things to do:

1. Take a look at the key takeaways for this course
2. Have you write a simple action plan
3. And introduce you to the supplemental online training for this course

Let’s start with the key takeaways. Turn to page 66 in your Resource Guide.
Key Takeaways, Action Plan, and Wrap-up (Continued)

It’s not easy to sum up a course that has covered as much ground as this one has. But we’ve tried, by identifying several key takeaways you can use once you get back on the job:

**Air Conditioning Safety Takeaways**

- Follow the correct safety procedures whenever you work with an air conditioning system. Do not cut corners or take risks.
- When testing or repairing an air conditioner, turn off any electrical power. Use a multimeter to make sure the power is off.
- Follow lockout/tagout procedures.
- Wear the correct personal protective equipment—in most cases, eye protection, breathing protection, and gloves—and wear non-slip soled shoes.
- Remember: To work with refrigerants, you must have the Environmental Protection Agency (EPA) Type II or Universal Certification for most split-systems used in apartment communities, and Type I for most window units.
- Before beginning any refrigerant repair, verify that all airflow and electrical/mechanical components in an HVAC system are operating properly.
- Call an air conditioning professional to do work for which you are not qualified.

**Air Conditioning Repair and Maintenance Takeaways**

- Use the repair techniques you’ve learned today to improve the speed and quality of your work.
- Do your best to keep up with the latest advances in tools, technology, and techniques as they relate to air conditioning maintenance and repair.
- Feel free to use this Resource Guide when you’re back on the job.

**Leader’s Instructions:**

Ask participants if they would like to add any key takeaways. Write any on the flipchart or whiteboard, and invite participants to write them in their Resource Guide.

With these takeaways in mind, let’s now move on to having you write an action plan. Turn to the next page in your Resource Guide.
Key Takeaways, Action Plan, and Wrap-up (Continued)

“Start/Stop/Continue” Action Plan

The point of an action plan is simple. It gets you thinking about what you’ve learned in this course, and then asks you to write down a few things you’ll do differently back on the job.

You’ll be doing a simple and realistic action plan today called “Start/Stop/Continue." All you need to do is reflect on the things you’ve learned in this course, and based on that, write at least one thing you want to start doing, stop doing, and continue doing when you return to your apartment community.

Then, if you can work on these things for the next month, you’ll most likely improve your on-the-job skills, feel more confident, and just enjoy your time as a maintenance technician even more.

I’m going to give you ten minutes now to work on your “Start/Stop/Continue” plan, and remember, this plan is for you and you alone. You don’t need to share with it anyone, unless you’d like to.

Leader’s Instructions:

Give participants ten minutes to work on their “Start/Stop/Continue” action plans, and answer any questions along the way.

Thank you for taking the time to work on your plan. I wish you all the best as you work on it over the next month.

Supplemental Online Training

Before we bring this course to its official close, I want to tell you about another way you can build on—and reinforce—what you’ve learned today.

As part of this course, you can also complete a brief online training course on Air Conditioning Maintenance and Repair. The course will take approximately 45 minutes, and it will cost you nothing extra. You can access and take the course on your home computer, a computer in a public place like a library, or a computer at work, as long as you have your supervisor’s permission to do so.

In this online course, you’ll get to complete three practice scenarios, in which you’ll play the role you know best, that of a maintenance technician.

These realistic scenarios will let you prioritize, diagnose, and repair air conditioning problems, just as you would on the job. You’ll also be able to ask questions and get feedback as you go along.

You can find the instructions for accessing the course on the inside cover of this Resource Guide.

Closing

Thank you for being a part of the Air Conditioning Maintenance and Repair course.

I wish you the best of luck as you pursue your CAMT designation, and all the best back on the job, too. It’s been my pleasure to be your instructor.

Leader’s Instructions:

If there are no further questions or comments, dismiss the participants.

On behalf of the NAA and your local affiliate, thank you for teaching the “Air Conditioning Maintenance and Repair” course.
Appendix: Suggested Training Kit for this Course

If you choose to conduct demonstration and hands-on practice, which is highly recommended, work with your NAA affiliate to put together a training kit of tools and materials you can use in the course. This kit will not be expensive, but it will take a little planning and time to complete.

Safety Equipment

Lockout/tagout kits
Pairs of goggles
Pairs of gloves
Masks

Tools

Screwdrivers
Nutdrivers
Tongue and groove pliers
Needlenose pliers
Adjustable wrenches
Ratchet wrenches
Allen wrenches
Utility knives
Manifold gauge sets (3 or 4)
Inexpensive digital multimeters
Inexpensive digital thermometers
Fan blade pullers

Equipment

Split air conditioning system, or, at a minimum a condensing unit
Refrigerant
Recovery unit
Vacuum pump
Empty cylinders
Replacement parts for the split system, such as compressors, capacitors, and fan motors (You can use the parts you already have in the split system as “replacements.”
Window air conditioner
Acknowledgments

Subject Matter Experts

The NAA Education Institute wishes to thank the following apartment industry professionals for contributing their time and expertise to the rewrite of the Certificate for Apartment Maintenance Technicians program:

Paul Rhodes, CAMT
National Maintenance & Safety Instructor
National Apartment Association Education Institute (NAAEI)
prhodes@naahq.org

Vicki Sharp, NALP, CAPS, CDPM
Senior Director of Property Management
Meridian Residential Group
Vickisharp@meridianres.net

Paul Perez
Instructional Assistant
Gudelsky Institute for Technical Education
Rockville Campus
Paul.Perez@montgomerycollege.edu

David Jolley, CAMT
National Director of Maintenance/Purchasing
Pinnacle Management
DJolley@Pinnacleliving.com

Scott F. Ployer, CPM, MFE, NAHP-E, CGPM
Vice President of Operations
Trinity Management LLC

Mark Vanderhoof
Corporate Maintenance Trainer
CWS Apartment Homes, LLC
mvanderhoof@cwsapartments.com

Keith Gibson
Director Maintenance Training
Post Properties, Inc.
Keith.Gibson@postproperties.com

NAAEI would like to thank the following individuals for their time and expertise in updating the CAMT Job Task Analysis:

Ed Kiper / David Jolley / Keith Gibson

NAAEI would like to credit the following companies for use of photos:

Carrier Corporation
www.Carrier.com

Wilmar Industries
www.Wilmar.com